MEDICAL FACULTY COMENIUS UNIVERSITY

HYGIENE – ENVIRONMENTAL MEDICINE

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and contributors

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Content

Preface

The main goal of the field of hygiene / environmental medicine is the protection and promotion of health. Tasks of this basic branch of preventive medicine include identification of environmental hazards to human health and implementation of safe hygienic standards for physical, chemical and biological environmental factors, as well as psychosocial and behavioural factors in order to improve the health of all population groups. An understanding of the causal relationships between environmental exposure and disease is based on principles of evidence-based medicine.

Health status monitoring, joined with identifying community health problems, leads to many different health care interventions implemented not only by health services but by a much broader range of disciplines which include providing satisfactory living conditions, encouraging healthy behaviour, intensifying health education, and regulating health policy and management on all levels.

The following chapters have been put together by authors from the Institute of Hygiene, Faculty of Medicine Comenius University with the aim of providing students of medicine and students of public health as well as physicians and public health professionals with information and knowledge of environmental health issues.

A new publication has been prepared due to the serious environmental worldwide changes and their impact on the health of populations.

It is difficult to include here all the advances in environmental health issues and their associated causes. Therefore these chapters are limited in scope. The authors assume that present-day methods and forms of e-learning provide students and professionals with the possibility of obtaining topical global, national and regional data and more information according to their interests.

I hope you enjoy learning about the environmental, behavioural and psychosocial aspects of environmental medicine/hygiene, their effect on the health of populations, and their subsequent application to health protection and promotion.

Ľudmila Ševčíková

1. HYGIENE – ENVIRONMENTAL MEDICINE BASIC TERMINOLOGY

1.1 HYGIENE (ENVIRONMENTAL MEDICINE)

Hygiene (Environmental medicine, Environmental hygiene, Environmental health) is a medical discipline. The goals of this basic branch of **preventive medicine** are to promote and protect health, taking into account the interactions between the environmental biological, physical, chemical and social factors and the human organism. It is concerned with the control of all biological, physical and chemical processes, influences and factors that exercise or may exercise, by direct or indirect means, a significant effect on the physical and mental health and social well – being of man and society.

Hygiene is the major discipline of **public health**, defined as a multidisciplinary field that combines and applies techniques from both social and natural sciences to assess the health state of a population, to promote human health, and to prevent diseases.

Hygiene closely relates to **epidemiology**, which studies the distribution and determinants of health-related states or events in a population, occurrence and causes of health effects in humans.

Community medicine is recognized as public health, preventive medicine and social medicine; stresses the preventive aspect of medicine and treatment of common ailments.

Environmental hygiene (Environmental health) comprises the same aspects of human health and disease that are determined by factors in the environment; refers to the theory and practice of assessing and controlling factors in the environment that can potentially affect health. Environmental health includes both the direct pathological effects of chemicals, and biological agents, and the effects (often indirect) on health and wellbeing of the broad physical, psychological, social and aesthetic environment.

The first goal of hygiene is to provide satisfactory living conditions. To facilitate this goal, i.e. reduction of disease to a minimum level, it is necessary to discover and standardize the environmental factors required biologically to maintain homeostasis in the human organism.

The second goal of hygiene is defensive; it is an attempt to set limits for biologically harmful changes in the environment. Man's activities, especially during the last century, have dramatically changed the natural order of substances in the surface layer of the earth.

Coal, oil, and gas accumulated over millions of years are now being consumed in ever – increasing quantities, liberating both heat and chemical substances into air and water. It also concerns radioactive substances, industrial, agricultural and other chemicals. The entire ecological system, including man, which

developed over millions of years, by obtaining energy, only from the transformation of solar energy, is today increasingly required to adapt to these drastic changes.

Biological acceptability of changes in the environment is very important, as the adaptive capacity of man is rather limited.

The defensive role of hygiene is extremely important because in his previous history, man was exposed only to challenge from or other independently developed parts of the ecological system.

Encounter with plague organisms, for example, a rodent parasite, gave rise to epidemics since man had not developed the necessary level of immunity to the organism owing to the rarity of such event in very early times. Nearly all the diseases of previous centuries have been of this type, i.e., the result of absence of adaptation to relatively simple changes in the natural environment.

In the meantime, however, encounters are of quite another kind, involving chemicals, radiation and other distortions of the environment, and constitute a greater challenge to man's biological capacity to adapt; sometimes there are no coded mechanisms to cope with the challenge. When the change is so small that a reaction detectable on first contact subsequently disappears, one can assume real adaptation. Practically all the changes in the environment have a definite threshold, regardless of the fact that the magnitude of some will be extremely small.

Environmental agents may produce varying degrees of change in the functional status of the human body, which is related to body's adaptive potential. With **environmental exposure** (contact with a substance by swallowing or breathing or by direct contact such as through the skin or eyes) occurring at low intensity over a longer period of time, a gradual transition usually takes place, with a wide range of reactions from minor, a discrete impairment of health to clinical illness and disability. The nature of adaptation is related to the different adjustment mechanisms due to the type of chemical exposure.

The complex of physiological reactions to natural changes in the environment is coded in the human genetic system and this has been built up over many generations. When environmental changes are biologically new and occur rapidly, the precoded physiological reaction is either non-existent or very weak.

The **nonspecific nature of biological response** is due primarily to an unstable functional balance between the organism and the environment. These changes are accompanied by a decrease in the adaptability of the organism, which can cause various pathological disorders.

The **specific nature of biological response** depends on the chemical nature of the toxic substance and its pathogenesis.

More frequent, but undesirable, is adaptation to environmental changes through disease.

The simplest case is the acquisition of immunity through illness, i.e. after contact with infection. Occasionally workers are found to acquire an apparently higher resistance to irritation by substances such as H_2S, SO_2 and dust, but during close health inspection, it is possible to detect hidden pathological changes (e.g. atrophic changes in the mucous membranes of the bronchi) that produce false compensatory effects.

All cases of manifest or hidden pathology represent consequences of high stress on adaptation mechanisms – inability to obtain a new level of homeostasis in one generation. Drastic changes require adaptation by evolution the weakest will die out and there will be a

slow accumulation of resistance by selection up to real adaptation in the following generations.

The most difficult case is whether adaptation is possible at all in the case of new chemicals or other environmental changes that man has not encountered before in his evolutionary development.

There is increased amount of ultraviolet radiation reaching the earth's surface with potentially harmful effects of human health.

Environmental hazards are all kinds of environmental factors or exposures that adversely affect health or the ecological balance necessary to human health, safety and well-being. Environmental factors involve characteristics of the occupational or personal environment such as work safety and housing conditions, but also the global environment such as water, air, soil and food. Environmental hazards are for example water contaminants, toxic chemicals, wastes, air pollution, disease transmitters and radiation. The new environmental hazards are constantly discovered or rediscovered. Approximately a quarter of the global burden of disease can be attributed to environmental factors. Identifying hazards, estimating the threats they pose to human general population and to workers, and evaluation of such risk is the task for environmental medicine. This appraisal needs a multidisciplinary approach of those who are involved in the measurement of health of populations as well as those who are competent in measurement of various environmental hazards.

Health risk is the probability of health impairment, disease or death of a person or population group as a result of exposure to chemical, physical, biological risk factors in the environment. Over time, major risks to health shift from traditional risks (e.g. inadequate nutrition or unsafe water and sanitation) to modern risks (e.g. overweight and obesity). Modern risks may take different trajectories in different countries, depending on the risk and the context. For risk assessment, management, perception, and communication see more in chapter 2 and 10.

The next basic terms in connection with environmental hygiene are norms, criteria and standards.

Norm is the most general term, encompassing such expressions of desiderate as goals, objectives, policies, standards.

Criteria are measurable components (or tests) of a standard that permit determinations to be made of whether or in what respects a standard has been met (e.g. a water quality standard has as its component criteria such measurements as pH, chlorine content, etc.).

Standard either is an explicit statement of conditions to be fulfilled in an operating process (e.g. personal cleanliness of food handlers) or as a characteristic of an end – state (e.g. water fit for drinking).

Environmental health standards are established based on quantitative relationships between the intensity, frequency, and duration of exposure to various environmental influences, and the risk or magnitude of an undesirable effect on man and his environment.

These relationships are derived from toxicological, epidemiological, and environmental studies. They can be established with fair precision if the exposures are high, as in some occupational situations. With low-level, long-term exposure (i.e. ambient air, foreign substances in food), the task becomes very complex and the interpretation is difficult. In many instances water, milk, and other food were made safe for consumption by imposing standards of quality based on relatively general and vague rules.

Environmental health standards are "acceptable" or "permissible" limits of concentration (or of other index of the intensity of exposure) established to protect a defined population from the undesirable effects of a specified exposure to one or several environmental hazards (e.g. the work environment, ambient air, water, foreign substances in food). Such limits are set for pollutants taken up by an organism or a population. This is sometimes called a "primary protection standard". It is the accepted maximum level of a pollutant (or its indicator) in the target or some part thereof, or an accepted maximum intake of a pollutant or nuisance into the target and specific circumstances.

The simplest case where a substance, present in only one medium, e.g. a food additive not otherwise occurring in nature may be associated quantitatively with a specific effect on man is rare. Most pollutants, if present in only one medium, are present in association with others. For example atmospheric SO_2 will be present in association with other pollutants such as carbonaceous matter and various substances derived from the burning of fossil fuels. It will be also associated with sulphuric acid and derived from the oxidation of a portion of SO_2.

Examples of a "primary protection standard" are **acceptable daily intakes (ADI)** of some chemical substances (food additives, pesticide residues and veterinary drug residues). The **maximum permissible intake (MPI)** of radioactive substances is other example. This standard is a special case of a "primary protection standard" as it relates to the absorption of energy and not of a substance. The special concern over children has led to a **provisional tolerable weekly intake (PTWi)** for some heavy metals, lead, cadmium and mercury.

Pollutants are present in specified environmental media (e.g. air, water) or in products (e.g. food, consumer goods). Such limits are sometimes called „derived working levels". They include mostly maximum allowable concentration for occupational exposures, ambient air quality standards and water quality standards.

In order to meet emissions or effluent standards, it is necessary to establish various types of "technological standards" concerned with the performance and design of equipment in those technologies and operations leading to the release of pollutants. In the developed countries, there is a general tendency to improve in this context all aspects of the performance of industry, which relate to cleaner technologies, protection of health, safety and the environment. Each country selects the standards that can best afford in the light of health, social, economic, and technological consideration.

From this point of view a pollutant release and transfer register (PRTR), this is an inventory, of toxic chemical releases from industrial sources and concerns the annual quantities of air emissions, water discharges and other forms of waste generation.

Health determinants

Definition of health, published by the World Health Organization is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity. From this point of view are distinguished the environmental, social, and economic determinants of health.

Environmental health indicators provide information about a population health status with respect to environmental factors. It can be used to assess health or a factor associated with health, such as a risk factor or an intervention, in a specified population through direct or indirect measures.

Environmental health indicators are a set of parameters that directly influence health and quality of life. This category of indicators includes air and water quality, food safety, and exposure to environmental substances. These indicators are presented in the next chapters.

Basic indicators to measure and monitor the health state of a population over time are:

- life expectancy at birth;
- crude / age-specific / age-adjusted mortality rate;
- infant mortality ratio / neonatal mortality ratio, and
- maternal mortality ratio.

Life expectancy at birth is the average number of years a newborn is expected to live if current mortality trends were to continue for the rest of his/her life. Life expectancy at birth reflects the overall mortality level of a population. Until about 400 years ago, life expectancy at birth averaged between 20 and 30 years. In Western Europe, life expectancy averaged between 30 and 40 years until about 1850. Since then, there has been a sharp and sustained increase in life expectancy at birth. Life expectancy rapidly increased throughout the world in past centuries. However, there is a huge health gap between industrialized and developing countries, with life expectancies of about 35 to 50 years in most African countries compared with about 75 to 80 years in Europe, Japan, Australia, and other developed countries. Differences in life expectancy between different ethnic groups within a country are good indicators for persistent health inequalities. In the US, for example, the average life expectancy at birth in 2003 was 72.8 years for African Americans compared with 78.0 years for Whites. Riskier behavior patterns and higher smoking rates in males, as well as wars, are some of the reasons why life expectancy at birth (and at any other age) is generally lower for men. Today, females in Japan, Australia, Canada, and some other countries have a life expectancy well over 80 years (WHO 2005).

The proposed indicators measuring all aspects of child health (at the level of European Member States) are divided into the following four groups:

- demographic indicators and socioeconomic indicators,
- indicators of child health status and well-being;
- health determinants, risk and protective factors; and
- indicators of child health systems and policy.

Most of these indicators are available from civil registration data or hospital data. This project has also identified areas where further research is needed to identify new indicators, such as child abuse, childhood behavior disorders, learning disorders, educational development, and family cohesion, etc.

Environment and Health Information Systems gather data from different sources to calculate core indicators and hosts topic assessments at country and at regional level. Reliable information is necessary to reduce hazardous environmental exposures and their health effects, to set priorities for action, and to evaluate the effectiveness of such actions.

EHIS (**European Environment and Health Information System of the World Health Organization/Regional Office for Europe)** offers comparable data and information on environment and health in Europe, including indicators, assessments and policies.

All the other specific terms and problems are presented in the next chapters.

1.2 DISEASES PREVENTION AND HEALTH PROMOTION

The greatest medical advance in the nineteenth century in context with diseases prevention was the discovery that infectious diseases were largely attributable to environmental conditions and could often be prevented by control of influences that led to them. The same significant advance in the twentieth century is the recognition that the same is true of many noncommunicable diseases.

The industrial and economic developments that led to the decline in infections, however, have brought new threats to health from profound changes in conditions of life for which the genes are not adapted. There are many over which the individual has little control: atmospheric pollution, chemicals used in industry and agriculture, adverse working conditions, road traffic, radiation from nuclear processes, risk associated with treatment, etc. Other hazards are due changes in behavior, many of which are made possible or encouraged by the affluence that resulted from modern life: smoking, excessive or risky use of alcohol, drugs, sedentary life and excessive or ill balanced diets. Hence, some temporary health problems can be resolved by public action, whereas others require modification of personal behavior.

Health depends essentially on removal of the long – standing deficiencies and hazards associated with poverty without incurring the risk of maladaptation that have appeared under modern conditions, particularly relating to affluence.

1.2.1 Diseases prevention

Disease prevention is distinguished in the context of level: primary, secondary, and tertiary prevention. The health pyramid (Figure 1.1) represents the levels of action.

Primary prevention aims to prevent disease occurrence; can be defined as the promotion of health by personal and community-wide efforts (see hygiene) e.g. making the environment safe, improving nutritional status, physical fitness, and emotional well-being, immunizing against infectious diseases; encompasses measures to reduce risk factors for disease or risk behavior and to reduce the risk for acquiring a pathogen.

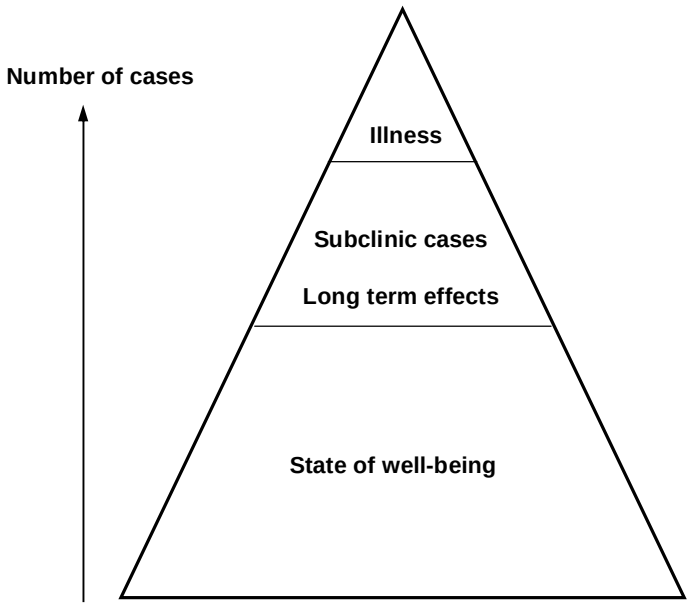

Figure 1.1 The health pyramid

Secondary prevention can be defined as the measures (e.g. screening programs) available to individuals and populations for the early diseases detection (subclinical level) and prompt and effective intervention to correct departures from good health.

An epidemiological interpretation of the distinction between primary and secondary prevention is that primary prevention is aimed at reducing incidence of disease (the number of new events / cases of a disease in a defined population within a specified time) and other departures from good health. Secondary prevention aims to reduce prevalence (all events / cases of a given disease in a given population at a designated time: old and new) by shortening the duration, and tertiary prevention is aimed at reducing the number or impact of complications.

Tertiary prevention aims to limit disease complications and disability; consists of the measures available to reduce impairments, minimize suffering caused by existing departures from good health, and promote the patient's adjustment to irremediable conditions. This extends the concept of prevention into the field of rehabilitation.

Preventing disease and injury is at the heart of public health disciplines. Only collaboration between different sectors can protect human health from risks from a hazardous or contaminated environment.

Different situation is in developing and developed countries that depends on degree of development, industrialization, population density, growth and other factors.

Vast number of people of all ages in the world, mostly in developing countries, are suffering and dying for the need of safe water, adequate sanitation and basic medicine.

Developed countries – have aging population, marked decrease of birth rate. Morbidity figures are closely linked with those of mortality. When some 50 % of deaths in the most

developed countries can be attributed to cardiovascular diseases (coronary heart disease, cerebrovascular diseases, and chronic obstructive pulmonary disease) and about 20 % to cancer, this of course is reflected in the morbidity. On the other hand a number of degenerative diseases, notably those of musculoskeletal system, cause significant morbidity without having any influence on mortality figures. The same is true for most psychiatric disorders.

The real significance of the environment for morbidity is difficult to assess. If, however the environment is taken in its broadest sense, embracing air, water and food, the industrial environment, housing and traffic, it is evident, that the impact is great. It may involve such major groups of disorders as congenital malformations (and early fetal deaths), gastrointestinal infections (and poisoning) in both children and adults, respiratory diseases, accidents – traffic, industrial, in the home and in the leisure time, musculoskeletal diseases stemming mainly from hard physical labor, local overload or from imposed position, cancers through exposure to factors in the industrial or external environment, indoor climate, nutrition, stress symptoms including psychosomatic diseases and disturbed sleeping patterns, degenerative diseases of the nervous system, hepatic and renal systems primarily due to industrial exposure, acute poisoning from chemicals.

1.2.2 Health promotion interventions

Health promotion and disease prevention are closely interrelated. Public health interventions typically apply to primary and secondary prevention strategies.

Health promotion in the context of the determination of health comprises actions directed toward changing both the determinants within the more immediate control of individuals, such as individual health behaviors, and those outside the immediate control of individuals, such as social, economic, and environmental conditions that influence health.

As well as prevention, health promotion may be divided into several other subdisciplines. To explain the nature and demands of health promotion more specifically, the Ottawa Charta (1986) will be considered closely as the fundamental description of the term “health promotion”. Contemplation of health goals, the actors and models of health promotion, and the fields of action of health promotion will be continuously discussed. Besides this, the principles of health education, motivation, and sustainability will be described. To have a complete view of health promotion, it is necessary to present the models of evaluation, the settings, and the target groups.

Health promotion is the process of enabling people to increase control over and improve their health. It involves the population as a whole in the context of their everyday lives, rather than focusing on people at risk for specific diseases, and is directed toward action on the determinants or causes of health.

During the last century, the health and life expectancy of persons in the United States dramatically improved. Since 1900, the average lifespan of persons has lengthened by greater than 30 years; 25 years of this gain are attributable to advances in public health. In December

1999 there were set 10 public health achievements published in a series of reports. The choices for topics for this list were based on the opportunity for prevention and the impact on death, illness, and disability.

For example "Ten Great Public Health Achievements – United States, 1900 – 1999" have been:

1. **Vaccination** (has resulted in the eradication of smallpox; elimination of poliomyelitis in the Americas; and control of measles, rubella, tetanus, diphtheria, *Haemophilus influenzae* type b, and other infectious diseases in the United States and other parts of the world).

2. **Improvements in motor-vehicle safety**, large reductions in motor-vehicle-related deaths which have resulted from engineering efforts to make both vehicles and highways safer and from successful efforts to change personal behavior (e.g., increased use of safety belts, child safety seats, and motorcycle helmets and decreased drinking and driving).

3. **Safer workplaces** Work-related health problems, such as coal workers' pneumoconiosis (black lung), and silicosis – common at the beginning of the century – have come under better control. Severe injuries and deaths related to mining, manufacturing, construction, and transportation also have decreased; since 1980, safer workplaces have resulted in a reduction of approximately 40% in the rate of fatal occupational injuries.

4. Control of infectious diseases has resulted from clean water and improved sanitation. Infections such as typhoid and cholera transmitted by contaminated water, a major cause of illness and death early in the 20th century, have been reduced dramatically by improved sanitation. In addition, the discovery of antimicrobial therapy has been critical to successful public health efforts to control infections such as tuberculosis and sexually transmitted diseases (STD).

5. **Decline in deaths from coronary heart disease and stroke** have resulted from risk-factor modification, such as smoking cessation and blood pressure control coupled with improved access to early detection and better treatment. Since 1972, death rates for coronary heart disease have decreased 51%.

6. **Safer and healthier foods** Since 1900, safer and healthier foods have resulted from decreases in microbial contamination and increases in nutritional content. Identifying essential micronutrients and establishing food-fortification programs have almost eliminated major nutritional deficiency diseases such as rickets, goiter, and pellagra.

7. **Healthier mothers and babies** have resulted from better hygiene and nutrition, availability of antibiotics, greater access to health care and technologic advances in maternal and neonatal medicine. Since 1900, infant mortality has decreased 90%, and maternal mortality has decreased 99%.

8. **Family planning** Access to family planning and contraceptive services has altered social and economic roles of women. Family planning has provided health benefits such as smaller family size and longer interval between the birth of children; increased opportunities for preconceptional counseling and screening; fewer infant, child, and maternal deaths; and the use of barrier contraceptives to prevent pregnancy and transmission of human immunodeficiency virus and other STDs.

9. **Fluoridation of drinking water** began in 1945 and in 1999 reaches estimated 144 million persons in the United States. Fluoridation safely and inexpensively benefits both children and adults by effectively preventing tooth decay, regardless of socioeconomic status or access to care. Fluoridation has played an important role in the reductions in tooth decay (40% – 70% in children) and of tooth loss in adults (40% – 60%)

10. **Recognition of tobacco use as a health hazard** Recognition of tobacco use as a health hazard and subsequent public health anti-smoking campaigns have resulted in changes in social norms to prevent initiation of tobacco use, promote cessation of use, and reduce exposure to environmental tobacco smoke. Since the 1964 Surgeon General's report on the health risks of smoking, the prevalence of smoking among adults has decreased, and millions of smoking-related deaths have been prevented.

The list of achievements was developed to highlight the contributions of public health and to describe the impact of these contributions on the health and well being of persons in the United States. A report also will review the national public health system, including local and state health departments and academic institutions whose activities on research, epidemiology, health education, and program implementation have made these achievements possible.

Current health protection and promotion policy in European countries come out from the World Health Organization European Region policy framework Health21 derived from the Health-for-all policy for the twenty-first century passed by the World Health Assembly in 1998. The framework was called "Health 21" not only because it dealt with health in the 21st century, but also because it laid out 21 targets for improving the health of Europeans.

The Health21 targets to 2005 / 2010 / 2015 / 2020:

1. Solidarity for health in the European Region, or closing the health gap between countries (2020);
2. Equity in health, or closing the health gap within countries (2020);
3. Healthy start in life, for example policies should create a supportive family, with wanted children and good parenthood capacity (2020);
4. Health of young people, that is, young people in the region should be healthier and better able to fulfil their roles in society (2020);
5. Healthy aging as reflected in increases in life expectancy, disability-free life expectancy, and the proportion of older people who are healthy and at home (2020);
6. Improving mental health (2020);
7. Reducing communicable diseases (2020);
8. Reducing noncommunicable diseases (2020);
9. Reducing injury from violence and accidents (2020);
10. A healthy and safe physical environment (2015);
11. Healthier living such as healthier behaviour in such fields as nutrition, physical activity and sexuality and increase in the availability, affordability and accessibility of safe and healthy food (2015);
12. Reducing harm from alcohol, drugs and tobacco (2015);
13. Settings for health, specifically, people in the region should have greater opportunities to live in healthy physical and social environments at home, at school, at the workplace and in the local community (2015);
14. Multisectoral responsibility for health (2020);
15. An integrated health sector with better access to family- and community-oriented primary health care, supported by a flexible and responsive hospital system (2010);
16. Managing for quality of care by focusing on outcomes (2010);
17. Funding health services and allocating resources, calling for sustainable financing and resource allocation mechanisms for health care systems based on the principles of equal access, cost–effectiveness, solidarity, and optimum quality (2010);
18. Developing human resources for health to ensure that health professionals and others have acquired appropriate knowledge, attitudes and skills to protect and promote health (2010);
19. Research and knowledge for health, health research, information and communication systems should better support the acquisition, effective utilization, and dissemination of knowledge (2005);
20. Mobilizing partners for health, including governments, professionals, nongovernmental organizations, the private sector, and individual citizens (2005);
21. Policies and strategies for health for all at country, regional and local levels 2010)

1.3 GLOBAL HEALTH PRIORITIES

The environment is a major determinant of health, estimated to account for almost 20% of all deaths in the WHO European Region. Environment is responsible for as much as 24% of the total burden of disease, which could be prevented through well-targeted interventions.

In 1989, concerned about the growing evidence of the impact of hazardous environments on human health, WHO/Europe initiated the first ever environment and health process, towards a broad primary prevention public health approach, and to facilitate intersectoral policy-making.

A healthy environment (air, safe water, food, fuel, secure shelter) is not only a need, it is also a right to live and work in an environment conducive to physical and mental health (The Universal Declaration of Human Rights). People need to be protected not only from physical, chemical, and biological hazards, but also from crime and violence, which are encouraged by poverty and the use of drugs, and from injuries.

In 2010, the 53 Member States in the WHO European Region (The European Environment and Health Ministerial Board in Parma) set clear targets to reduce the harm to health from environmental threats in the next decade.

The Parma Declaration is the first time-bound outcome of the environment and health process.

"We the Ministers and Representatives of Member States in the European Region of WHO are committed to act on the key environment and health challenges of our time. These include:

(a) The health and environmental impacts of climate change and related policies;

(b) The health risks to children and other vulnerable groups posed by poor environmental, working and living conditions (especially the lack of water and sanitation);

(c) Socioeconomic and gender inequalities in the human environment and health, amplified by the financial crisis;

(d) The burden of noncommunicable diseases, in particular to the extent that it can be reduced through adequate policies in areas such as urban; development, transport, food safety and nutrition, and living and working environments;

(e) Concerns raised by persistent, endocrine-disrupting and bio-accumulating harmful chemicals and (nano) particles; and by novel and emerging issues; and

(f) Insufficient resources in parts of the WHO European Region."

The environmental health interventions pose effective measure for health systems to reduce deaths and diseases.

Community-focused interventions are useful in reducing most of infections and non-communicable diseases.

2. ENVIRONMENTAL HYGIENE – ENVIRONMENTAL HEALTH

Environmental medicine centers on the interface between the person and the environment. Most diseases arise when the body is exposed to some agent or stressor in the environment, and the assessment of exposure assumes the maximal importance as the principal feature of environmental medicine.

Ecology, environmental science, environmental health, and environmental medicine all deal with the four environmental media: air, water, soil and food. Ecology, emerging mainly in the early twentieth century, is the basic and theoretical study of the relationships between living organisms (including humans) and their environment. Environmental health emerged mainly after World War I as a public health endeavor studying the control of environmental factors harmful to human health, initially with a heavy emphasis on sanitation and control of communicable disease. Environmental science, arising mainly after 1960, focuses mainly on the physical environmental media, particularly with regard to pollutants in air, water and soil. Environmental medicine is the preventive medicine and clinical arm of environmental health focusing on how pollutants in the environmental media enter the body and cause harm. Although historically environmental health was heavily involved in studying and controlling infectious diseases, modern environmental medicine specialists are inclined to relinquish much of the area of infectious disease to other disciplines and to focus mainly on chemical and physical hazards in the environment.

Not only do the various disciplines overlap, but the media interdigitate as well. Airborne pollutants can be deposited on soil, water and food. Waterborne pollutants can volatilize into the air, can contaminate soil, and may be taken up by plants, thereby entering the food chain. Soil-borne contaminants can enter air when dust is created, can be carried into surface and groundwater, and can be taken up by plants. Foodborne contaminants contribute less to the other media, although microbial degradation of foods, potential foods, or food wastes can contribute to soil and water pollution.

2.1 TYPES AND SOURCES OF ENVIRONMENTAL HAZARDS

The study of environmental health hazards may be approached in various ways. Examining the nature of the hazard, which can be biological, chemical, physical, mechanical, or psychosocial, is one way. Or it can be studied by sub-type within these categories. The biological hazards can, for instance, be divided into viruses, bacteria, parasites, etc. The study of environmental health hazards may also be organized by route of exposure; air, water, land, and each route can be further subdivided; indoor vs. outdoor air, groundwater vs. surface water vs. drinking water, etc. Another approach is to focus on the setting where the hazard

occurs, for example home, work, school, hospitals, or communities. Table 2.1 provides a conceptual framework of biological, chemical and physical hazards by routes of exposure and related factors.

Table 2.1 Biological, Chemical and Physical Hazards by Routes of Exposure (Source: Yassi et al., 2001)

	Biological	**Chemical**	**Physical**
Air			
Agent/Source	Microorganisms	Fumes, dust,particles	Radiation, noise
Vectorial factors	Coughing, exhalations	Contaminated food and water	Weather
Routes	Inhalation, contacts	Ingestion, contacts	Unguarded exposures
Water			
Agent/source	Microorganisms, decayed organic material	Discharges, leaching, dumping	Radiation
Vectorial factors	Insects, rodents,snails; animals excreta; food chain	Contaminated food and water	Accidents, contaminated food and water
Routes	Bites, ingestion, contact	Ingestion, contact	Ingestion, contact
Soil			
Agent/source	Soil organisms	Solids, liquids	Energy discharges, heat
Vectorial factors	Decaying organic matter, leading to vector breeding	Contaminated food	Accidents; contaminated soil and food
Routes	Contact, bites	Ingestion, contact	Contact, ingestion

More information about environmental health hazards, characteristics, types and sources of environmental hazards can be found in chapter Risk assessment applied to Environmental Medicine and Occupational hygiene.

2.2 AIR, WATER, SOIL, SOLID WASTE AND HAZARDOUS WASTE

2.2.1 Air

The atmosphere of Earth is a layer of gases surrounding the planet that is retained by Earth's gravity. The atmosphere protects life on Earth by absorbing ultraviolet solar radiation, warming the surface through heat retention (greenhouse effect), and reducing temperature extremes between day and night.

Chemical properties From the point of atmospheric chemistry composition air is the mixture of gases in the lower atmosphere. Dry air at sea level is composed in volume of nitrogen (78.08 %), oxygen (20.5 %), argon (0.93 %) and carbon dioxide (0.03 %), together with very small amounts of other gases. The remaining gases are often referred to as trace gases, among which are the greenhouse gases such as water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Filtered air includes trace amounts of many other chemical

compounds. Many natural substances may be present in tiny amounts in an unfiltered air sample, including dust, pollen and spores, sea spray, volcanic ash, and meteoroids. Various industrial pollutants also may be present, such as chlorine (elementary or in compounds), fluorine compounds, elemental mercury, and sulfur compounds such as sulfur dioxide (SO_2).

Earth's atmosphere can be divided into five main layers. These layers are mainly determined by whether temperature increases or decreases with altitude. From highest to lowest, these layers are:

Exosphere The outermost layer of Earth's atmosphere extends from the exobase upward. The exosphere is mainly composed of hydrogen and helium.

Thermosphere Temperature increases with height in the thermosphere from the mesopause up to the thermopause, then is constant with height. The top of the thermosphere is the bottom of the exosphere, called the exobase. Its height varies with solar activity and ranges from about 350 – 800 km.

Mesosphere The mesosphere extends from the stratopause to 80 – 85 km. It is the layer where most meteors burn up upon entering the atmosphere. Temperature decreases with height in the mesosphere. The mesopause, the temperature minimum that marks the top of the mesosphere, is the coldest place on Earth and has an average temperature around -85 °C. Due to the cold temperature of the mesophere, water vapor is frozen, forming ice clouds.

Stratosphere The stratosphere extends from the tropopause to about 51 km. Temperature increases with height, which restricts turbulence and mixing. The stratopause, which is the boundary between the stratosphere and mesosphere, typically is at 50 to 55 km.

Troposphere The troposphere begins at the surface and extends to between 7 km at the poles and 17 km at the equator, with some variation due to weather. The troposphere is mostly heated by transfer of energy from the surface, so on average the lowest part of the troposphere is warmest and temperature decreases with altitude. This promotes vertical mixing. The troposphere contains roughly 80% of the mass of the atmosphere. The tropopause is the boundary between the troposphere and stratosphere.

Other layers Within the five principal layers determined by temperature are several layers determined by other properties.

- The ozone layer is contained within the stratosphere. It is mainly located in the lower portion of the stratosphere from about 15 – 35 km, though the thickness varies seasonally and geographically. About 90% of the ozone in our atmosphere is contained in the stratosphere.
- The ionosphere, the part of the atmosphere that is ionized by solar radiation, stretches from 50 to 1,000 km and typically overlaps both the exosphere and the thermosphere. It forms the inner edge of the magnetosphere. It has practical importance because it influences, for example, radio propagation on the Earth.
- The homosphere and heterosphere are defined by whether the atmospheric gases are well mixed. In the homosphere the chemical composition of the atmosphere does not depend on molecular weight because the gases are mixed by turbulence. The homosphere includes the troposphere, stratosphere, and mesosphere. Above the turbopause at about 100 km (essentially corresponding to the mesopause), the composition varies with altitude. This allows the gases to stratify by molecular weight, with the heavier ones such as oxygen and nitrogen present only near the bottom of the heterosphere. The upper part of the heterosphere is composed almost completely of hydrogen, the lightest element.
- The planetary boundary layer is the part of the troposphere that is nearest the Earth's surface and is directly affected by it, mainly through turbulent diffusion. The depth of the planetary boundary layer ranges from as little as about 100 m on clear, calm nights to 3,000 m or more during the afternoon in dry regions.

Physical properties The basic physical qualities of the air are: **temperature, moisture and pressure**. On grounds of their different values in different places and at different

altitudes – air currents (air flows) arise in vertical and horizontal directions (those, in the horizontal are the winds); air turbulence and other kinds of air movements are the result. The motion of the air is very important in processes of air cleaning, assists in the dispersion of air pollutants and participates in forming of the weather and the climate. The usual temperature gradient (hot air below and cool above) allows convection of warm air from the earth's surface into the upper atmosphere, thus removing pollutants from the breathing zones of people. The term temperature inversion refers to the atmospheric condition during which a warm layer of air stalls above a layer of cool air that is closer to the surface of the earth. During a temperature inversion, pollutants (e.g. smog, smog-forming chemicals and VOCs) can build up when they are trapped close to the earth's surface. Temperature inversions contribute to the creation of smog.

Biological properties Troposphere has been the natural environment for many species of living organisms, for some of them temporary. They reach the air from several sources: from the soil, plants, animals and from the man himself. There are various saprophytic and patogenic microorganisms such as *Staphylococcus pyogenes aureus, S. albus, Streptococcus haemolyticus, S. viridans, Clostridium tetani, Mycobacterium tuberculosis*, etc., that can survive in the air for different amounts of time. From saprophytic microorganisms there are moulds, yeasts, actinomycetas, sarcinas (S. lutea) and other cocci and sporulative and non-sporulative sticks. The most frequent transmission of microorganisms, especially in the indoor air, has been through aerosol; so called droplet transmission. In the air there is a wide range of biological pollutants; most of them are allergens and cause asthma, hay fever and other allergic diseases.

Air is a fundamental necessity for almost all forms of terrestrial life, two thirds of all biological species, including man, depend on it.

Air is also an **economic resource**. It is essential to a number of processes of economic importance: agricultural and forestry production, fuel combustion, steel production, heating, cooling and so on.

Socially there is a demand for clean air: opinion polls reflect public concern about health effects, deteriorating visibility and effect on the cultural heritage and natural environment.

Air pollution is the emission into the air of hazardous substances at a rate that exceed the capacity of natural processes in the atmosphere to convert them, precipitation (rain or snow) to deposit them, or of winds and air movement to dilute them It is the problem of obvious importance in most of the world that affects human, plant and animal health. Air pollution affects health most obviously when these compounds accumulate to relatively high concentrations, producing a biologically significant effect. However, recent studies have shown that even low levels of exposure can produce illness and even deaths in a community. Air pollution can also affect the properties of materials (such as rubber), visibility, and the quality of life in general.

Air pollution and the need to protect the health and welfare of the general public from it are not new issues: there have been laws passed since the Middle Ages to reduce atmospheric

emissions. However, the occurrence of air pollution was not perceived as a major problem in most countries until the late 1950s and 1960s. Only in recent years the air pollution has evolved as a problem of regional and international importance.

Man's pursuit of development has caused air pollution problems on various scales: locally, especially in urban areas; regionally, often beyond national frontiers and globally, affecting the planet as a whole. Polluted air affects our lives in many different ways. Not only it does bring unpleasant odor and decreased visibility, but it can also cause adverse health effects and, in some cases, even death. Since most atmospheric pollutants enter the body by inhalation, the greatest effect of air pollution is on the respiratory system and in particular the lungs. There are, however pollutants that affect other parts of the body – brain, blood, bones (e.g. cadmium, benzene and mercury).

The main sources of air pollution are industrial sources (power generation, other industry and waste disposal), road transport, domestic sources and agriculture.

It is estimated that 30 – 40% of Europeans living in cities are exposed to concentrations of air pollutants such as sulphur dioxide and nitrogen dioxide that are above WHO or European Union (EU) guidelines (Air Quality Guidelines, Global Update 2005). However, not everyone who lives in such areas will have health problems. Level, extent, and duration of exposure, age, individual susceptibility, and other factors play a significant role in determining whether or not someone will experience pollution-related health problems.

2.2.1.1 Traditional air pollutants

The most common air pollutants – those that occur in the greatest quantities and whose effects on human health and the natural environment were acknowledged the earliest – include sulphur dioxide (SO_2), nitrogen oxides (NO_x, including NO and NO_2), carbon monoxide (CO), ozone (O_3) in the lower atmosphere, lead (Pb) and suspended particulate matter (SPM). All of these, with exception of ozone are emitted directly into the air from human and industrial activities and, to a certain extent, from natural sources.

The major sources of these pollutants are the combustion of fossil fuels (for energy generation, industrial processes and transportation), and of solid fuels, such as coal and wood, for domestic purposes. Air pollution is different from other forms of pollution in that, once the pollutants are in the air, exposure cannot be easily avoided. If high levels of outdoor air pollution are occurring in a city, it may be expected that a large proportion of the population will be exposed.

Levels of air pollution may vary markedly even at the local level, especially in the case of ground-level emissions (e.g. from road transport). Short-term variations in pollution levels will also occur due to variations in emission activity. The level of total human exposure will vary depending on the proportion of time one spends outdoors, the ability of the individual pollutants to enter the indoor environment and the levels of pollutants generated indoors cookers, paints, furnishings and building materials. Most people spend a much larger

proportion of their life indoors than outdoors. Therefore indoor air pollution is a significant public health problem, especially for children.

Air pollutants may be either emitted into the atmosphere (primary air pollutants) or formed within the atmosphere itself (secondary air pollutants). Apart from the physical state of pollutants (such as gaseous or particulate matter) it is important to consider the geographical location and distribution of sources. The local, urban, regional and global scale of air pollution can be distinguished, depending primarily on the atmospheric lifetime of specific air components.

Primary air pollutants include sulfur dioxide, oxides of nitrogen, carbon monoxide, volatile organic compounds, and carbonaceous and noncarbonaceous primary particles. Secondary air pollutants arise from chemical reactions of primary pollutants in the atmosphere, often involving natural components of the environment such as oxygen and water. Prominent secondary pollutants in the air include ozone, oxides of nitrogen and secondary PM (particulate matter).

Air pollution is a very complicated physical and chemical system. Its constituents may exist in any of the three phases of matter; they may be solid, liquid or gas, or often all three are present at once. Small solid or liquid particles (fine drops or droplets) that are suspended in air are called aerosols. Dust consists of particles in the solid phase. The most important characteristic that predicts the behavior of aerosols are size and composition. Size predicts how the particle will travel in air and composition determines what will happen when it settles or lands on something. It has been shown that particles below 10 μm can be associated with health effects. Particles over 2 μm diameter are associated with building soiling and corrosion.

From the human health perspective the most important aspect of the particle size relates to how a particle behaves in the respiratory tract. In discussions of health a special measure of size, the aerodynamic diameter, is used, which reflects the behavior of a particle more accurately than a physical measurement.

The effect of particles on the body reflects the efficiency with which they penetrate all the way to and within the lung and their chemical reactivity and toxicity. Larger particles carry much more substance, but are much less likely to have an effect on the body because they do not penetrate into the lower respiratory tract. The largest particles are mostly filtered out in the nose. Particles above 100 μm may be source of irritation to the mucous membranes of the eyes, nose and throat, but they do not get much further. Those particles below 100 μm make up the **inhalable** fraction because they can be inhaled into the respiratory tract. Particles larger than 20 μm do not enter lower respiratory tract below the throat (trachea). The particles below 20 μm comprise the **thoracic** fraction, because high proportion can penetrate into the lungs, below 10 μm enter the airways and may be deposited in the alveoli, or airspaces. Particles between 10 μm and 2.5 μm are called **coarse** particles, below 2.5 μm are deposited in the alveoli and are called *fine* particles, below 0.1 μm are called ultrafine particles. Air pollution is predominantly in the course and fine range. The greatest penetrattion and

retention of particles is in the range 10.0 to 0.1 μm, which is called **respirable** range (Figure 2.1).

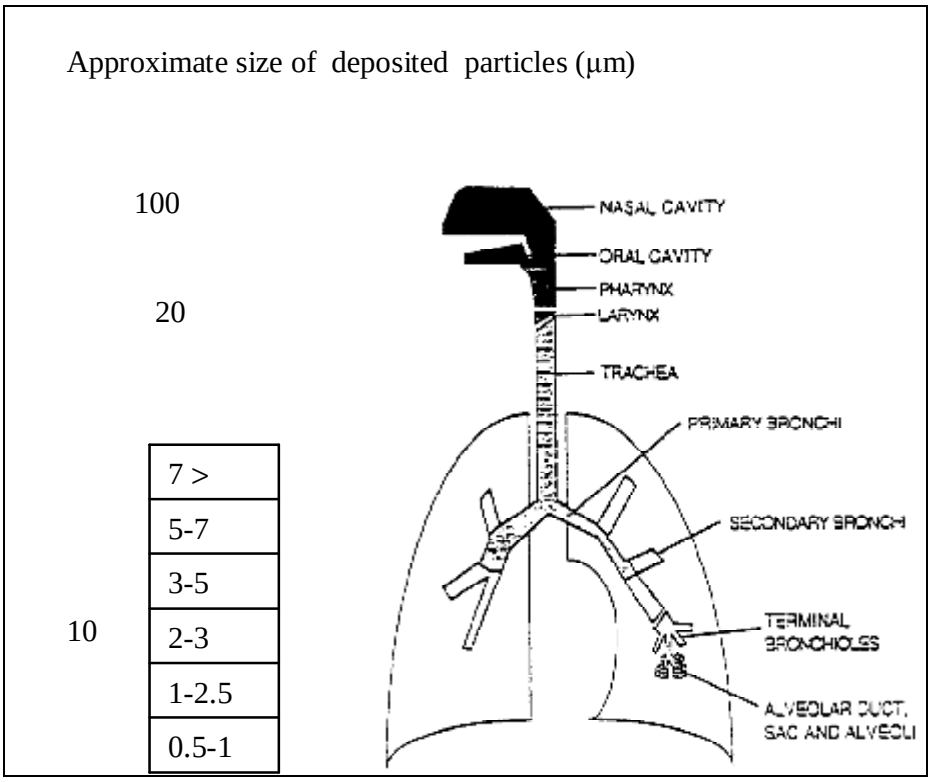

Figure 2.1 Deposition of dust particles by size (Source: Yassi et al., 2001)

2.2.1.1.1 Sulphur dioxide

The traditional urban mix of air pollutants contains sulphur dioxide from either coal or oil-burning, suspended particulates of various kinds and inorganic components from industrial coal combustion. Secondary reactions in the air lead to the formation of acid sulphates. While further pollutants may be present, acute and chronic respiratory effects have been linked primarily with the sulphur dioxide particulate acid aerosol content.

Sulphur dioxide (SO_2) is generated mainly from the combustion of fossil fuels containing sulphur. Eighty percent of worldwide emissions come from burning coal and lignite, 20% come from oil. Coal typically contains about 2% sulphur and heavy fuel oil about 3% by weight. Sulphur dioxide in water vapour and clouds produces acid rain.

Earlier last century in London high concentrations of SO_2 and smoke (from the burning of coal in homes and for industrial purposes) usually occurred at the same time. Effects on health were demonstrated in a series of epidemiological studies. These found that daily death rates, and a worsening of the condition of people with chronic bronchitis, were directly related to raised levels of smoke and SO_2.

Inhalation of SO_2 produces narrowing of the airways (bronchoconstriction), which people suffering from asthma are more sensitive to than other individuals. Long-term effects of exposure may result in chronic bronchitis and increased death rate, particularly from cardio-

respiratory diseases. Apart from this problem, many other factors such as smoking and socio-economic circumstances need to be taken into account.

The increased mortality, morbidity and deficits in pulmonary function associated with SO_2 and suspended particulates are widely documented. Daily mean SO_2 and smoke concentrations above 500 µg/m^3 significantly increase baseline mortality. Increased acute respiratory morbidity is observed at 250 µg/m^3. Based on this evidence, it is recommended that a SO_2 concentration of 500 µg/m^3 should not be exceeded over averaging periods of 10 minutes duration. In consideration of the uncertainty of SO_2 in causality, the practical difficulty of attaining levels that are certain to be associated with no effects, and the need to provide a greater degree of protection by the recent WHO Air Quality Guidelines (AQG) (Global Update 2005, Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide) assuming that reduction in exposure to a causal and correlated substance is achieved by reducing SO_2 concentrations, there is a basis for revising the 24-hour guideline for SO_2 downwards to a value of 20 µg/m^3 (in 2006). Formerly the WHO Quality Guideline (in 2000) 24-hour average was 125 µg/m^3 and annual average 50 µg/m^3 (Table 2.2).

2.2.1.1.2 Particulate matter (PM)

Among air pollutants, particulate matter (PM) is widely present and people are exposed where they live and work. To a great extent, PM is generated by human activities such as transport, energy production, domestic heating and a wide range of industries. Concentrations of ambient PM_{10} (particles with a diameter of up to 10 µm, which are small enough to pass into the lungs) are a good approximation of population exposure to PM from outdoor sources (see details above, Figure 2.1).

The importance of particulate matter exposure is supported by numerous epidemiological studies, conducted in Europe and in other parts of the world, which show links between various indicators of children's health and outdoor PM_{10}. Although PM_{10} is the more widely reported measure, and also the indicator of relevance to the majority of the epidemiological data, for reasons that are discussed below, the WHO Air Quality Guidelines for PM are based on studies that use $PM_{2.5}$ (particles with a diameter of up to 2.5 µm) as an indicator.

Based on known health effects, both short-term (24-hour) and long-term (annual mean) guidelines are needed for both indicators of PM pollution. An annual average concentration of 10 µg/m^3 was chosen as the long-term guideline value for $PM_{2.5}$ and 20 µg/m^3 for PM_{10}. Besides the guideline value, three interim targets (IT) are defined for $PM_{2.5}$ and PM_{10}. When evaluating the WHO Air Quality Guidelines and interim targets, it is generally recommended that the annual average take precedence over the 24-hour average. For PM_{10}, the Air Quality Guidelines for the 24-hour average is 50 µg/m^3, and for $PM_{2.5}$ 25 µg/m^3 (Table 2.2).

2.2.1.1.3 Ozone

There are two sorts of ozone. Ozone in the stratosphere (15 – 50 km above the earth's surface) forms what is known as the „ozone layer" and is essential in limiting the amount of

ultraviolet radiation reaching the earth‘s surface. However, ozone in the troposphere – the level that contains the air we breathe – is a pollutant and it can damage health and vegetation.

At ground level, ozone is a secondary pollutant formed by the action of sunlight on primary pollutants; these are nitrogen oxides from vehicle emissions and industry and volatile organic compounds from vehicles, solvents and industry. Nitrogen oxides react in sunlight (photochemical reaction) to form ozone, a major constituent of photochemical smog.

High concentrations of ground level ozone are often a problem in hot sunny climates such as in southern Europe, with cities like Athens having a particular problem. In northern Europe concentrations are usually higher in rural areas, because ozone production occurs in polluted air as it drifts away from cities.

The biological response to ozone is dependent upon the concentration to which an individual is exposed and the duration of exposure; the dose received is also dependent upon the volume of air inhaled per minute as nearly all the ozone inhaled is absorbed. Thus people, who do strenuous physical exercise, e.g. jogging, inhale more ozone and are likely to show a proportionally greater response to its effects.

The importance of the duration of exposure, and the fact that this may extend over 8 hours on a sunny day, has led to guidelines and air quality standards for ozone usually being defined in terms of an 8-hour average concentration. This is commonly exceeded in Europe.

In terms of producing inflammation of the respiratory tract, ozone is one of the most toxic of the common air pollutants. According to WHO hourly concentrations of 200 $\mu g/m^3$ can cause eye, nose and throat irritation, chest discomfort, cough and headache; exposure for about six hours to concentrations of 160 $\mu g/m^3$ have been shown to produce inflammation of the airways and changes in standard indices of lung function. Since the publication of the second edition of the WHO Air quality guidelines for Europe (in 2000) which sets the guideline value for ozone levels at 120 $\mu g/m^3$ for an 8-hour daily average, new information about the health effects of ozone has been obtained from chamber studies and field studies, and the new guideline value (in 2006) for daily maximum 8-hour mean was set to 100 $\mu g/m^3$ (WHO Air Quality Guidelines, Global Update 2005) (Table 2.2).

Ozone has also been shown to increase the response, or the sensitivity, of some people to allergen exposure. This has been confirmed in several volunteer studies and in an epidemiological study of hay fever sufferers in London. The fact that peak levels of pollen and of ozone often occur together may make this an important observation.

2.2.1.1.4 Nitrogen dioxide (NO_2)

Nitrogen Dioxide (NO_2) is produced both as a primary and as a secondary pollutant by combustion processes. In many countries some 50 % of NO_2 is produced by motor vehicles. Thus concentrations tend to be higher around busy streets than in rural areas.

Most atmospheric NO_2 is emitted as NO, which is rapidly oxidized by ozone to NO_2. Nitrogen dioxide, in the presence of hydrocarbons and ultraviolet light, is the main source of

tropospheric ozone and of nitrate aerosols, which form an important fraction of the ambient air $PM_{2.5}$ mass.

Table 2.2 Guideline values for individual substances based on effects other than cancer or odour /annoyance

Substance	Time-weighted average	Averaging time
Cadmium*	5 ng/m^3	annual
Carbon disulfide*	100 µg/m^3	24 hours
Carbon monoxide*	100 mg/m^3	15 minutes
	60 mg/m^3	30 minutes
	30 mg/m^3	1 hour
	10 mg/m^3	8 hours
1,2-Dichloroethane*	0.7 mg/m^3	24 hours
Dichloromethane*	3 mg/m^3	24 hours
	0.45mg/m^3	1 week
Fluoride*	-	-
Formaldehyde*	0.1 mg/m^3	30 minutes
Hydrogen sulfide*	150 µg/m^3	24 hours
Lead*	0.5µg/m^3	annual
Manganese*	0.15µg/m^3	annual
Mercury*	1µg/m^3	annual
Nitrogen dioxide**	200µg/m^3	1-hour mean
	40 µg/m^3	annual mean
Ozone**	100 µg/m^3	8- hour mean
Particulate matter ($PM_{2.5}$)**	10 µg/m^3	annual mean
	25 µg/m^3	24-hour mean
Particulate matter (PM_{10})**	20 µg/m^3	annual mean
	50 µg/m^3	24-hour mean
Platinum*	-	-
PCBs*	-	-
PCDDs/PCDFs*	-	-
Styrene*	0.26 mg/m^3	1 week
Sulfur dioxide**	20 µg/m^3	24- hour mean
	500 µg/m^3	10-minute mean
	50 µg/m^3	annual
Tetrachloroethylene*	0.25 mg/m^3	annual
Toluene*	0.26 mg/m^3	1 week
Vanadium*	1 µg/m^3	24 hours

* Based on WHO Air quality guidelines 2000. Second edition.
** Based on WHO Air quality guidelines. Global update 2005 for particulate matter, ozone, nitrogen dioxide and sulfur dioxide

Concentrations of NO_2 show a distinct daily variation with peak levels typically being recorded during morning and evening rush hours.

Nitrogen dioxide is an irritant gas and exposure to exceedingly high concentrations produces narrowing of the airways in both asthmatic and non-asthmatic individuals. Asthmatic individuals are more sensitive to NO_2 than non-asthmatic individuals. In asthmatics, an exposure to concentrations of about 560 µg/m^3 for 30 minutes produces a small change in standard indices of lung function; in non-asthmatics exposure to about 1800 µg/m^3 would be necessary to produce a similar response.

The guideline values for NO_2 remain unchanged in comparison to WHO Air Quality Guideline levels (2000), i.e. 40 µg/m^3 for annual mean and 200 µg/^{m3} for 1-hour mean (WHO Air Quality Guidelines, Global Update 2005).

Smog in London, December 1991

A dramatic example of the effect that weather can have on the dispersal of pollutants occurred in London in December 1991; from the morning of 12 December until the evening of 15 December, London was blanketed in its worst smog since 1952. During those four days nitrogen dioxide concentrations were well above 190 µg/m^3 for most of the time, peaking at 800 µg/m^3 in south-west London on Friday 13 December. Up to 160 additional deaths are thought to have occurred during this period. Deaths from respiratory disease (including asthma) were 22% higher and from cardiovascular disease 14% higher than expected when compared with the same period the previous year.

2.2.1.1.5 Carbon monoxide (CO)

Carbon Monoxide (CO) has an affinity for haemoglobin (Hb) 200 times greater than that of oxygen. It impairs the oxygen-carrying capacity of blood as carboxyhaemoglobin (COHb) is formed rather than oxyhaemoglobin. When too much oxygen is displaced by CO, it can progressively lead to oxygen starvation. Thus at levels of only a few percent COHb, effects may be significant in tissues which are already deprived of oxygen, perhaps as a result of poor blood supply. The escalating symptoms of CO poisoning are headache and vomiting and, in severe cases, collapse and death, although the effects of brief exposure are reversible.

Carbon monoxide is a problem both as an indoor and as an outdoor air pollutant. Large amounts of carbon monoxide enter the outdoor air primarily through the incomplete combustion of motor vehicle fuels.

Susceptible persons ought not to be subjected to levels of COHb exceeding 2.5 %. In healthy, non-smoking individuals effects of exposure to CO appear at COHb concentration of about 5 %.

The following guideline values (ppm values rounded) and periods of time-weighted average exposures have been determined so that the COHb level of 2.5% is not exceeded, even when a normal subject engages in light or moderate exercise (Air Quality Guidelines for Europe, 2000):

- 100 mg/m^3 (90 ppm) for 15 minutes;
- 60 mg/m^3 (50 ppm) for 30 minutes;
- 30 mg/m^3 (25 ppm) for 1 hour;
- 10 mg/m^3 (10 ppm) for 8 hours.

2.2.1.2 Polycyclic aromatic hydrocarbons (PAHs)

This group of compounds, which includes established carcinogens such as benzo(a)pyrene (BaP), is associated with the incomplete combustion of any of the fossil fuels. These compounds or their derivatives may be responsible for the mutagenic and (weak) carcinogenic action that has been demonstrated experimentally and in studies of certain heavily exposed

occupational groups to diesel particulates. Whether in the population at large there is any clear effect of exposures to PAHs in coal smoke, diesel smoke, or in other emissions in terms of lung cancer incidence is difficult to determine, mostly because of the overriding effect of cigarette smoking. Annual mean concentrations of BaP in major European urban areas are in the range 1 – 10 ng/m^3. In rural areas, the concentrations are < 1 ng/m^3.

2.2.1.3 Volatile organic compounds (VOC) and other chemicals

This group comprises over 200 different hydrocarbon pollutants, many of which are highly reactive and can have considerable environmental and health implications. Alkanes, such as isopentane, n-butane and propane, and alkenes, such as ethylene and xylene, are the dominant hydrocarbons effecting ambient air quality. Carbonyls, alcohols and carboxylic acids may also be present. Many of these hydrocarbon compounds are also secondary pollutants formed by atmospheric reactions.

The group is also comprised of dibenzo-dioxins and n-furans, formaldehyde, vinyl chloride etc., radioactive particles and gases, such as radionuclides and radon, and fibers, such as asbestos.

People may be exposed to toxic trace pollutants by inhalation, by contact with skin, and ingestion. The health effects of these compounds are probably more diverse than those of traditional air pollutants because many of them are of remarkably higher toxicity and, due to their excellent lipid solubility, affect a much wider range of organs in the human body.

Many of them may cause hormonal disturbances, cancer, birth defects, and other reproductive effects as do, for example, polychlorinated biphenyls. As in the case of heavy metals, toxic air pollutants may be transferred from the atmosphere to other environmental media, where they can cause additional damage to humans and the natural environment.

Toxic organic compounds are released by chemical factories, dry cleaning establishments, waste treatment plants and incinerators, and automobiles. Reactive gases and particles, as well as toxic fibers, are often released from building materials where they either occur naturally or were added for insulation purposes. The chemical industry is expected to grow faster than any other industry, and this growth is likely to increase the range and quantity of toxic substances released into the environment.

It is much more difficult to estimate the exposure of the population to toxic trace pollutants than to the traditional air pollutants, because the former are not routinely monitored in most countries, and it is even more difficult to assess the health risk. To date, negative health effects have been observed only at occupational levels, which are higher than those normally in the ambient or indoor air. For most of these pollutants, data regarding their effects on humans are not available, but are deduced from animal studies. In addition, it may not be sufficient to know the health risks associated with only one of these toxic pollutants since they can be additive, cumulative, and possibly synergistic.

Although a few of the toxic trace pollutants present an ambient air problem in the outdoors, many of them constitute a greater risk to people indoors (at home, in vehicles, in the office and other working places) where concentrations are much higher because of lack of ventilation, etc. This is of particular importance in so far as most people spend about 80 – 90 percent of their time indoors.

2.2.1.4 Indoor air pollutants and health effects

Although there are many similarities between the health effects associated with indoor and outdoor air, there are important differences in many parameters which contribute to those effects. The occupational groups of workers are relatively healthy. Of course the average health status can depend on the type of occupation (e.g. chemical industry, clerical staff, etc.). The general population, which spends some time outdoors, has a relatively large variation in health status. However, the aged and infirm spend almost all of their time indoors. Thus, non-occupational indoor pollution affects the most susceptible population. It is therefore necessary for indoor health standards to be more stringent than their work place analogs in order to protect the indoor population. Harmful substances that have been measured inside homes and office buildings include: radon, asbestos, mercury, and an array of organic compounds such as formaldehyde, chloroform, and perchloroethylene. These pollutants come, for instance, from tobacco smoke, building materials, furnishing, space heaters, gas ranges, wood preservatives, cleaning agents, glues and other solvents. Harmful trace pollutants of concern in the outdoor air are mainly: benzene from traffic and gasoline vapors, polycyclic organic compounds from wood and other incomplete combustion processes, and tetrachloroethylene form industrial solvent use, as in automobile coating or dry cleaning operations.

For more information about this topic see Chapters Occupational hygiene and Housing and health.

2.2.1.5 Global atmospheric issues

This chapter discusses global issues that have received increasing attention: stratospheric ozone depletion, greenhouse effect (global warming) and acid rain.

Stratospheric ozone depletion leads to an increased amount of ultraviolet radiation reaching the earth's surface and this has potentially harmful effects on human health, and on the productivity of aquatic and terrestrial ecosystems. Exposure to ultraviolet radiation increases the risk of skin cancer and eye cataracts, can depress the human immune system. Scientists warn that over the least ten years the average global ozone concentrations have decreased by 3 %. There are efforts to reduce the production and use of chemicals affecting the ozone layer (e.g. chlorofluorocarbons – CFCs, halons, carbon tetrachloride, hydrochlorofluorocarbons – HCFCs). Many manufacturers and consumers are encouraged to avoid ozone-depleting chemicals.

The second global issue is the greenhouse effect (or global warming). The effect itself is undisputed: certain gases absorb and emit long-wave radiation coming from the earth's

surface and thus warm the surface and the lower atmosphere. These gases (CO_2, methane, CFC_S, nitrous oxide and tropospheric ozone) called also greenhouse gases are observed in the atmosphere in increased concentrations.

Most scientists now agree that the climate is warming up. The expert Inter-Governmental Panel on Climate Change (IPCC) has predicted a possible rise in the average global temperature of 1 °C by 2025 and 3 °C before the end of the 21st century.

The advent of climate change may be expected to have both direct and indirect effects on health. Direct effects might involve an increasing incidence of heat illness during "heat-waves". Long-term indirect effects may include those brought about diminished food production and altered distribution of vector-borne diseases. In addition, climate changes over a long period of time may ultimately provoke large-scale human migrations with their great health problems.

One of the most important direct effects of global warming on human health could arise from exposure to unaccustomed heat stress. This can lead to a rapid deterioration in health especially in the elderly, the very young groups and those with existing incapacitating disease. Severe heat stress may lead to a rapid deterioration in health with adverse effects ranging from mild syncope to fatal heat – stroke. There are also important psychological impacts that should be considered (e.g. social intolerance).

Major indirect health consequences may also arise from alterations in agricultural and animal husbandry practices (e.g. food supplies could be threatened by spatial shifts in agro-climactic zones, changes in crop, livestock, and fish – farming productivity, reduced water availability and the loss of arable land). Under these conditions, infants, children, and pregnant women who require balanced nutrition for health, growth, and development could be especially at risk.

Climate change could also bring about other important indirect consequences for health through increased and changing patterns in the spread of communicable diseases. These could be brought about through two mechanisms, first by modifying the ecology of disease vectors (e.g. mosquitoes), particularly those currently prevalent in the tropics and subtropics, and second, by increasing exposure to pathogens through contamination required not only of desired air quality (expressed in terms of air quality standards) but also of the existing air and sources of pollution. The stringency of a control program will depend on the difference between the existing or estimated future air quality and the desired air quality standards and goals.

The term “acid rain“ was used as long ago as 1858 to mean rain made more acidic by acid gas pollution. A more accurate term is acid deposition. Wet deposition occurs when pollutants are carried in rain, snow, mist and low cloud; pollutants may be wet deposited after being carried long distances. Dry deposition is the direct fallout and occurs mostly close to the source of emission. Since most acid pollution comes from burning fossil fuels (SO_2), local

authorities can help to reduce national emissions by reducing the overall demand for energy, by encouraging energy conservation and by improving the efficiency of electricity generation.

2.2.1.6 Control of air pollution

The control of air pollution is ultimately an engineering problem. In principle it should be possible to reduce air pollution below the levels recommended by air-quality guides by applying one or more of the following procedures:

- containment, i.e. prevention of escape of toxic substances into the ambient air;
- replacement of certain technological processes or fuels by new ones that produce less air pollution; or
- reduction of the concentration of toxic substances in the air by dilution (should be used only if the first two methods are not applicable or are unsatisfactory for either technological or economic reasons).

Air quality standards (guidelines) are based on air quality criteria, where these are available. In many countries there have been already concerned air quality standards for some of the pollutants, designed to protect the health of the public, though in practice compliance is not necessarily achieved everywhere. These guidelines incorporate margins of safety and are below the lower-observed-effect levels. How close they can be approached in practice is influenced not only by social and economical circumstances, but also by local topographical and meteorological features. Though related primarily to outdoor environments, they are intended to be applicable indoors as well.

The WHO Air quality guidelines represent the most widely agreed and up-to-date assessment of health effects of air pollution, recommending targets for air quality at which the health risks are significantly reduced. The 2005 WHO Air quality guidelines (AQGs) are designed to offer global guidance on reducing the health impacts of air pollution. The guidelines first produced in 1987 and updated in 1997 had a European scope. The new (2005) guidelines apply worldwide and are based on expert evaluation of current scientific evidence. They recommend revised limits for the concentration of selected air pollutants: particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2), applicable across all WHO regions. In addition to guideline values, the AQGs give interim targets related to outdoor air pollution, for each air pollutant, aimed at promoting a gradual shift from high to lower concentrations. If these targets were to be achieved, significant reductions in risks for acute and chronic health effects from air pollution can be expected. Progress towards the guideline values, however, should be the ultimate objective. The WHO ambient guidelines for selected pollutants based on Air quality guidelines for Europe 2000 and the new (2005) guidelines for PM, SO_2, NO_2 and O_3 are shown in Table 2.2.

Emission standard is a limit placed on the amount or concentration of a pollutant from a source (stationary or mobile). It is necessary for the control of pollution. It is most commonly expressed in terms of the concentration of a substance in a given volume of gaseous effluent

(objective emission standard) or in terms of opacity of a smoke plume (often assessed by subjective means).

The best practical approach should reduce pollution while maintaining reasonable cost. Alert levels are a special type of air quality standards. When the ambient air concentrations of specific pollutants (e.g. ozone) reach these levels, which can be related to various degrees of health hazard, the operation of certain industrial plant, power – plants and motor vehicles is restricted, or other procedures are set in motion (e.g. exercise of children).

Fuel standards (e.g. gasoline without lead) and design standards (e.g. the establishment of sanitary or puffer zones around areas in which specific industries or power plants are located) also exist. Such standards are also related to the desired purity of ambient air and may therefore be said to be related to air quality criteria.

The stringency of a control program will depend on the difference between the existing or estimated future air quality and the desired air quality standards and goals. Air quality management encourages joint action by those concerned, e.g., with town planning, industrial development, and transport policies, in drawing up program designed to achieve or maintain the desired air quality.

2.2.2 Water

Water is a necessity for human survival, and access to safe drinking water is a required cornerstone of public health. Conscientious water quality management and access to renewable water resources are vital to every sector of our industrialized society and every sector of our nation's agricultural economy. The uses of water in any community are numerous and diverse, and the requirements for the quantity and quality of water for these multiple functions are wide ranging and multifaceted.

The uses and applications for water are numerous and include

- drinking and food preparation purposes;
- personal hygiene activities including bathing and laundering;
- residential and commercial heating and air conditioning;
- urban irrigation and street cleaning;
- recreational venues including swimming and wading pools, water parks, and hot tubs and spas;
- amenity purposes such as public fountains and ornamental ponds;
- power production from hydropower and steam generation;
- commercial and industrial processes including bottled water and food production;
- residential and commercial fire protection;
- agricultural purposes including irrigation and aquaculture;
- the process of carrying away human and industrial wastes from all manner of establishments and community facilities.

Water is a unique and remarkable substance. “Pure” water is a clear, colorless, tasteless, and odorless fluid. It is also a strong solvent and in nature washes gases from the atmosphere, dissolves minerals and humic substances from the soil through which it flows, and carries substantial quantities of silt as it moves through the environment. Many of the natural and man-made uses of water affect its quality, and, accordingly, water is seldom appropriate for human use without some kind of treatment. In addition, a varied array of microorganisms finds their way into waters and, depending on environmental conditions, may replicate or expire. Some of these microorganisms are beneficial or at least not harmful while others may be pathogenic to man and other animals. Many scourges of mankind have been waterborne, and the potential for spread of enteric disease is always present.

Water is an important constituent of all living matter, constituting approximately 70% of the weight of the human body. It is a very effective and efficient medium for transferring nutrients and removing waste materials from the human body as well as maintaining thermostability through heat transfer and evaporation.

In theory, man can exist on quantities of water as small as 5 liters or less per day; some nomadic peoples do, in fact, live for long periods on such quantities. However, 40 to 50 liters per day are required for personal and domestic hygiene, if he is to remain healthy, while still greater amounts are necessary in different environments to enable him to engage in animal husbandry and rural industry: thus a villager will need 100 liters. In a developed country, it is not uncommon for 400 to 600 liters to be needed per head. Such needs are becoming increasingly difficult to meet, as pollution has reduced the quality of many water sources.

2.2.2.1 Water sources

The main sources of drinking water are **surface water** (in bogs, ponds, lakes, rivers and streams) and **ground water** (in aquifers and underground streams)**.** Surface water is more contaminated and has low mineralization. It was more used in the past few decades, because groundwater sources are very limited and water consumption in developed countries is now 4 – 12 times higher than before Second World War. Ground water is cleaner, mineralized and has higher hygienic quality than surface water. Its biological value is higher (Ca, Mg, Fe, iodine, fluorine content), but sources are very limited. Under no circumstances can surface water be used in untreated form for drinking purposes. Surface water sources should be used only when underground water is inadequate or not available. **Rainwater** is the source of all freshwater in the world. It may be collected directly from roofs and other prepared catchment systems and stored in cisterns for later use. Since catchment areas for the direct capture of rainwater are necessarily limited in size, such water supplies are useful only for individual households or small communities. The quality of rainwater is generally reasonable but it may be contaminated by gases and particles that are washed out of the atmosphere or by the accumulation of dust and other debris in catchment systems.

The two types of **surface water** (1. lakes, ponds, man-made reservoirs and 2. rivers, streams) differ in the water oxygen regimen. **Reservoirs and lakes** store water for many months, during which time considerable changes may occur in its quality (oxygen consuming

bacterial decay, algae growth, dissolution of various metals due to acidification, products of chemical reduction due to lack of oxygen, presence of other contaminants), which may render the water difficult to treat. **The amount of oxygen is an indicator of the surface water purity.** The oxygen gets into the water from the air and by water plant life as a product of photosynthesis. The higher the oxygen amount and the smaller the biological oxygen demand (BOD), the better is the surface water quality. The greater the water pollution, the faster is the consumption of oxygen.

Crude oil and petroleum products disturb the **oxygen regimen**. Detergents (washing powders and softeners) reduce the surface tension of water and lower the self purification process. **Eutrophication** is a serious problem of surface water. This term is applied when water bodies are overenriched with nutrients, especially compounds of nitrogen and/or phosphorus. Nutrients may contribute to excessive growth of algae, microorganisms, some planktonic and benthic animals. Oxygen-consuming decay commences and may reach the point when oxygen is consumed at a rate that cannot be met by natural processes. In addition, the accumulation of organic material can foster the growth of pathogenic microorganisms. Eutrophication is more status than a trend and the term describes the qualitative conditions of an aquatic environment that has been disrupted, more than its quantitative (biomass) productivity. **Acidification** of water helps to mobilize metals into freshwater. Metals and other toxic substances which are referred to as “micropollutants“ are often persistent, accumulate into bottom sediments and can be released over long periods of time. **Radioactive substances** may also contribute to the surface water quality.

Acidification of land areas and surface waters may effect the distribution of mercury in the ecosystem. The mercury concentration in lake water, as well as the pH of the water, is important factors influencing the amount of mercury in fish. Increase of mercury concentration in fish of 0.1 – 0.3 $mg.kg^{-1}$, and in some cases up to 1 $mg.kg^{-1}$ above the concentration normally found, are thought to be related to acidification of lake water. Mercury levels in hair of up to 10 $\mu g.g^{-1}$ have been found among Swedes with high intakes of fresh water fish. Exposure to methyl mercury, giving rise to concentrations of 10 – 20 μg mercury per hair in pregnant mothers is related to a 5 % risk for the development of neurological disorders in the offspring.

If acidic and corrosive water was distributed in piping systems for drinking water, parts of which contain cadmium, considerable contamination can occur (up to 15 $mg.l^{-1}$ and higher). There were a few cases of acute cadmium poisoning in Sweden, when neutralization of acidic drinking water with consequent reduction or dissolution of cadmium was not employed. If moderately increased levels (up to a few percent of concentration giving rise to acute symptoms) persist over longer times, there may be a risk of chronic health effects with kidney damage.

Increased levels of copper in acidic drinking-water can give rise to gastrointestinal symptoms. A few cases of childhood liver cirrhosis, similar to Indian childhood cirrhosis, have been reported in Europe and the possibility of a relationship to the excessive intake of copper-containing water has been suggested.

Increases in aluminium (Al) concentrations in acidic waters are well documented. Aluminium has been identified as a probable cause of dialysis encephalopathy in kidney patients and recent research has linked Al to other forms of dementia, for example, Alzheimer disease.

Domestic discharges, which often contain oxygen-consuming materials as well as nutrients, have created water quality problems for many years. Control of domestic discharges

has long been recognized as a primary tool in the management of freshwater systems. Primary treatment, normally designed to remove suspended material, was often improved to secondary treatment designed to remove oxygen-consuming materials and, less frequently, nutrients through biological and chemical treatment.

One particular problem is the operation of **sewage treatment** plants and **sludge** disposal. Sewage sludge is produced in almost all purification processes. Sludge is frequently disposed of on land after dehydration, by using it as fertilizer for agricultural processes or by processing it into compost or other useful products. Concentrations of toxic substances, particularly heavy metals, in the sludge may restrict its use for growing agricultural commodities for livestock feed or direct human consumption. Incineration or land disposal of the sludge may then be the only means of handling.

What concerns the **industrial discharges**, the trends in the volume of contaminants they discharge are not well known. Industry may produce contaminants that can have acute or chronic toxic effects even in small concentrations. The contaminants include a wide variety of metals and synthetic organic compounds. Management of industrial discharges has taken the form of requirements, guidelines, or permit systems that allocate to each discharges on a water body an allowable volume of pollution.

Ground water may come to the surface naturally (springs) or by digging or boring a hole (wells). Springs and wells with water coming from above the first impermeable layer are designated as **shallow**. Springs and wells supplied by water imprisoned between two impermeable strata (escaping through a natural fault or fissure, or a borehole made above them) are called **deep**. Underground water from deep boreholes is considered to be the most palatable and safest water since the passage through the ground acts as a natural filtration process. The water obtained from wells or springs is usually clear, sparkling and well aerated. When obtained from a considerable depth, it is usually hard.

In general, the ground water is more sanitary, less exposed to pollution than surface sources, and of a higher bacteriological quality due to its passage through the soil.

Ground water can be also highly vulnerable and negatively affected when located in areas where agriculture is practiced. Fertilizers and pesticides are applied in large quantities, sometimes in such a way that they affect ground waters.

Inappropriate disposal of wastes, both hazardous and domestic, has repeatedly been found responsible for the deterioration of local ground water supplies. This applies also to disposal in waste piles and landfills without proper containment and failure of industrial storage devices (e.g. petroleum products).

Inadequate supplies of water increase the problem of maintaining water quality, especially when there are multiple sources of water pollution. In most countries the four most important sources of water pollution are sewage, industrial effluents, storm and urban run-off, and agricultural run-off. In certain countries mines and oil production systems are also a major source of water pollution.

The ultimate water resource management objective is to conserve, improve and then maintain the quality of water bodies.

2.2.2.2 Water pollution

Inadequate supplies of water increase the problem of maintaining water quality, especially when there are multiple sources of water pollution. Water pollution may be defined in terms of:

Its nature:

- physical: temperature, suspended matter, colour, etc.;
- microbiological: microorganisms such as bacteria, viruses, protozoa, etc.;
- chemical: mineral pollution (salts, heavy metals, etc.) or organic pollution (pesticides, hydrocarbons, solvents, etc.);

Its origin:

- urban: community wastewater, rainwater, refuse tips, etc.;
- industrial: liquid and solid wastes from industrial activities (refineries, paper mils, etc.), storage of products (hydrocarbons, industrial wastes, etc.) or extraction of raw materials (mines, quarries, etc.);
- agricultural: farming practices (fertilizers, plant protection products, etc.), slurry spreading, the food industry (slaughterhouses, etc.);
- natural as are storms, urban run-off, floods;

Its distribution in time:

- permanent: infiltrations from leaching of waste discharges, etc.;
- accidental: broken pipes, overturned tanks, etc.;
- seasonal: plant protection products, highway deicing products, etc.;

Its distribution in space:

- diffuse: of agricultural origin, on-site sanitation, etc.;
- localized: storage facilities, industries, urban waste, etc.;
- linear: highways, railways, rivers and watercourses, etc.

Effects on health Drinking polluted water may give rise to diseases of differing degrees of severity, depending on the health status and age of the people concerned and on general hygiene conditions. However; the effects depend in the first instance on the types of microorganisms or substances ingested.

There are two main types of pollution:

Effects linked to microbiological contamination: numerous microorganisms, especially those of human or animal origin, may be responsible for waterborne diseases; the disorders caused by these germs are often of moderate severity but they may sometimes be very severe (cholera, typhoid, etc.). The discharge, near water sources, of wastewater contaminated by people who are ill of healthy carriers of pathogens is the main cause of microbiological contamination of water resources.

Effects related to chemical pollution: ingestion of mineral or organic chemical substances, sometimes even at low doses, can generate risks in the longer term. Among such risks, that of cancer is the most feared by the population whereas it is, in general, relatively limited.

2.2.2.2.1 Communicable diseases associated with water

Most of the disease agents that contaminate water and food are biological and communicable and come from animal and human feces. They include bacteria, viruses, protozoa, and helmints and are ingested with water and food or conveyed to mouth by contaminated hands. Once ingested, most of them multiply in the alimentary tract and are excreted with the feces. Without proper sanitation, they find their way into other water bodies, from where they can again infect other people.

The diseases associated with water can be classified in several categories: waterborne, water-washed, water-based, water-related and examples are listed in the Table 2.3.

Waterborne diseases arise from the contamination of water by human or animal feces or urine infected by pathogenic bacteria or viruses, which are directly transmitted when the water is drunk or used in the preparation of food. Cholera, thyphoid and cryptosporidiosis are typical examples of waterborne diseases.

Water-washed diseases result from impossibility to use water for personal hygiene and cleanliness. Prevalent are these types of diseases, such as scabies, typhus and trachoma. All waterborne diseases can also be water-washed diseases, transmitted through water contact in daily life rather than by ingestion of contaminated water.

Water-based diseases are based on the fact that water provides the habitat for intermediate host organisms in which some parasites pass part their life cycle. These parasites are later the cause of helminthic diseases in people as their infective larval forms in fresh water find their way back to humans boring through wet skin or being ingested with water plants. Schistosomiasis is an example of a water-based disease.

Water-related diseases are based on the fact that water may provide a habitat for water-related insect vectors of disease (e.g. mosquitoes). Mosquitoes breed in water and the adult mosquitoes may transmit parasite diseases such as malaria, and virus infections such as dengue, yellow fever and Japanese encephalitis. African trypanosomiasis (sleeping sickness) is transmitted by the vector fly „tse-tse“.

Water-dispersed infections refer to infections whose agents can proliferate in fresh water and enter the human body through the respiratory tract. Some fresh water amoebas that are not usually pathogenic can proliferate in warm water and if they enter the host in large numbers they can invade body along the olfactory tracts and cause fatal meningitis. Bacteria of genus Legionella have demonstrated the capacity to proliferate in the water of air-conditioning systems, from which they may be dispersed as aerosols and infect substantial number of people through the respiratory tract. It is likely that other opportunistic pathogens will appear that find a suitable habitat in new technological devices using water. Other water-related infections such as that caused by waterborne Cryptosporidium may achieve increased clinical importance as the number of immunosuppressed people increase a wing to acquired immunodefficiency syndrome (AIDS) or to chemotherapy facilitating organ or tissue transplants.

Table 2.3 Diseases related to water and sanitation (Source: Compiled from WHO, 2008)

Group	Disease	Pathogen	Source
Waterborne diseases	Cholera	*Vibrio cholerae*	Human feces, sewage, contaminated water
	Poliomyelitis	*Poliovirus*	Human feces, sewage, contaminated water
	Diarhoeal diseases (Salmonellosis, Shigellosis, Campylobacteriosis, Rotavirosis, Giardiasis)	*Salmonella enteritidis* *Shigella species* *Campylobacter jejuni* *Escherichias coli* *Rotavirus* *Giardia lamblia*	Drinking water, food, sewage Human feces, sewage, contaminated water, shellfish
	Roundworm	*Ascaris lumbricoides*	Human feces, sewage, contaminated water, food, soil
	Enteric fevers: typhoid	*Salmonella paratyphi*	Human feces, sewage, contaminated water, shellfish
	Whipworm	*Trichuris trichiura*	Poor hygiene, contaminated water, food, soil
	Hepatitis A	*Hepatitis A virus*	Human feces, sewage, contaminated water, shellfish
Water-washed diseases	Scabies	*Sarcoptes scabiei*	Overcrowded conditions with limited access to water and health care, cutaneous
	Typhus	*Samonella typhi*	Human feces, sewage, contaminated water, shellfish
	Trachoma	*Chlamydia trachomatis*	Overcrowded conditions with limited access to water and health care, cutaneous.
	Leishnmaniasis	*Leishmania species*	Humans, animals, poor sanitation
Water-based diseases	Schistosomiasis	*Schistosoma haematobium*	Water for domestic, occupational and` recreational purposes, urine, feces.
	Dracunculiasis (Guinea-worm disease)	*Dracunculus medinensis*	Humans, contaminated water, cutaneous

Group	Disease	Pathogen	Source
Water-related diseases	Malaria	*Plasmodium species*	Mosquitoes breeding in water, water sources development
	Onchocerciasis	*Onchocerca volvulus*	Blackflies breed in water, fast-flowing rivers
	African trypanosomiasis	*Trypanosoma genus*	Tse-tse flies in vegetation by rivers, lakes
	Yellow fever	*Yellow fever virus*	Mosquitoes breeding in water
	Dengue	*Dengue viruses*	Mosquitoes breeding in water, primarily in man-made containers used for domestic water storage, discarded plastic food containers, items that collect rainwater
	Filariasis	*Filarial worms Wuchereria bancrofti, Brugia Malawi, B. timori*	Mosquitoes breeding in water
Water-dispersed diseases	Legionnaires disease	*Legionella Pneumophila*	Water for cooling systems, hot water systems, shower heads
	Cryptosporidiosis	*Cryptosporium species*	Untreated water affected by animals
	Primary amebic encephalitis	*Naegleria fowleri*	Recreational water use

2.2.2.2.2 Chemical and radioactive constituents of water supplies

Chemical contamination of drinking-water may also have effects on health, although in general these tend to be chronic rather than acute, unless a specific pollution event has occurred and are therefore generally considered of lower priority than microbiological contamination.

It must be recognized that raised concentrations of any chemicals known to have an impact on human health may lead to the long-term problems. In general, water sources used for drinking-water supply should be protected from chemical contamination through land-use control, definition of protection zones and application of adequate wastewater treatment.

To assess the health impact the chemicals in drinking water are classified according Global Environment Monitoring System (GEMS) (The GEMS/Water programme of UNEP (United Nations Environment Programme), a global water quality monitoring and assessment programme, provides information on the state and trends of global inland water quality) into three categories:

1. Substances (various metals, nitrates, cyanides, etc) which exert an acute and/or chronic toxicity when consumed. As the concentration of these substance in the drinking water increases, so does the severity of the health problem; below a certain threshold concentration, however, there are no observable health effects.

2. Genotoxic substances (synthetic organics, chlorinated microorganics, pesticides and arsenic) which cause health effects such as carcinogenicity, mutagenicity and birth defects. There is no threshold level for these substances.

3. Essential elements (fluoride, iodine, selenium) which are a mandatary part of intake to sustain human health. Deficiencies or high concentrations of these elements cause different types of side effects.

Some of the chemicals present in water that are of particular importance for health include (see tables 2.4 and 2.5):

Nitrates Excess nitrates in drinking-water have been linked to methemoglobinemia in infants, the so called 'blue-baby' syndrome with clinical symptoms of cyanosis (a dark blue coloration) and breathing difficulties, asphyxiation and even death. The death can occur when methemoglobin content of the blood rises about 20 % of total hemoglobin concentration At first, it may be emphasized that not nitrate, but nitrite, is the pathogenic agent that binds hemoglobin, especially the fetal one, that remains in newborns for a certain time and that has a greater affinity to nitrites than to oxygen. This causes hemoglobin to increase, which is unable to transport the oxygen towards the tissues. The reduction of nitrates to nitrites in the baby's stomach is due to the bacterial activity and the nitrites are resorbed into the blood. Dyspepsia usually precedes the methemoglobinemia, lessening the activity of gastric juice and making possible the ascent of bacteria from the bowels to the stomach. Another way for bacteria to get into baby's stomach is to supply them with the formula. Bottle-fed infants may be exposed to nitrates if contaminate water is used for mixing formula. There were cases of methemoglobinemia without the presence of a higher level of nitrate in drinking water used for the preparation of the baby's food. The dyspepsia was treated with an extract of rice and carrots. The latter ingredient may contain a considerable amount of nitrates, as a residue of excessive fertilization.

In adults the higher content of nitrate in drinking water or food represents the risk of carcinogenic nitrosamines (responsible for colorectal carcinoma), arising in the sour medium of the stomach and by the microbial activity in guts and urinary bladder. It has therefore been suspected that long-term exposure to nitrates may increase the incidence of various forms of cancer (gastric, colon), but epidemiological studies have so far to confirm it.

The WHO Guideline Value (GV) and Slovak Standard Norm for nitrate (adult use) of 50 mg/l has been set on the basis of the acute health risk to infants and is unusual for this reason as most guideline values are set for long-term risks. Many countries are now experiencing problems with elevated nitrates, particularly in groundwaters caused through poor treatment and disposal of excreta, intensification of animal husbandry and large-scale applications of inorganic and organic fertilizers. Standard limit of nitrates for infants' nutrition is below 15 mg/l and is mostly maintained in packaged water and special infant packaged water.

In some countries, notably in the Countries of Central and Eastern Europe (CCEE) such as Moldova and Romania, levels have been recorded in shallow groundwater at up to 1 000 mg/l, whilst in India anecdotal evidence suggest levels of up to 1 500 mg/l. At these levels,

more widespread chronic effects are likely to be noted including a possible greater likelihood of gastric cancer.

Nitrate is a conservative element in natural groundwaters and therefore once large-scale nitrate contamination has occurred, it will take a considerable period of time before it is naturally attenuated through denitrification or diluted. In these circumstances, short term measures will include identifying alternative sources of water, for instance deeper boreholes, or through blending with low-nitrate waters. Removal of nitrate by ion exchange in treatment plants is expensive as most anion exchangers are non-selective for nitrate and therefore nitrate specific resins must be used.

Long-term solutions must involve the reduction in the release of nitrate into the environment through, for example, control of fertilizer application and improvements in human and anima excreta treatment and disposal.

Calcium and magnesium substances are very important for water mineralization. The salts (carbonate, sulphate) of calcium and magnesium are responsible for **water hardness**. Carbon dioxide and the dilute solution of carbonic acids increases the solvent properties of the water and enables it to dissolve calcium and magnesium from limestone and chalk strata, and to hold them in solution as bicarbonates (calcium and magnesium carbonates are insoluble in water). Hardness of water may be either temporary (due to the presence of bicarbonates of calcium and magnesium) or permanent (due to sulphates of calcium and magnesium). Temporary hardness may be diminished by boiling water, when the carbon dioxide is driven off and carbonate deposit. Permanent hardness is not affected by boiling. Both types of hardness are expressed as mg/l $CaCO_3$ (milligrams per litre of calcium carbonate). Water in which these salts are dissolved is described as being hard. The groundwater sources are mineralized more than freshwater sources of drinking water and mineralization represents biological value of drinking water. Optimal concentration of Ca and Mg substance should be 1.2 – 2.5 mmol/l, minimal concentration 0.4 mmol/l. Epidemiological studies have suggested that there is an inverse relationship between the hardness of water and the cardiovascular disease mortality rate (ischemic heart disease and myocardial infarction). The frequent use of water with high mineral content (calcium, sodium, magnesium) may overload kidney system and the salt is an important dietary factor for hypertension.

Fluoride excess may lead to dental or skeletal fluorosis, the latter being a crippling disease which affects a number of areas including the Rift valley of East Africa and parts of India, Mexico and the former Soviet Union. However, a lack of fluoride may cause dental caries, a weakening of the teeth, thus in some circumstances fluoride may be added to the drinking-water supply.

The acceptable concentration of fluoride in water is in part related to climate, as in warmer climates the quantities of water consumed are higher thus leading to a greater risk of fluoride related problems as overall intake increases. Susceptibility of individuals to fluorosis may also be determined by renal impairment.

Table 2.4 Selected chemical water pollutants, their guideline values, common sources and major adverse health outcomes (Source: Compiled from WHO, 2008)

Contaminant	Who guideline value [mg/litre]	Common sources	Major adverse health effects
Inorganic chemicals			
Arsenic	0.01	Natural erosion, pesticide run-off, coal burning, smelting, glass and electronic production waste	Skin damage, circulatory damage, increased risk of cancer
Fluoride	1.5	Natural erosion, discharge from fertilizer and aluminium factories	Bone disease, mottled teeth
Lead	0.01	Natural erosion, plumbing, solder, lead-glazed ceramics, old paint, deposits from leaded petrol	Impaired growth and development, behavioural problems, kidney damage
Mercury (inorganic)	0.001	Natural erosion, discharge from refineries and factories, run-off from landfills and croplands	Kidney damage
Nitrite/nitrate	3/50	Run-off from fertilized land, septic tanks, sewers, erosion from natural deposits	Methaemoglobinaemia in young infants
Selenium	0.01	Natural erosion, occupational exposure	Nail deformities, gastrointestinal problems, dermatitis, dizziness
Cadmium	0.003	Steel industry, plastics, batteries, wastewater, contamination from fertilizers, local air pollution, pipes and solders, food, smoking	Kidney damage, Carcinogen group 2A
Chromium	0.05	Earth's crust, food	Carcinogen group 1 via inhalation route, group 3 via oral route
Manganese	0.4	Earth's crust, manufacture of iron and steel alloys, surface water, groundwater, food	Neurological effects
Copper	2	Interior copper plumbing, food, water	Gastrointestinal tract, long-term effects on sensitive populations
Uranium	0.015	Leaching from natural deposits, release in mill tailings, nuclear industry, the combustion of coal, other fuels and the use of phosphate fertilizers	Nephritis, carcinogenicity (insufficient data)

Fluoride in drinking-water can have toxic effects in both excess and deficiency, although WHO only set a GV of 1.5 mg/l for excess fluoride as susceptibility in deficiency is highly dependent on nutritional status.

Control options for fluoride contamination of water include blending of fluoride-rich waters with waters of low fluoride content, selection of low-fluoride sources and removal of fluoride by treatment at public water supply or household level. Fluoride can be successfully removed by precipitation by use of coagulants (commonly an alum-lime mix), adsorption on activated carbon substrates, osmosis or ion exchange.

Table 2.5 Selected chemical water pollutants, their guideline values, common sources and major adverse health outcomes (Source: Compiled from WHO, 2008)

Contaminant	Who guideline value [µg/litre]	Common sources	Major adverse health effects
Organic chemicals			
Disinfectants and disinfection by-products		Drinking water disinfection	Increased risk of cancer
Chlorine	5 mg/l		
Chlorate	700		
Bromate	10		
Bromoform	100		
Chloroform	300		
Dichloroacetonitrile	20		
Trichloroacetate	200		
Trihalomethanes	The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1		
Pesticides		Urban and rural run-off	Multiple, including endocrine and neurological damage
Atachlor	20		
Adicarb	10		
Chlordane	0.2		
DDT	1		
Lindane	2		
Chlorinated alkanes		Industry, disposal to the soil, groundwater	Genotoxic, carcinogenic
Carbon tetrachloride	4		
Dichloromethane	20		
Chlorinated ethenes		Industry, production of PVC	Genotoxic, carcinogenic
Vinyl chloride	0.3		
1,2-dichloroethene	50		
Trichloroethene	20		
Tetrachloroethene	40		
Aromatic hydrocarbons		Industry, solvents	Genotoxic, carcinogenic
Benzene	10		
Toluene	700		
Xylenes	500		
Styrene	20		
Bennzo[a]pyrene	0.7		

Iodine Its shortage in drinking water causes the endemic goiter and in serious cases mental retardation, with growth disturbances, called cretenism. As prevention salt is enriched with the iodine.

Arsenic is a naturally occurring element, which can be introduced into water through the dissolution of minerals, from industrial effluent (drainage from goldmines) and from atmospheric deposition (burning of fossil fuels and wastes). These sources make significant contributions to arsenic concentrations in drinking-water and may be harmful to health. The

body rapidly excretes organic forms of arsenic, and it is the inorganic trivalent form that is of most concern.

While concentrations in natural water are generally less than 0.005 mg/litre, some countries have reported very high concentrations particularly in groundwater supplies. In Bangladesh, for example, over 25,000 wells are contaminated with arsenic at levels above 0.05 mg/litre. Food is also a significant source of arsenic, but usually in highly complex forms that are biologically unavailable and essentially non-toxic.

Although studies indicate that arsenic may be essential for some animal species, there is no indication that it is essential for humans.

Arsenic compounds are readily absorbed by the gastrointestinal tract, and then bind to haemoglobin and are deposited in the liver, kidneys, lungs, spleen, and skin. Inorganic arsenic does not appear to cross the blood-brain barrier, but can cross the placenta. The major health effects are caused by low-level chronic exposure from the consumption of arsenic-contaminated water. Consumption of water with elevated concentrations of arsenic (> 0.3 mg/litre) over periods of 5 to 25 years was reported to produce skin lesions, skin cancer, vascular disease, effects on the nervous system, and possibly cancer of other organs. The most well-documented cases of arsenic poisoning from drinking-water have come from India, Bangladesh and West Bengal where there is arsenic contamination of large numbers of rural water supplies. Arsenic contamination has also been noted in southern Thailand and the Countries of Central and Eastern Europe (CCEE). The only available treatment for chronic arsenic poisoning is to remove the patient from the source of exposure and provide supportive care.

Control options for arsenic contamination will vary according to the source. Arsenic derived from industrial effluents should be controlled through proper treatment of wastes and monitored by the pollution control agency. The control of arsenic from natural sources must include sustainable groundwater resource management.

In all cases, short-term options will include treatment of water in home using, use of alternative sources or a switch to an alternative source, such as deep groundwater unaffected by arsenic contamination. Arsenic may be removed at treatment plants through a variety of processes, although like most treatment aimed at chemical removal, increase the costs of producing drinking-water.

Pesticides can be based on several chemical compounds the most common are pesticides based on DDT or pesticides based on organophosphates. DDT has accumulating effect in human tissues; the highest amount can be found in human fat tissues. Long term exposure to very low doses leads to impairment of liver function. Some chlorinated hydrocarbons have carcinogenic and mutagenic effect. Pesticides based on organophosphates can cause acute poisoning in farmers and agricultural workers.

Heavy metals cadmium, mercury, lead, chromium, nickel are toxic substance causing acute and chronic poisoning. **Mercury** occurs naturally in drinking water at extremely low

levels, but contamination can result from industrial emissions and spills. Inorganic mercury compounds have a long biological half-life, accumulating in the kidneys where the toxic effects may lead to kidney failure. The major concern is the organic methylmercury formed from inorganic mercury by bacteriological action. It is known to accumulate in fish and fish products and the consumption of these foods may cause human illness (neurodevelopmental deficits, neurological disorders, mental disability). In Minamata Bay, Japan, two major methylmercury poisonings were caused by release of mercury compounds from industrial processes that accumulated in fish. High levels of **lead** in drinking water are the result of urban run-off into source waters and human activities, where lead piping or leaded solders are still being used. Lead is a developmental toxicant and can damage the peripheral nervous system, the kidneys, and the reproductive system. Many epidemiological studies have been carried out on the effects of lead exposure on the intellectual development of children and although there are some conflicting results they suspect that exposure to lead adversely affects intelligence.

Chlorophorm and disinfection by-products Chlorination as a method of water disinfection has been practiced worldwide. Chlorine is free to react with various organic compounds present in the water, producing chlorinated hydrocarbons. The primary public health concern respect to chloroform and other disinfection by-products is chronic toxicity, particularly cancer. The epidemiological picture with respect to human cancer and drinking of chlorinated water is still uncertain.

Asbestos fibers In the case of asbestos fibers in drinking water the researchers did not find any relationship between the use of asbestos (asbestos water pipes) and the frequency of intestinal cancer and gastrointestinal cancer, even if asbestos fibers in the water are naturally releasing from soil, for example in Canada or Brasil.

Radiologic contamination of public water supplies may be naturally occurring or result from man-made activity. The radiologic agents of importance that are regulated in drinking water include alpha particles, beta particles and photon emitters, ^{226}Ra and ^{228}Ra, and U. ^{226}Ra is among the more important of the naturally occurring radionuclides and is found in groundwater as a result of geological conditions such as erosion of natural deposits. On the other hand, man-made radiologic contamination of water generally affects surface waters as a result of fallout from weapons testing and releases from nuclear power plants and users of radioactive materials. Naturally occurring radium contamination in drinking water is often of greater concern than man-made radioactive contamination, particularly since naturally occurring radiologic contamination disproportionably affects small water supplies that draw from groundwater. Radon is a naturally occurring radionuclide in groundwater, and surveys indicate that many groundwater supplies in the world have detectable radon. Accordingly, while radon is not likely to pose a problem for larger community supplies, it may be a problem for individual or very small supplies.

2.2.2.3 Drinking water quality guidelines, criteria and standards

WHO produces international norms on water quality and human health in the form of guidelines that are used as the basis for regulation and standard setting, in developing and developed countries world-wide. Guidelines must be appropriate for national, regional and local circumstances, which require adaptation to environmental, social, economic and cultural circumstances and priority settings.

The primary purpose of the Guidelines for Drinking-water Quality by WHO is the protection of public health.

The first and second editions of the Guidelines for Drinking-water Quality published during 1983 – 1984 and 1993 – 1997 as successors to previous WHO International Standards (1958, 1963 and 1971) were used by developing and developed countries worldwide as the basis for regulation and standard setting to ensure the safety of drinking-water. They recognized the priority that should be given to ensuring microbial safety and provided guideline values for a large number of chemical hazards. The third edition of the Guidelines has been comprehensively updated to take account of developments in risk assessment and risk management since the second edition. It describes a Framework for Drinking-water Safety and discusses the roles and responsibilities of different stakeholders, including the complementary roles of national regulators, suppliers, communities and independent "surveillance" agencies.

Developments in the third edition of the Guidelines during 2004 – 2008 include significantly expanded guidance on ensuring the microbial safety of drinking-water – in particular through comprehensive system-specific water safety plans. Information on many chemicals has been revised to account for new scientific information and information on chemicals not previously considered has been included.

The WHO guidelines outline a preventive management that comprises five key components:

- health based targets based on an evaluation of health concerns;
- system assessment to determinate whether the drinking water supply as a whole can deliver water that meets the health based targets;
- operational monitoring in the process of drinking water supply;
- management plans documenting the system assessment and monitoring plans and describing actions to be taken in normal operation;
- a system of independent surveillance that verifies that the above are operating properly.

Health-based targets are an essential component of the drinking-water safety framework.

They provide the basis for the application of the Guidelines to all types of drinking-water supply. Constituents of drinking-water may cause adverse health effects from single exposures (e.g., microbial pathogens) or long-term exposures (e.g., many chemicals). There are four principal types of health-based targets used as a basis for identifying safety requirements:

Health outcome targets In some circumstances, especially where waterborne disease contributes to a measurable burden, reducing exposure through drinking-water has the

potential to appreciably reduce overall risks of disease. In such circumstances, it is possible to establish a health-based target in terms of a quantifiable reduction in the overall level of disease. This type of health outcome target is primarily applicable to some microbial hazards in developing countries and chemical hazards with clearly defined health effects largely attributable to water (e.g., fluoride). In other circumstances, health outcome targets may be the basis for evaluation of results through quantitative risk assessment models.

Water quality targets (WQTs) are established for individual drinking-water constituents that represent a health risk from long-term exposure and where fluctuations in concentration are small or occur over long periods. They are typically expressed as guideline values (concentrations) of the substances or chemicals of concern.

Performance targets are employed for constituents where short-term exposure represents a public health risk or where large fluctuations in numbers or concentration can occur over short periods with significant health implications. They are typically expressed in terms of required reductions of the substance of concern or effectiveness in preventing contamination.

Specified technology targets National regulatory agencies may establish targets for specific actions for smaller municipal, community and household drinking-water supplies. Such targets may identify specific permissible devices or processes for given situations and/or for generic drinking-water system types.

It is important that health-based targets are realistic under local operating conditions and are set to protect and improve public health.

Most countries apply several types of targets for different types of supply and different contaminants. In order to ensure that they are relevant and supportive, representative scenarios should be developed, including description of assumptions, management options, control measures and indicator systems for verification, where appropriate.

WHO Guidelines for drinking water quality distinguish several **aspects for water quality** parameters:

- **microbial aspects;**
- **chemical aspects;**
- **radiological aspects;**
- **acceptability aspects.**

Guidelines for **bacteriological** water quality are based on organisms that are not pathogenic themselves, but merely they are an indication of possible contamination. For chlorinated or otherwise disinfected supplies, it should not be possible to demonstrate the presence of thermotolerant coliform organisms in any 100 ml sample of water entering the distribution system; in established non-disinfected supplies, there should be no (fecal) E. coli in 100 ml (Table 2.6).

In small community supplies, such as individual wells, bore wells or springs, it should be possible to reduce the coliform count of even shallow water to less than 10 per 100 ml. If this cannot be achieved, the water should not be used for drinking.

The health concerns associated with **chemical constituents** of drinking-water differ from those associated with microbial contamination and arise primarily from the ability of chemical constituents to cause adverse health effects after prolonged periods of exposure. There are few chemical constituents of water that can lead to health problems resulting from a single exposure, except through massive accidental contamination of a drinking-water supply. Moreover, experience shows that in many, but not all, such incidents, the water becomes undrinkable owing to unacceptable taste, odour and appearance.

There are many chemicals that may occur in drinking-water; however, only a few are of immediate health concern in any given circumstance. The priority given to both monitoring and remedial action for chemical contaminants in drinking-water should be managed to ensure that scarce resources are not unnecessarily directed towards those of little or no health concern.

Table 2.6 Bacteriological quality of drinking water (Source: WHO, 2008)

Organisms	**Guideline value**
All water intended for drinking	
E. coli or thermotolerant coliform bacteria	Must not be detectable in any 100 ml sample
Treated water entering the distribution system	
E. coli or thermotolerant coliform bacteria	Must not be detectable in any 100 ml sample
Total coliform bacteria	Must not be detectable in any 100 ml sample
Treated water in the distribution system	
E. coli or thermotolerant coliform bacteria	Must not be detectable in any 100 ml sample
Total coliform bacteria	Must not be detectable in any 100 ml sample Must not be detectable in any 100 ml sample. In the case of large supplies, where sufficient samples are examined, must not be present in 95 % of samples taken throughout any 12-month period

Guideline values are derived for many chemical constituents of drinking-water. A guideline value normally represents the concentration of a constituent that does not result in any significant risk to health over a lifetime of consumption. Selected chemical water pollutants, their guideline values, common sources and major adverse health outcomes see on the Tables 2.4 and 2.5.

The health risk associated with the presence of naturally occurring **radionuclides** in drinking-water should also be taken into consideration, although the contribution of drinking-water to total exposure to radionuclides is very small under normal circumstances.

Formal guideline values are not set for individual radionuclides in drinking-water. Rather, the approach used is based on screening drinking-water for gross alpha and gross beta radiation activity. While finding levels of activity above screening values does not indicate any immediate risk to health, it should trigger further investigation into determining the radionuclides responsible and the possible risks, taking into account local circumstances.

Water should be free of tastes and odours that would be **acceptable** to the majority of consumers. Microbial, chemical and physical water constituents may affect the appearance, **odour** or **taste** of the water and the consumer will evaluate the quality and acceptability of the water on the basis of these criteria. Although these substances may have no direct health effects, water that is highly turbid, is highly coloured or has an objectionable taste or odour may be regarded by consumers as unsafe and may be rejected. In extreme cases, consumers may avoid aesthetically unacceptable but otherwise safe drinking-water in favour of more pleasant but potentially unsafe sources. Changes in the normal appearance, odour or taste of a drinking-water supply may signal changes in the quality of the raw water source or deficiencies in the treatment process and should be investigated.

Drinking-water should ideally have no visible **colour**. Colour in drinking-water is usually due to the presence of coloured organic matter (primarily humic and fulvic acids) associated with the humus fraction of soil. Colour is also strongly influenced by the presence of iron and other metals, either as natural impurities or as corrosion products. It may also result from the contamination of the water source with industrial effluents and may be the first indication of a hazardous situation. Levels of colour below 15 true colour units (TCU) in a glass of water are usually acceptable to consumers.

Turbidity in drinking-water is caused by particulate matter that may be present from source water as a consequence of inadequate filtration or from resuspension of sediment in the distribution system. It may also be due to the presence of inorganic particulate matter in some groundwater or sloughing of biofilm within the distribution system. The appearance of water with a turbidity of less than 5 NTU (nephelometric turbidity units) is usually acceptable to consumers. Particulates can protect microorganisms from the effects of disinfection and can stimulate bacterial growth. In all cases where water is disinfected, the turbidity must be low so that disinfection can be effective. No health-based guideline value for turbidity has been proposed; ideally, however, median turbidity should be below 0.1 NTU for effective disinfection.

Cool water is generally more palatable than warm water, and **temperature** will impact on the acceptability of a number of other inorganic constituents and chemical contaminants that may affect taste. High water temperature enhances the growth of microorganisms and may increase taste, odour, colour and corrosion problems.

Not every possible pollutant of water, however, is identified in the Guidelines for drinking water quality and there are many pollutants for which safe limit has not been specified. Hence water conforming to the Guidelines may, in fact, be unsafe and may produce adverse long-term effects on health. There is no scientific evidence, however, that such adverse effect on health have been produced as yet.

2.2.2.3.1 Bottled drinking water

Bottled water and ice are widely available in both industrialized and developing countries. Consumers may have various reasons for purchasing packaged drinking-water, such as taste,

convenience or fashion; for many consumers, however, safety and potential health benefits are important considerations.

Water is packaged for consumption in a range of vessels, including cans, laminated boxes and plastic bags, and as ice prepared for consumption. However, it is most commonly prepared in glass or plastic bottles. Bottled water also comes in various sizes, from single servings to large carboys holding up to 80 liters. In applying the Guidelines to bottled waters, certain chemical constituents may be more readily controlled than in piped distribution systems, and stricter standards may therefore be preferred in order to reduce overall population exposure. Similarly, when flexibility exists regarding the source of the water, stricter standards for certain naturally occurring substances of health concern, such as arsenic, may be more readily achieved than in piped distribution systems.

However, some substances may prove to be more difficult to manage in bottled water than in tap water. Some hazards may be associated with the nature of the product (e.g., glass chips and metal fragments). Other problems may arise because bottled water is stored for longer periods and at higher temperatures than water distributed in piped distribution systems or because containers and bottles are reused without adequate cleaning or disinfection. Control of materials used in containers and closures for bottled water is, therefore, of special concern. Some microorganisms that are normally of little or no public health significance may grow to higher levels in bottled water. This growth appears to occur less frequently in gasified water and in water bottled in glass containers than in still water and water bottled in plastic containers.

The public health significance of this microbial growth remains uncertain, especially for vulnerable individuals, such as bottle-fed infants and immunocompromised individuals. In regard to bottle-fed infants, bottled water should be disinfected as it is not sterile – for example, by boiling – prior to its use in the preparation of infant formula.

Ozone is sometimes used as an oxidant before bottling to prevent precipitation of iron and manganese, including natural mineral water. Where the water contains naturally occurring bromide, this can lead to the formation of high levels of bromate unless care is taken to minimize its formation. When ozone is used after the addition of the minerals to demineralized water, the presence of bromide in the additives may also lead to the formation of bromate.

There is a belief by some consumers that natural mineral waters have medicinal properties or offer other health benefits. Such waters are typically of high mineral content, sometimes significantly higher than concentrations normally accepted in drinking water. Such waters often have a long tradition of use and are often accepted on the basis that they are considered foods rather than drinking-water *per se*.

The international framework for packaged water regulation is provided by the Codex Alimentarius Commission (CAC) of WHO and the FAO. CAC has developed a *Standard for Natural Mineral Waters*. The Standard describes the product and its compositional and quality factors, including limits for certain chemicals, hygiene, packaging and labeling. The CAC has also developed a *Standard for Bottled/Packaged Waters* to cover packaged drinking-water other than natural mineral waters.

2.2.2.4 Water supplies

There are two types of water supplies and systems:

1. **Central** – public system is available for many inhabitants in large cities. This kind of water supply is easy to control, easy to maintain, but there is higher risk of infections in a case of accident – earthquake, war, floods or other disasters. In this case also might result higher risk from chemical poisoning because the large amount of people in the community is supplied. The recommended amount of bacteria and levels of chemical contaminants is lower than in individual form of water supply.

2. **Individual system** – this is a private system of wells and springs in villages and small community settings (mostly not controlled, higher nitrates level due to agricultural activity and feces disposal). The levels of chemical contaminants and the amount of bacteria could be higher, but epidemiological and chemical risk of disease is lower.

2.2.2.5 Hygienic protection of water sources

The protection of water sources is part of an overall approach advocated by WHO, aimed at:

- protecting the health of present and future generations;
- ensuring sustainable development of the planet while preserving its resources;
- prevention rather than cure.

Protection is based on the physical delimitation of geographical areas known as „protection zones“. The main objectives of this protective measure are to:

- prevent damage to water extraction plants;
- avoid the discharge of pollutants that might adversely affect the quality of water extracted;
- control the development of all new activities which are incompatible with conservation of the resources being extracted;
- strengthen prevention and control measures in water sources.
- Meeting these objectives also makes it possible to:
- limit the use of expensive and sophisticated treatment measures, by maintaining the initial
- quality of the water;
- improve the effectiveness of the treatments given to water, by ensuring that its characteristics are as stable as possible. Treatment is matched to the specific quality of the natural water; any variation in the chemical characteristics of the water may thus reduce the effectiveness of the treatment being given.

Protection zones around underground water sources act as a „passive shield“ against pollution; their establishment therefore offers the best guarantee of permanently obtaining water of a satisfactory quality. Water distribution authorities are responsible for establishing zones around public water sources and ensuring that they are continuously maintained.

2.2.2.5.1 Underground water sources

Most countries which currently have regulations on the protection of underground water sources have adopted the principle of protection by means of successive zones. There are generally **three such zones**:

1. The inner protection zone (zone 1 or "zone around the well") The limits of the inner zone are frequently defined in terms of distance from the water source (from several dozen to a few hundred meters). In Slovakia, for instance, this zone, referred to as the „strict protection zone" covers an area of from 10 to 50 meters around water extraction plants.

The main function of the inner protection zone is to prevent damage to water extraction plants and to avoid discharges of pollutants in the immediate vicinity of the water source. It covers preferential penetration points. The land within this zone must be purchased, fenced off and maintained by the authority operating the water resource. Any activity other than those required for operation of the plant and maintenance of the zone must be banned.

This form of protection is particularly suitable for the prevention of microbiological pollution. For instance, in regions with frequent cholera epidemics, the establishment of (and compliance with) an inner protection zone around water sources is the most effective measure for protecting the water from contamination by such microorganisms.

2. The outer protection zone (zone 2 or "prevention zone") In most European countries, the limits of the outer protection zone are set on the basis of an evaluation of the risk of underground migration of pollutants. The transfer time for a pollutant is often taken into account when setting the limits of such a protection zone: 50 days in Germany and Slovakia, 10 days in Switzerland. Protection measures are imposed in the form of **"**servitudes". Within this zone, certain activities such as building, farming, industry, refuse tips, extraction of raw materials or discharges of wastewater will be banned or restricted.

3. The catchment area protection zone (zone 3) The limits and scope of the catchment area protection zone are very variable. In some cases (Germany), this zone is designed to offer protection against chemical or radioactive pollution. It is optional in France: its establishment is envisaged only if it is likely to reduce risks in a significant manner: it is defined on the basis of a transfer time (10 – 25 years) in the Netherlands and a distance (2,000 meters) in Belgium. In Austria, the limits of this zone are defined in terms of the whole catchment area.

Depending on the country, total bans or merely restrictions may be imposed on activities within this zone.

The disparities in different countries´ regulations concerning water protection are essentially attributable to differences in the geological and hydrogeological context.

2.2.2.5.2 Surface water sources

Few countries have yet laid down principles for the protection of surface water. In general, protection zones cover the areas sensitive to pollution upstream of water sources (for streams) or near to them (for reservoirs).

Protection measures entail:

- quality requirements to be met by discharges in the water sources;
- the implementation of protection arrangements in case of pollution;
- analytical monitoring and early warning systems.

In the case of reservoirs, protection is achieved by establishing successive zones around the body of water.

2.2.2.6 Water conditioning

Water, especially the surface one, especially the surface one, coming from lakes and rivers has to be treated before its distribution through the water supply system – in waterworks. The water treatment or conditioning consists of some of the following procedures:

The first step, if necessary, is to let the water pass through a screen or a lattice to catch all floating objects. Then follow:

a) **Sedimentation** – removal of coarse grained suspended particles

b) **Coagulation** – removal of submicroscopical particles hindered in free settling by Brownian motion by water clarification. A small quantity of aluminium sulphate is added to the water, forming with it a gelatinous flocculent clot of aluminium hydroxide. It sediments carrying electrostatically adsorbed particles of impurities, including bacteria. It has been experimentally proved, that water gets rid of 90% of microorganisms in this way.

c) **Filtration** – afterwards the water is passed through the filters, filled with few strata (stones, coarse gravel, fine gravel and sand – from the bottom upwards). This process is not only mechanical but also biological. After 2 – 3 days of filtration a continuous gelatinous sheet is being formed on and between the grains of sand in the upper layer. A lay of adhered bacteria, protozoa, algae and organic substances makes the decomposition similarly to the self-purification activity in natural conditions. The filter may be a slow one or a rapid one. In some cases filters working under the higher pressure can be used.

d) **Aeration** – removal of Fe and Mn by their oxidation and transformation to insoluble compounds removed from water by sedimentation and filtration. The aeration also supports natural processes of decomposition.

e) **Disinfection** – by different methods, but most common is water chlorination. From public health point of view it is the most important procedure. In waterworks the gaseous chlorine (molecular Cl_2) is used compressed in dosing devices. The dose of chlorine is 0.2 – 0.5 mg Cl_2 per liter of water. For individual water supply that is for wells the chlorine preparations as chlorinated lime or calcium hypochlorite are used. The disinfection effect

represents the active chlorine Cl^+. That is the same chemical bond as in hypochlorous acid $HOCl^+$ not as in hydrochloric acid HCl^-. This active chlorine is dosed in the amount of 1 mg per liter of water. We must know the content of Cl^+ in chlorinated lime, which can be maximally 38%. If it were 20% we must dose 5 mg of the lime per liter water. The exposition time is 30 minutes. Only after this time is the disinfection effective. When the pollution of water is high, the dose of chlorine must be increased. For the security sake superchlorination is made. A **residuum of chlorine** is required after the disinfection has been done in the amount of **0.2 – 0.3 mg in a liter of water**.

f) **Dechlorination** – is the removal of the residual chlorine or the smell of it with sodium thiosulphate which changes the chlorine to the not smelling chloride ion or by filtering the water through a charcoal filter.

Drinking water disinfection Chlorine is by far the oldest and the most commonly used biocide. Originally, the use of chlorine was based on the idea of a link between waterborne diseases and the bad (or septic) smell of the water. Although it preceded discovery of the bacteria responsible for water contamination, the use of chlorine for deodorization of water proved to be very effective. Through the work of scientists such as Pasteur and Escherich the microbiological origin of waterborne diseases was discovered and the bactericidal action of chlorine explained. The widespread use of water chlorination in Europe has eradicated epidemics of typhoid fever and cholera in many countries. Disinfection by chlorine is still the best guarantee of microbiologically safe water. The concentration of the biocidal chemical agent and the water/biocide contact time are the main factors which determine proper disinfection of water. The chlorines residuum is present in consumers, what is a good marker for proper disinfections. The control for swimming pools water disinfection is the same. Other water disinfectants are chlorine substances (chloramines), ozone, argentum substances, UV radiation. The addition of air containing ozone to the water can be used in smaller settlements with short pipes length. The other possible method is the exposure of the water to UV rays from a mercury vapor lamp. Either of these methods is capable of giving good results, but it is doubtful if they can be regarded as serious competitors with chlorine. In past few decades there is an ongoing research on potential chronic and carcinogenic effect of substances that are created in water following chlorine disinfection. Chlorine is free to react with various organic compounds present in water, producing organochlorines or chlorinated hydrocarbons (trihalomethanes – chloroform, chlorinated compounds of acetic acid and acetonitrile).

2.2.2.7 Waste waters and health hazards

Wastewater is increasingly used in agriculture in both developing and industrialized countries. The use of wastewater for crop irrigation is becoming increasingly common, especially in arid and semi-arid areas. Crop yields are higher as the wastewater contains not only water for crop growth, but also plant nutrients (mainly nitrogen and phosphorus). However, there is the risk that wastewater irrigation may facilitate the transmission of excreta-related diseases.

From an appraisal of the available epidemiological evidence, it was established that the major risks were:

- the transmission of intestinal nematode infections both to those working in the waste-water irrigated fields and to those consuming vegetables grown in the fields; these infections are due to *Ascaris lumbricoides* (the human roundworm), *Trichuris trichiura* (the human

whipworm), and *Ancylostoma duodenale* and *Necator americanus* (the human hookworms); and

- the transmission of faecal bacterial diseases – bacterial diarrhea and dysentery, typhoid and cholera – to the crop consumers.

Hazards associated with the consumption of wastewater-irrigated products include extra-related pathogens and some toxic chemicals. The risk from infectious pathogens is significantly reduces if foods are eaten after thorough cooking. Cooking has a little or no impact on the concentration of toxic chemicals that might be present.

A variety of health protection measures can be used to reduce health risks to consumers, workers and their families and local communities.

The following health protection measures have an impact on **product consumers**:

- wastewater treatment;
- crop restriction;
- waste application techniques that minimize contamination (e.g. drip irrigation);
- withholding periods to allow pathogen die off after the last wastewater application;
- hygienic practices at food markets and during food preparation;
- health and hygiene promotion;
- produce washing, disinfection and cooking;
- chemotherapy and immunization.

Other health protection measures for **workers** and their families include:

- use of personal protective equipment;
- access to safe drinking water and sanitation facilities at farms;
- heath and hygiene promotion;
- chemotherapy and immunization;
- disease vector and intermediate host control;
- reduced vector contact.

To reduce health hazards, the following health protection measures for **local communities** may be used:

- wastewater treatment;
- restricted access to irrigated fields and hydraulic structures;
- access to safe recreational water, especially for adolescents;
- access to safe drinking water and sanitation facilities in local communities;
- health and hygiene promotion;
- chemotherapy and immunization;
- disease vector and intermediate host control;
- reduced vector contact.

2.2.2.8 Bathing, recreational water

Safe bathing water is an essential factor in public health. Poor-quality recreational water has been shown to be the cause of outbreaks of waterborne diseases involving many tourists as well as local people. There are two types of bathing water: **coastal and fresh water** and **swimming pools, spas** and **similar recreational water environments.**

2.2.2.8.1 Coastal and fresh waters

The quality of bathing waters may be affected by inadequate sewage treatment and agricultural pollution, resulting in microbial and chemical contamination and eutrophication. There is considerable epidemiological evidence in the literature to suggest that contact with recreational waters is associated with illness, primarily gastrointestinal symptoms, although outbreak data also suggest that there is a risk of more serious illnesses such as those caused by *Shigella sonneri*, *Escherichia coli* O157, protozoan parasites and enteric viruses. A recent assessment of the global burden of disease attributable to gastroenteric infections arising from unsafe recreational marine water environments has estimated it as 66 000 disability-adjusted life years (DALYs) annually.

The population groups that may be at higher risk of disease include the young, the elderly and tourists who do not have immunity against locally occurring endemic diseases. Children tend to play for longer periods in recreational waters and are more likely than adults to swallow water intentionally or accidentally.

The water quality of coastal zones in Europe improved steadily between 1992 and 2004 and remained high in the period 2005 – 2007. The new Bathing Water Directive 2006/7/EC has set higher standards for the management of bathing waters.

The water quality in freshwater zones has fallen since 2003. Some of the new European Union (EU) Member States have experienced problems with relatively poor water quality but water quality improved slightly between 2006 and 2007.

Directive 76/160/EEC defined quality criteria for bathing waters and obliged the Member States to monitor bathing sites. This has been replaced by Directive 2006/7/EC, which sets new standards for the monitoring and management of bathing waters and for providing relevant information to the public, taking into account the scientific evidence of recent years.

The new Bathing Water Directive requires Member States to have a management plan for each site, based on an assessment of the pollution sources. Owners of sites with poor water quality must be prepared to close the bathing area when conditions conducive to pollution are forecast. If the quality standards are not met, remedial measures must be taken.

The new Directive also obliges Member States to disseminate information on bathing water quality, the reasoning behind assessments of resulting health risks and recommendations for the safest behaviour to the public.

2.2.2.8.2 Swimming pools, spas and similar recreational water environments

The hazards that are encountered in swimming pools and similar environments vary from site to site, as does exposure to the hazards. In general, most available information relates to health outcomes arising from exposure through swimming and ingestion of water. The most

frequent hazards associated with the use of swimming pools and similar recreational water environments are physical hazards (leading to, for example, drowning, near-drowning or injury); heat, cold and sunlight; water quality; and air quality.

The risk of illness or infection associated with swimming pools and similar recreational water environments is primarily associated with faecal contamination of the water. This may be due to faeces released by the bathers or contaminated source water or, in the case of outdoor pools, may be the result of direct animal contamination (e.g. from birds and rodents).

Shigella and *Escherichia coli* O157 are two related bacteria that have been linked to outbreaks of illness associated with swimming in pools. The risk of illness in swimming pools associated with faecally-derived protozoa mainly involves two parasites: Giardia and Cryptosporidium. Most of the legionellosis, an often serious infection caused by *Legionella species*, associated with recreational water use has been associated with public and semi-public hot tubs and natural spas. Natural spas (especially thermal water) and hot tub water and the associated equipment create an ideal habitat (warm, nutrient-containing aerobic water) for the selection and proliferation of *Legionella. Pseudomonas aeruginosa* is also frequently present in hot tubs, as it is able to withstand high temperatures and disinfectants and to grow rapidly in waters supplied with nutrients from users.

There is also risk associated with chemicals found in swimming pool water derived from a number of sources, namely the source water, deliberate additions such as disinfectants and pool users themselves (these include sweat, urine, soap residues, cosmetics and suntan oil).

Chlorination is the most widely used pool water disinfection method, usually in the form of chlorine gas, sodium, calcium or lithium hypochlorite but also with chlorinated isocyanurates. These are all loosely referred to as „chlorine“. Practice varies widely around the world, as do the levels of free chlorine that are currently considered to be acceptable in order to achieve adequate disinfection while minimizing user discomfort. For example, free chlorine levels of less than 1 mg/l are considered acceptable in some countries, while in other countries allowable levels may be considerably higher. It is recommended that acceptable levels of free chlorine continue to be set at the local level, but in public and semi-public pools these should not exceed 3 mg/l and in public/semi-public hot tubs these should not exceed 5 mg/l. Lower free chlorine concentrations may be health protective when combined with other good management practices (e.g. pre-swim showering, effective coagulation and filtration, etc.) or when ozone or UV is also used.

Disinfectants can react with other chemicals in the water to give rise to by-products Although there is potentially a large number of chlorine-derived disinfection by-products, the substances produced in the greatest quantities are the trihalomethanes (THMs), of which chloroform is generally present in the greatest concentration, and the haloacetic acids (HAAs), of which di- and trichloroacetic acid are generally present in the greatest concentrations. It is probable that a range of organic chloramines could be formed, depending on the nature of the precursors and pool conditions.

Data on their occurrence in swimming pool waters are relatively limited, although they are important in terms of atmospheric contamination in enclosed pools and hot tubs.

2.2.3 Soil

The soil is the surface layer of the Earth’s crust that is not covered with water. It represents 1/3 of the continental part of the lithosphere. The importance of the soil for people is reflected in agriculture, construction and location of buildings, engineering and infrastructure and industries.

The basic natural roles of soil include **life support, cycling of elements and stabilization.**

Life support soil systems are found both on and under the surface. The **topsoil** contains the predominantly organic portions: nutrients and moisture to support surface-dwelling plants and animals through litter, leaf mold and humus; habitat for near surface dwellers, decompose organisms, worms and insect larvae that form the ecosystem. Within the **subsoil** are found predominantly **inorganic portions** of extracted soil and mineral soil. The latter is formed from the bits and pieces of rocks and minerals chipped away from the Earth's crust. The rocks and minerals contain chemicals for plant nutrition and determine the **acidity of the soil**. One kg of rich soil in Central and Northern Europe contains up to a trillion bacteria, a trillion fungi, and a billion algae, as well as thousands of different worms, insects and mites.

The cycling of elements by soil involves minerals, nutrients and water. Minerals from plant and animal decomposition are held in the soil by humus and made available for plant uptake. Soil is a good habitat for decomposers, which recycle inorganic and organic chemicals such as nitrogen, phosphorus and carbon. Soil with stable vegetation and a topsoil layer becomes a good route for water to percolate into ground water, an important step in the hydrologic cycle. Soil types tend to govern the chemical composition of ground water. Soil bacteria have been useful in treating wastes.

Out of all the chemical elements that make up the surface of the earth's crust, oxygen and silicon are present in the highest proportion (over 80%), followed by aluminum, calcium and iron. Minerals originating from the soil are classified into two main groups according to quantity and physiological function in the human organism (major elements and essential trace elements, see chapter 5).

Deficiency of some trace elements (such as iodine, fluorine, and selenium) in regions with naturally anomalous distribution of them is manifested in the disturbance of health in the form of enzootic and/or endemic disease. The global problem of shortage or reduced bioavailability of some trace elements in the soil is slowly spreading to many regions of the world due to acid rain (deposited sulfates and nitrates) changing the chemical properties of the soil.

2.2.3.1 Soil pollution

Soil pollution is usually a consequence of insanitary habits, agricultural practices, and incorrect methods of disposal of solid and liquid wastes, but can also result from fallout from atmospheric pollution.

In most cases, pollution of the soil is reversible, and decomposition of the pollutants is continuous, occurring simultaneously with decomposition of the soil. The self-cleaning ability of the soil mostly depends on the mechanical structure of the soil, physical and chemical characteristics (such as oxygen and moisture, pH), and composition of microflora, flora and fauna (types and quantities), which often become damaged as a result of excessive pollution. It is important that there are zones of unpolluted soil from which the living species may recolonize a damaged area and initiate the natural process of purification. The process of

decomposition of waste in the soil depends on the type and quantity of natural or artificial waste substrate (carbohydrates, fats and proteins, chemical products). If the soil is polluted with large quantity of organic waste materials, there are adverse conditions for their decomposition, and they can leave by-products and gases of unpleasant odor.

2.2.3.1.1 Soil pollution by biological agents

Biological agents that can pollute the soil and cause disease in man can be divided into three groups:

1. Pathogenic microorganisms by man and transmitted to man by direct contact with contaminated soil or by the consumption of fruit or vegetables grown in contaminated soil (**man-soil-man**). Enteric bacteria and protozoa can contaminate the soil as a result of insanitary excreta disposal practices, or the use of night soil or sewage sludge as a fertilizer, or the direct irrigation of agricultural crops with sewage. This concerns the contamination with the bacterial agents of salmonellosis, bacillary dysentery, typhoid and paratyphoid fever, cholera, or with the protozoa agent of amoebas. Parasitic worms (helminths, geo-helmints) and their eggs became infective after incubation and life cycle in the soil. The most important soil transmitted helmints are ***Ascaris lumbricoides*** (round worm), ***Trichuris trichiura*** (whip worm) and ***Ancylostoma duodenale***.

2. Pathogenic organisms from animals, transmitted to man by direct contact with soil contaminated by the wastes of infected animals (**animal-soil-man**). This group is presented by many zoonoses – diseases transmitted from animals. In the soil the agent of **leptospirosis** can survive, where the source animals are mostly rodents and agents are get to the soil by urine or feces. There is also a possible transmission of **tularemia** (sources are rabbits), **salmonellosis** (poultry and domestic animals), **toxocarosis** (dogs, foxes), **listeriosis and Q fever** (cattle);

3. Pathogenic organism are found naturally in soil and transmitted to man by contact with contaminated soil (**soil-man**). Most of the serious subcutaneous, deep seated and systemic **mycoses** are caused by fungi and actinomycetes that grow normally as saprophytes in soil or vegetation. Under certain circumstances, however, they become pathogenic and invade specific tissues or entire systems.

The most common soil born illnesses and soil associated pathogens are summarized in Table 2.7.

2.2.3.1.2 Contamination of the soil by toxic chemicals

Soil pollution by chemical agents causes poisoning or long term chronic effect disease. One of the most remarkable problems, which encounter soil, is the excessive use of **agricultural fertilizers and pesticides**. Fertilizers are intended to fortify the soil raising of crops, but incidentally may contaminate the soil with their impurities. Irrigation of farmlands may do this if the source of water is polluted by industrial wastes that contain synthetic organic chemicals. During the last several decades pesticides (mostly insecticides, fungicides

and herbicides) have produced intentional alterations of agricultural and other arable soils. The present trend in the manufacture of pesticides is to synthesize short-lived degradable compounds because this minimizes the persistence of residues of pesticides and their degradation products on food and forage crops.

Tab. 2.7 Soil-associated pathogens (Source: Brooks et al., 1995)

Pathogen	**Disease**
Parasites	
Ascaris	Pneumonitis; intestinal, pancreatic, and biliary obstruction; appendicitis, intussception, volvulus
Hookworm	Intestinal disease, malabsorption, anemia, hypoproteinemia, edema, congestive heart failure
Whipworm	Diarrhea, rectal prolapse
Strongyloides	Intestinal autoinfection, shock, death
Nematodes	Cutaneous and visceral larva migrans
Entamoeba histolytica	Amebic dysentery
Toxocara spp.	CNS disease
Bacteria	
E. coli	Intestinal disease (from fecal contamination)
Clostridium tetani	Tetanus
Bacillus anthracis	Anthrax
Fungi	
Dermatophytes	Ringworm (*Tinea corporis, pedis, cruris*)

A number of pesticides and other soil pollutants such as **heavy metals** like **chromium** are carcinogenic to all populations. **Lead** is especially hazardous to young children, a group with a high risk of developmental damage to the brain and nervous system. **Mercury** is known to induce higher incidences of kidney damage, and **PCBs** and cyclodienes are linked to liver toxicity. Chronic exposure to **benzene** is known to be associated with a higher incidence of leukemia. Many **chlorinated solvents** induce liver and kidney changes and depression of the central nervous system. **Organophosphates** and **carbamates** can induce acute intoxication, leading to neuromuscular blockage.

2.2.3.1.3 Assessment and control of soil pollution

Soil pollution is investigated by means of toxicological, radiological, bacteriological, and parasitological methods. Large projects related to the prevention of chemical pollution of the soil include implementation and control of the production process, aiming at a decrease in production, and increase in recycling and neutralization as well as efficient disposal and protection of non-decomposable waste materials and infectious waste materials (from veterinary and public service facilities).

Strategies for reducing soil **desertification** (a natural process of ecosystem degradation in arid regions, it can result from continued human land abuse during droughts) and **erosion** (an intrinsic natural process, increased by human exploitation; the total ground surface is stripped of vegetation and seared of all living organisms; the upper soils are vulnerable to both wind

and water erosion; the main cause is slashing and fire treatment of tropical forests) in some regions include planting of cover crops, establishment of windbreaks, strip cropping, terracing, and minimum tillage farming.

Soil acidification is a problem in many regions of the world due to acid rain deposits, which change the chemical properties of the soil. **Soil salination** might be a natural process that results from high levels of salt in the soil, features that allow salts to become mobile or climatic trends that favor salt accumulation.

Recent activities have developed successful new methods in artificial purification of the soil like **georemediation** (accelerated geochemical remineralization), **phytoremediation** and **bioremediation** by natural plants and microorganisms stimulated with additional nutrients).

2.2.4 Solid wastes

Wastes may be classified by their physical, chemical, and biological characteristics. An important classification criterion is their consistency.

Solid wastes are waste materials having less than approximately 70% water. This class includes municipal solid wastes such as household garbage, industrial wastes, mining wastes, oil-field wastes and sludge from water supply or waste treatment plants, material from air pollution control facilities and other discarded materials. Solid waste does not include solid or dissolved materials in irrigation return flows or industrial discharges. **Liquid wastes** are usually wastewaters, including municipal and industrial wastewaters, that contain less than 1% suspended solids. Such wastes may contain high concentrations (greater than 1%) of dissolved species, such as salts and metals. More details on wastewaters see in Chapter 2.2.2.7.

Federal regulations classify wastes into three different categories, based on hazard criteria: (a) **nonhazardous**, (b) **hazardous**, and (c) **special.**

Nonhazardous wastes are those that pose no immediate threat to human health and/or the environment, for example, municipal wastes such as household garbage and many high-volume industrial wastes.

Hazardous wastes are of two types: (a) those that have characteristic hazardous properties, that is, ignitability, corrosively, or reactivity, and (b) those that contain leachable toxic constituents. Other hazardous wastes include liquid wastes, which are identified with a particular industry or industrial activity.

Waste is an issue in every European country, and waste quantities are generally growing. Unfortunately, the lack of available and comparable data for many countries does not always allow reliable comprehensive assessment of waste-related issues. It is estimated that more than 3, 000 million tonnes of waste are generated in Europe every year. This equals 3.8 tonnes/capita in Western Europe (WE), 4.4 tonnes in central and eastern Europe (CEE) and 6.3 tonnes in the countries of eastern Europe, the Caucasus and central Asia (EECCA).

Manufacturing industry, construction and demolition, mining and quarrying, and agriculture are the main sectors that contribute to waste generation. Other important waste streams are municipal waste, hazardous waste, waste from end-of-life vehicles, sewage sludge, packaging waste and waste from energy generation.

Solid waste comes from various sources and can be considered in various categories:

Municipal – residential waste is a category about which good deal is known. This category generally includes household waste and certain "white" goods as well as similar wastes from commercial and industrial firms and the residues from markets and gardens. The average quantity of municipal waste per capita in the developed countries is more than 500 kg per annum. **Residential waste** is a familiar household waste from private homes and apartments and is a mixture of organic waste with food scraps, newspaper and unwanted household items. The sources are houses, hotels and restaurants.

Commercial waste – institutional waste contents office waste, manufacturing waste. The main sources are schools, prisons, hospitals and other institutions.

Construction and demolition waste includes a wide variety of material often saturated with paints, asbestos and building or cement products.

Sewage sludge is a material retained on sewage treatment screens, settled solids and biomass sludge. Sludge is a class of waste intermediate to solid and liquid wastes. Sludge usually contain between 3% and 25% solids, while the rest of the material is water-dissolved species. These materials, which have a slurry-like consistency, include municipal sludge, which is produced during secondary treatment of wastewaters, and sediments found in storage tanks and lagoons.

Agricultural waste comes from agricultural activities including both plant and organic wastes.

Hazardous waste if improperly handled, pose a substantial threat or potential hazard to human health (see Chapter 2.2.5).

2.2.4.1 Health effects of solid wastes

The risk resulting from solid wastes is the possibility to contaminate an air, soil, water, to cause smelling odor and to transmit communicable diseases.

The risk is connected with releasing:

- particulate matter,
- dioxins (carcinogenic) and furans,
- acid and irritant gases, oxides of nitrogen, hydrogen chloride, carbon monoxide, hydrogen fluoride,
- volatile organic compounds,
- heavy metals,
- noise,

- odor,
- biological agents of communicable diseases (zoonoses, waterborne diseases).

Solid wastes have mostly indirect human health effect – they may pollute soil, air, surface water, or underground water. Compounds such as DDT (dichlorodiphenyltrichloroethane), PCBs (polychlorinated biphenyls) and dioxins are more soluble in fats than in water and therefore tend to build up in the fats within plants and animals. These substances may interfere with egg production and bone formation in birds; they are also called estrogen-like products.

2.2.5 Hazardous wastes

Among the various types of waste produced by society, particular attention needs to be paid to waste that is potentially harmful to health and the environment, usually known as hazardous waste. Poor management of such waste can endanger public health and give rise to public concern.

Hazardous waste is a waste whose physical, chemical and biological characteristics necessitate special handling, treatment or disposal in order to avoid elevated risks to health or adverse impact on the environment. Substances are consider hazardous if they are ignitable (capable of burning or causing a fire), corrosive (able to corrode steel or harm organisms because of extreme acidic and basic properties), reactive (able to explode or produce toxic cyanide or sulfide gas), or toxic (containing poisonous substances). Hospital or health care waste and radioactive waste are covered by this definition as well. Their management is dealt with in Chapters 4 and 7.

Hazardous wastes may entail short-term and long-term **health risks**. In the **short-term**, the risk may be one of poisoning by ingestion, inhalation or contact absorption, of corrosive action on the skin or eyes, or of fire or explosion. **Long-term risks** may include chronic poisoning as a result of repeated exposure or carcinogenicity. The long-term effects of particular concern include genetic damage and birth defects.

Knowledges about the health risks of hazardous wastes are inadequate especially concerning the environmental contamination from hazardous waste sites. A review of research on the public health aspects of toxic waste disposal stated that although studies on the health of populations in the vicinity of disposal sites have found only inconclusive evidence thus far implicating exposure to these dangerous wastes in the occurrence of disease the following adverse health effects have been suggested: decreased birth-weight, increase in the frequency of congenital malformations and abortions, and increase in the occurrence of certain forms of cancer. Further studies will be required to confirm the validity of these effects and to determine whether other risks may also exist.

2.2.5.1 Categorization of hazardous waste

There are three basic approaches in the classification of hazardous waste:

- by origin and specific components;
- by physical, chemical and toxic characteristics;
- by composition and concentration.

Municipal hazardous waste is only a small part of municipal waste. Hazardous materials in municipal solid waste are paint and paint-related products, garden products, motoring products, household cleaners, pharmaceutical products, water treatment chemicals and other items, like batteries and smoke alarms.

Industrial hazardous waste produces all industries to differing degrees. The largest quantities are generated by major industrial manufacturing sectors such as chemicals and pharmaceuticals, metalworking and metal finishing, oil and coal based products, leather tanning, dying and textiles.

Agricultural waste is pesticides and herbicides and the materials used in their application. Fluoride wastes are by-products of phosphate fertilizer production and soluble nitrates from manure may dissolve into groundwater and contaminate drinking-water wells.

Medical waste is contaminated with blood and tissue. Especially careful must be with scalpels and glassware called „sharps“. For more details see Chapter 7.

Radioactive waste is coming from nuclear power plants after burning process of nuclear fuel. It is one of the most dangerous and specific soils wastes. For more details see Chapter 4.

2.2.5.2 Waste management

There is an evidence that improper disposal of hazardous wastes poses serious threats to the environment and public health (groundwater, air and soil pollution, damage to sewer systems, habitat destruction, fish kills, livestock losses, and damages to crops and wildlife). Figure 2.2 shows the ways in which migrating contaminants from a hazardous landfill can contaminate air, water and soil. It is particularly important that hazardous products are not disposed of through the sewerage system. Water pollution by certain types of liquid waste may constitute a serious hazard to sewerage personnel and the staff of wastewater treatment plants as well as making the water harder to clean.

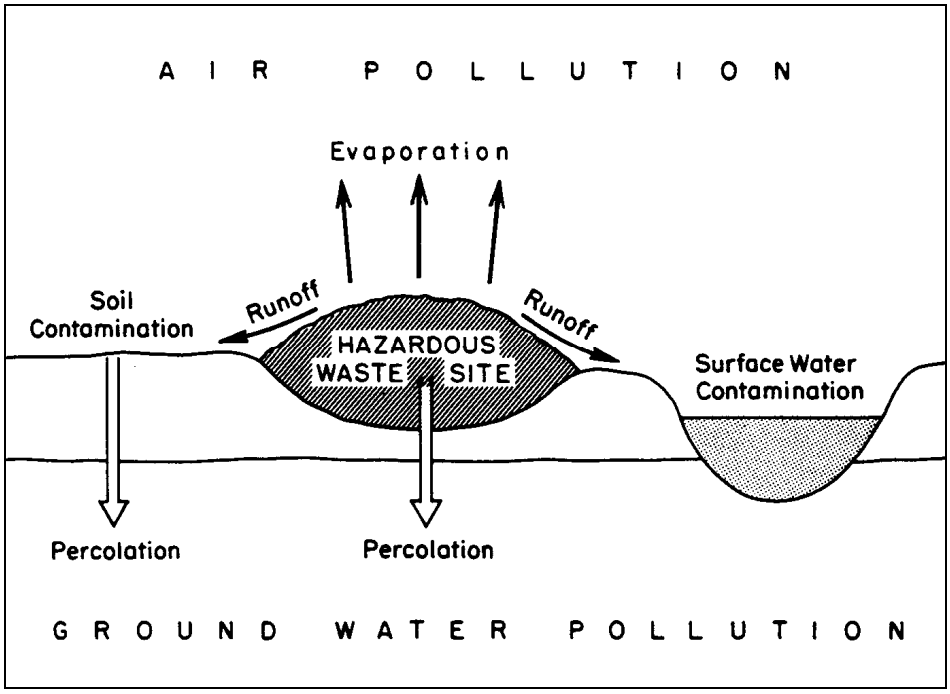

Figure 2.2 Environmental contamination from hazardous waste sites (Source: Tarcher et al., 1992)

Disposal of solid waste on land (**landfill**) is by far the most common method. **Incineration** is on the second place and **composting** of solid wastes accounts for only an insignificant amount. **Reuse and recycling** is the most economic method.

Landfill is the cheapest satisfactory means of disposal, but only if suitable land is within technical, social and economic range of the source of wastes. These aspects should include, when necessary, arrangements for compensating communities near the proposed facility.

Composting means using of decayed matter as fertilizer. It is more used in the disposal of organic part of the municipal waste in rural areas.

Incineration use incinerators of conventional design, refuse is burned on moving grates in refractory-lined chambers; combustible gases and solids are burned in secondary chambers. In addition to heat, the products of incineration include the primary products of combustion-carbon dioxide and waters - as well as oxides of sulphur and nitrogen, dioxins and other gaseous pollutants; non-gaseous products are fly ash and unburned solid residue.

Recycling is used if hazardous material cannot be **re-used** as such. Sophisticated technologies now allow the recycling of solvents which become suitable for equipment cleaning, ferric chloride waste from titanium dioxide manufacture which find a new function as wastewater conditioners in water treatments; or galvanic sludge loaded with heavy metals which can be recycled into bricks for building construction.

Local authorities are generally directly responsible for the collection and treatment of hazardous municipal waste. They can also indirectly influence, through regulation and promotion activities, the management of hazardous materials mixed with industrial waste.

The transport of hazardous waste should be strictly monitored to ensure compliance with national regulations and international agreements.

Treatment facilities are needed to avoid hazardous waste being unsafely disposed of. When considering the establishment of a new facility, or the operation of an existing one, particular attention should be paid to a dialogue with industry, as well as to the enforcement of regulations and to communication with the public.

The most satisfactory approaches to managing hazardous wastes are those which help to minimize the quantity of waste requiring disposal. The best way is preventing its generation.

3. OCCUPATIONAL HYGIENE

Within the scope of public health practice, occupational hygiene is the health profession devoted to the recognition, evaluation, and control of hazards in the working environment. These include chemical, physical and biological hazards, psychosocial factors, and ergonomic factors that cause or contribute to injury, disease, impaired function, or discomfort.

During the past decades, work life has undergone great changes. Not only work itself, but also our opinion of work, has changed. Now it is known that a good work environment should not only be healthy and safe, but should also encourage personal and professional development, job satisfaction and personal fulfillment, all of which contribute to improved work quality and productivity. It is also known that the way work is organized is of importance, and that the situation in the labour market affects the work, the worker and the worker's health and well-being.

The role of occupational health services has changed in recent years, with increasing emphasis on health promotion and prevention of occupational hazards. The major concern is no longer to diagnose occupational diseases. Instead of, the occupational health specialist aims at diagnosing sick workplaces before they endanger the health of the employees. In this way such workplaces are the real "patients" and their "diseases" are what need to be cured.

3.1 OCCUPATIONAL HEALTH PROTECTION AND HEALTH PROMOTION

The steps that are involved in the workers´ health protection in the workplace are: hazard recognition, hazard evaluation, and hazard control/intervention.

Hazard recognition involves a systematic review of a worker's occupational environment to identify exposures and potential exposures. This review should include information on the materials used and produced, the characteristics of the workplace including the equipment used, and the nature of each worker's interaction with the sources of workplace hazards. Specific information is obtained on the raw materials used in a process, materials produced or stored, and the by-products formed during the production process. Hazard recognition also includes gathering information on the types of equipment used in the workplace, the cycle of operation and/or frequency of exposure, and the operational methods and work practices used. A workplace review for the purpose of hazard recognition also includes identification of health and safety controls in place, including use of personal protective equipment.

Hazard evaluation is a type of risk assessment, developed from the information gained in the hazard recognition and identification process and the characteristics of the (exposed)

population at risk. The series of steps in reaching a conclusion about the degree of hazard associated with a particular exposure or work condition is known as hazard evaluation. Hazard evaluations are essential to determine the need for control measures to minimize exposures and to identify clues to the etiology of an adverse health condition observed in a worker or group of workers.

For purposes of **hazard control** and disease prevention, contaminants are classified largely on the basis of their physical and chemical characteristics, as these characteristics determine the route of exposure. Workers may be exposed to contaminants by inhalation, by absorption through the skin, by ingestion, or by injection, as in the case of accidental puncture wounds. Inhalation and skin absorption are the primary routes of exposure for most materials in the occupational environment. In cases where poor hygiene practices such as consumption of food and beverages in contaminated work areas are allowed, ingestion may be an important source of exposure. The elimination or reduction of hazards to the extent feasible is the primary means of prevention for occupational disease and injury. The strategy for effective hazard control is an ordered hierarchy. The three elements of this effective ordered hierarchy of control solutions are:

1. Prevent or contain hazardous workplace emissions at their source.

2. Remove the emissions from the pathway between the source and the worker.

3. Control the exposure of the worker with barriers between the worker and the hazardous work environment. This strategy mandates the use of environmental controls as the primary means of exposure prevention. These controls may take several forms and are frequently used in combinations as part of an overall prevention strategy.

Methods commonly employed to control exposures fall into three basic categories: Engineering controls, work practice controls (including administrative controls), and personal protective equipment.

Engineering controls (also known as passive controls) employ mechanical means or processes redesign to reduce exposure. The contaminant may be eliminated, contained, diverted, diluted, or collected at the source. Employee isolation or machine and process enclosure are also used to protect workers from excessive fumes or noise. Closed material-handling systems, product substitution, and exhaust ventilation are also commonly employed.

Work practice controls rely on employees to perform certain activities in a carefully specified manner so that exposures are reduced or eliminated. For example, employers may instruct workers to keep lids on containers, to clean up spills immediately, or to observe specific, required hygiene practices. Such work practices are often required to complement engineering controls. This is particularly true in cases where engineering controls cannot provide complete compliance with the standard. Noise hazards are often controlled by a combination of engineering steps and work practices limiting the amount of time workers are exposed to excessive noise levels.

Personal protective equipment (PPE) is at the lowest level of the hierarchy of exposure control methods. PPE is used to supplement engineering controls and work practices. These devices are intended to provide a barrier between workers and contaminated environments. They include equipment to protect the eyes (safety glasses, goggles, and face shields); the skin (gloves, aprons, and full body suits made of impervious materials); the respiratory tract (a wide variety of respiratory protective devices), etc. The selection and use of these devices is largely driven by the particular application, and there is a large number of choices available to protect against chemical, physical, and biological hazards. Often overlooked is the great importance of personal hygiene, which includes the use of protective clothing to provide barriers to both of the worker and the worker's family, the provision for shower facilities, and the cleaning of protective clothing so that contaminants are not transferred to others.

Worker education and training are essential components of effective programs of primary prevention and exposure control. Any of the control strategies just described function best when workers understand the physical and chemical hazards associated with their work, as well as methods for controlling these hazards.

Health promotion A common understanding of workplace health promotion throughout Europe was defined for the first time in the Luxembourg Declaration in 1997. According this Declaration, the workplace health promotion (WHP) is the combined efforts of employers, employees and society to improve the health and well-being of people at work.

Work today means more to most people than a mere source of income. Work plays an important role not only in the health and well-being of an individual, but also of the whole population. Accidents and illnesses can be prevented here and healthy workplaces can be designed, but it is also the setting where people can acquire the knowledge and motivation to influence their own health and their attitudes to health, both within and outside their working environment.

Evidence-based prevention programs that promote workplace health and safety and that are cost effective and produce the desired results need to be developed. The workplace offers the ideal opportunity to keep people healthy. These are places for health promotion information, screening programs to detect disease at an early stage, and many others health promotion activities.

3.2 OCCUPATIONAL ENVIRONMENT

3.2.1 Indoor air quality

Indoor air quality (IAQ) refers to the quality of the air inside workplaces represented by concentrations of pollutants and thermal conditions (temperature and relative humidity) that affect the health, comfort, and performance of employees. Usually, temperature (too hot or too cold), humidity (too dry or too damp), and air velocity (draftiness or motionlessness) are considered "comfort" rather than indoor air quality issues. Unless they are extreme, they may make someone uncomfortable, but they won't make a person ill. Other factors affecting

employees, such as light and noise, are important indoor environmental quality considerations, but are not treated as core elements of indoor air quality problems.

Poor IAQ may only be annoying to one person, or, at the extreme, could be fatal to all the occupants in the workplace. The concentration of the contaminant is what is crucial. Potentially infectious, toxic, allergenic, or irritating substances are always present in the air; there is nearly always a threshold level below which no effect occurs. Workplace structures (buildings) exist to protect workers from the elements and to otherwise support worker activity, should not make workers sick, cause them discomfort, or otherwise inhibit their ability to perform.

Air quality is affected by the presence of various types of contaminants in the air.

Indoor air contaminants include but are not limited to particulates, pollen, microbial agents, and organic toxins. These can be transported by the ventilation system or originate in various parts of the ventilation system—wet filters, wet insulation, wet under coil pans, cooling towers, or evaporative humidifiers. Some are in the form of gases. These would be generally classified as toxic chemicals. The types of interest are **combustion products** (carbon monoxide, nitrogen dioxide), **volatile organic compounds** (formaldehyde, solvents, perfumes and fragrances, etc.), and **semi-volatile organic compounds** (pesticides). Volatile organic and reactive chemicals often contribute to indoor air contamination. The facility's ventilation system may transport reactive chemicals from a source area to other parts of the building. Tobacco smoke contains a number of organic and reactive chemicals and is often carried this way. In some instances the containment source may be the outside air. Outside air for ventilation or makeup air for exhaust systems may bring contaminants into the workplace (e.g., vehicle exhaust or fugitive emissions from a neighboring smelter).

Other pollutants are in the form of animal dander; soot; particles from buildings, furnishings and occupants such as fiberglass, gypsum powder, paper dust, lint from clothing, carpet fibers, etc.; dirt (sandy and earthy material); etc. (Table 3.1).

People exposed to these agents may develop signs and symptoms related to "humidifier fever," "humidifier lung," "air conditioner lung." In some cases, indoor air quality contaminants cause clinically identifiable conditions such as occupational asthmas, reversible airway disease, and hypersensitivity pneumonitis.

3.2.2 Workplace building associated illnesses

The rapid emergence of IAQ problems and associated occupant complaints have led to terms which describe illnesses or effects particularly associated with buildings. These include (1) sick building syndrome, (2) building related illness, and (3) multiple chemical sensitivity.

3.2.2.1 Sick building syndrome

Sick building syndrome (SBS) is a catch-all term that refers to a series of acute complaints for which there is no obvious cause and where medical tests reveal no particular

abnormalities. It describes situations in which more than 20 % of the building occupants experience acute health and comfort effects that appear to be linked to time spent in a building because all other probable causes have been ruled out.

Table 3.1 Indoor air pollutants and potential sources

Pollutant or pollutant class	**Potential sources**
Environmental Tobacco Smoke	Lighted cigarettes, cigars, pipes
Combustion Contaminants	Furnaces, generators, gas or kerosene space heaters, tobacco products, outdoor air, vehicles
Biological Contaminants	Wet or damp materials, cooling towers, humidifiers, cooling coils or drain pans, damp duct insulation or filters, condensation, re-entrained sanitary exhausts, bird droppings, cockroaches or rodents, dustmites on upholstered furniture or carpeting, body odors
Volatile Organic Compounds (VOCs)	Paints, stains, varnishes, solvents, pesticides, adhesives, wood preservatives, waxes, polishes, cleansers, lubricants, sealants, dyes, air fresheners, fuels, plastics, copy machines, printers, tobacco products, perfumes, dry cleaned clothing
Formaldehyde	Particle board, plywood, cabinetry, furniture, fabrics
Soil gases (radon, sewer gas, VOCs, methane)	Soil and rock (radon), sewer drain leak, dry drain traps, leaking underground storage tanks, land fill
Pesticides	Termiticides, insecticides, rodenticides, fungicides, disinfectants, herbicides
Particles and Fibers	Printing, paper handling, smoking and other combustion, outdoor sources, deterioration of materials, construction/renovation, vacuuming, insulation.

A single causative agent (e.g., a contaminant) is seldom identified and complaints may be resolved when building operational problems and/or occupant activities identified by investigators are corrected. Increased absenteeism, reduced work efficiency, and deteriorating employee morale are the likely outcomes of SBS problems which are not quickly resolved.

A critical feature of such symptoms is their association with occupancy of the building. The summarized **symptoms** of SBS are as follows:

- Irritated, dry or watering eyes (sometimes described as itching, tiredness, smarting, redness, burning, and difficulty in wearing contact lenses).
- Irritated, runny or blocked nose (sometimes described as congestion, nose bleeds, itchy or stuffy nose). Dry or sore throat (sometimes described as irritation, oropharyngeal symptoms, upper airway irritation, difficulty swallowing).

- Dryness, itching or irritation of the skin, occasionally with rash (or specific clinical terms such as erythema, rosacea, urticaria, pruritus, xerodermia).
- Less specific symptoms such as headache, lethargy, irritability and poor concentration.
- Despite much investigation into SBS, it is now considered probable that it has multifactorial causes, with no single cause showing a clear association to the symptoms.

The knowledge on **potential causes** is as follows:

- Ventilation rate – in some cases symptoms have been reduced by increasing fresh air intake.
- Ventilation systems – air-conditioning is strongly associated with SBS but mechanical ventilation and humidification are not; the association may be due to poor air distribution, poor maintenance, or the creation of an environment conducive to growth of micro-organisms and dust mites.
- Airborne chemical pollution – many pollutants probably contribute.
- Micro-organisms and particulates – evidence is increasing that an important role is played by a mixture of organic and non-organic dust from poorly maintained air-conditioning systems and furnishings.
- Temperature – temperatures above 21°C have been shown to increase symptoms, but possibly only where humidity is low or under particular conditions of (low) air movement.
- Humidity – relative humidity below 30 % may be associated with symptoms.
- Lighting – certain symptoms may be promoted by poor lighting, the absence of windows, or flicker from fluorescent tubes operated at 50 Hz.
- Personal and organizational factors – symptoms are more frequent among women, workers in routine jobs, those with a history of allergy, workers at video display units, and those who perceive they have poor control over their indoor environment.

3.2.2.2 Building related illness

Building related illness (BRI) refers to a defined illness with a known causative agent resulting from exposure to the building air. While the causative agent can be chemical (e.g., formaldehyde), it is often biological. Typical sources of biological contaminants are humidification systems, cooling towers, drain pans or filters, other wet surfaces, or water damaged building material. Symptoms may be specific or may mimic symptoms commonly associated with the flu, including fever, chills, and cough. Serious lung and respiratory conditions can occur. Legionnaires' disease, hypersensitivity pneumonitis, and humidifier fever are common examples of BRI.

3.2.2.3 Multiple chemical sensitivity

It is generally recognized that some workers can be sensitive to particular agents at levels which do not have an observable affect in the general population. In addition, it is recognized that certain chemicals can be sensitizers in that exposure to the chemical at high levels can result in sensitivity to that chemical at much lower levels. Sometimes it is recognized as multiple chemical sensitivity.

3.3 OCCUPATIONAL HAZARDS

Occupational health hazards typically occur over a longer period of time and could result in occupational illness.

3.3.1 Physical occupational hazards

Physical hazards are measured through physics, and include noise, vibration, temperature extremes, defective illumination, hyperbaric and hypobaric atmospheres, and ionizing and non-ionizing radiation (ultraviolet, infrared, microwave, and laser radiations).

The physical agents usually produce tissue injury by imparting energy in a harmful form to the tissue. This energy may be great and applied to the whole surface of the body such as in the instance of increased air pressure. On the other hand the energy may be small but applied at the cellular level such as noise or at the intracellular as in the case of ionizing radiation.

3.3.1.1 Microclimatic conditions in workplace

Microclimatic comfort Appropriately controlling the temperature, humidity, and air distribution in work areas is an important part of providing a safe and healthy workplace. A work environment in which the temperature is not properly controlled can be uncomfortable. Extremes of either heat or cold can be more than uncomfortable – they can be dangerous.

Thermal comfort in the workplace is a function of a number of different factors. Temperature, humidity, air distribution, personal preference, and acclimatization are all determinants of comfort in the workplace.

3.3.1.1.1 Heat hazards

Heat disorders and health effects Heat stress can manifest itself in a number of ways depending on the level of stress. The most common types of heat stress are heat stroke, heat exhaustion, heat cramps, heat rash, transient heat fatigue, and chronic heat fatigue. These various types of heat stress can cause a number of undesirable bodily reactions including prickly heat, inadequate venous return to the heart, inadequate blood flow to vital body parts, circulatory shock, cramps, thirst, and fatigue.

Heat exhaustion is associated with physical exertion when vasomotor control and cardiac output are inadequate to meet the increased demand placed upon them by peripheral

vasodilatation. Heat exhaustion may include lassitude, dizziness, syncope, profuse sweating, and cool moist skin. There is usually no attendant hyperthermia.

Psychological reactions include mainly increased irritability, lassitude, increased anxiety, and inability to concentrate.

Operations involving high air temperatures, radiant heat sources, high humidity, direct physical contact with hot objects, or strenuous physical activities have a high potential for inducing heat stress in employees engaged in such operations. Such places include: iron and steel foundries, nonferrous foundries, brick-firing and ceramic plants, glass products facilities, rubber products factories, electrical utilities (particularly boiler rooms), bakeries, confectioneries, commercial kitchens, laundries, food canneries, chemical plants, mining sites, smelters, and steam tunnels.

Outdoor activities conducted in hot weather, such as construction, refining, asbestos abatement, and hazardous waste site activities, especially those that require workers to wear semipermeable or impermeable protective clothing, are also likely to cause heat stress among exposed workers.

Thermal stress control Ventilation, air cooling, fans, shielding, and insulation are the five major types of engineering controls used to reduce heat stress in hot work environments. Heat reduction can also be achieved by using power assists and tools that reduce the physical demands placed on a worker. However, for this approach to be successful, the metabolic effort required for the worker to operate these devises must be less than the effort required without them. It may be possible to reduce the effort necessary to operate power assists. The worker should be allowed to take frequent rest breaks in a cooler environment.

The human body can adapt to heat exposure to some extent. This physiological adaptation is called **acclimatization**. After a period of acclimatization, the same activity will produce fewer cardiovascular demands. The worker will sweat more efficiently (causing better evaporative cooling), and thus will more easily be able to maintain normal body temperatures.

3.3.1.1.2 Cold hazards

However, temperature extremes at the other end of the spectrum – cold – can also be hazardous. Employees who work outdoors in colder climates and employees who work indoors in such jobs as meatpacking are subjected to cold hazards. There are four factors that contribute to cold stress: cold temperature, high or cold wind, dampness, and cold water. These factors, alone or in combination, draw heat away from the body. The wind-chill factor increases the level of hazard posed by extremes of cold. Safety engineers need to understand this concept and how to make it part of their deliberations when developing strategies to prevent cold stress injuries. Other cold stress factors include age, disease, and overall physical condition. If the individual is physically active, cooling develops with fatigue and as exhaustion approaches, the vasoconstrictor mechanism is overpowered and sudden vasodilatation occurs with resultant rapid loss of heat.

3.3.1.1.3 Ventilation

Ventilation is one of the most important engineering control techniques. Ventilation can be used to either exhaust contaminants from a fixed source, or dilute contaminants from all sources within a space.

The purpose of industrial ventilation is essentially to (under control) recreate what occurs in natural ventilation.

Natural ventilation results from differences in pressure. Air moves from high-pressure areas to low pressure areas. This difference in pressure is the result of thermal conditions.

Ventilation is often used to maintain an adequate oxygen supply in an area. In most workplaces, this is not a problem because natural ventilation usually provides an adequate volume of oxygen; however, in some work environments (deep mining and thermal processes which use copious amounts of oxygen for combustion) the need for oxygen is the major reason for an installed ventilation system.

An **installed ventilation system** can remove odors from a given area. In performing this function, the noxious air may be replaced with fresh air, or odors may be masked with a chemical masking agent. One of the primary uses of installed ventilation is providing heating, cooling, and humidity control.

A ventilation system can remove undesirable contaminants at their source, before they enter the workplace air (e.g., from a chemical dipping or stripping tank). Obviously, this technique is an effective way to ensure that certain contaminants never enter the breathing zone of the worker – exactly the kind of function safety engineering is intended to accomplish.

An important concept regarding ventilation systems is the difference between exhaust and supply ventilation.

An **exhaust system** removes air and airborne contaminants from the workplace. Such a system may be designed to exhaust an entire work area, or it may be placed at the source to remove the contaminant prior to its release into the workplace air.

The **supply system** adds air to the work area, usually to dilute work area contaminants to lower the concentration of these contaminants.

Local exhaust ventilation (the most predominant method of controlling workplace air) is used to control air contaminants by trapping and removing them near the source. Local exhaust ventilation surrounds the point of emission with an enclosure, and attempts to capture and remove the emissions before they are released into the workers' breathing zone. The contaminated air is usually drawn through a system of ducting to a collector, where it is cleaned and delivered to the outside through the discharge end of the exhauster. A typical local exhaust system consists of a hood, ducting, an air-cleaning device, fan, and a stack.

3.3.1.2 Light and lighting

Visible light is the band of the electromagnetic spectrum which occupies the approximate wavelength range between 380 and 760 nm. It is capable of stimulating the photoreceptors of the eye producing a vision. Light can be produced by a variety of processes: thermo radiation, electrical discharges, chemiluminescence, photoluminescence and radiation emitted by high local electric fields.

Light is a natural phenomenon required to enable everyday activities to be carried out. It is essential for our basic existence. The role of light and lighting in the field of occupational hygiene has become progressively more important. Lighting plays an important role in health and safety, and lighting requirements are increasingly being included in legislation and standards, albeit that primary legislation tends to specify that lighting shall be “sufficient and suitable”.

The illuminance (lighting level) required depends upon such things as the visual performance necessary for the tasks involved and general comfort and amenity requirements. The eye has the faculty of adjusting itself to various conditions and to discriminating between detail and objects. This visual capacity takes time to adjust to changing conditions as, for example, when leaving a brightly lit workroom for a darkened passage. Sudden changes of illuminance and **excessive contrast** between bright and dark areas of a workplace should be avoided.

Glare causes discomfort or impairment of vision and is usually divided into three aspects, i.e. disability glare, discomfort glare, and reflected glare.

It is referred to as **disability glare** if it impairs the ability to see clearly without necessarily causing personal discomfort. The glare caused by the undipped headlamps of an approaching car is an example of this.

Discomfort glare causes visual discomfort without necessarily impairing the ability to see and may occur from unscreened windows in bright sunlight or when over-bright or unshaded lamps in the workplace are significantly brighter than the surfaces against which they are viewed, e.g. the ceiling or walls.

Reflected glare, which can be disability glare or discomfort glare, is the effect of light reflected from a shiny or polished non-matt surface. The visual effect may be reduction of contrast, or distortion, and can be both irritating and, in certain workplaces, dangerous.

Glare from **sunlight** coming through windows can be reduced by using exterior or interior blinds but this reduces the amount of natural lighting. It may be more effective to rearrange the workplace so that the windows are not in the normal direct field of view.

The most common cause of glare results from looking directly at unscreened **lamps** from normal viewing angles. Any form of diffuser or louvre fitted over the lamp, or a suitably placed reflector used as a screen will help to reduce the effect of glare from a lamp.

One of the most important aspects of light as an occupational hazard is the lack of sufficient lighting. Poor lighting increases the risk of injuries in the workplace, and increases eye strain in people who have to read or perform precision tasks in their work. Eye strain can lead to headaches and other psychosomatic symptoms. The lighting needed for fine tasks increases significantly with age, due to the natural deterioration of eyesight with age.

Proper placement of light sources in relation to the workplace can provide adequate light while reducing glare. Despite the potential dangers of exposure to high-intensity sources, most standards refer to the minimum light required in the workplace.

The workplaces can be illuminated naturally by daylight, or by artificial lighting, or by mixed lighting, i.e. simultaneous illumination by both of daylight and artificial lighting.

3.3.1.2.1 Daylight

Daylight, if properly arranged, may be a very effective source of good illumination in a room. The sources of daylight are sunlight and skylight. The amount of daylight reaching a room varies with the location and orientation of the building, with the presence of surrounding buildings, and with the time of day, season, weather, and degree of atmospheric pollution.

The corresponding interior illuminance due to daylight is significantly lower than outdoor one, with typically less than 10 % of the exterior illuminance filtering through to interiors. Furthermore, this figure is variable and is influenced, for example, by distance from windows.

The relationship connecting values of internal illuminance and external illuminance, both values being restricted to daylight as a source, is referred to as the **daylight factor** (DF), where:

$$\text{Daylight factor} = \frac{\text{daylight illuminance at point within a room}}{\text{simultaneous illuminance on a horizontal plane outside the building from a completely unobstructed sky (excluding sunlight)}} \times 100\%$$

The daylight factor is essentially a geometrical characteristic of an interior/window combination. Its value is not influenced by changes in external illuminance and, at any point in an interior; its numerical value is constant.

3.3.1.2.2 Artificial lighting

Most people prefer to work in daylight making the best possible use of natural light, though this may not always be the most energy efficient approach. However, for many working environments natural light is often insufficient for the whole working day, and in deeper spaces may not be adequate at any time. It therefore has to be supplemented or replaced by artificial lighting, usually electric lighting. The quality of the lighting installation can have a significant effect on health, productivity and the pleasantness of interior spaces in addition to its role in safety.

Artificial lighting systems used in commercial and industrial interiors can be divided into three major groups: general lighting, localized lighting and local lighting.

- General lighting installations aim to provide, as far as is practical, an approximately uniform illuminance over the whole of the working plane.
- Localized lighting is a system designed to provide the required illuminance on the work areas, together with a reduced level of illuminance in adjacent areas.
- Local lighting is lighting for a small area surrounding the task, typically provided by small fluorescent luminaires.

Stroboscopic effect The earlier type of tubular fluorescent lamp and discharge lamp were criticized because of the possibility of a stroboscopic effect. The light output from most lamps shows a cyclical variation with the alternating current, although in most circumstances this is not noticeable. However, it can cause a piece of rotating machinery to appear stationary or to be rotating slowly when, in fact, it is rotating at many times a second. This can be extremely dangerous. Where stroboscopic effects pose a particular danger they can be eliminated since it is possible to operate linear fluorescent and compact fluorescent lamps on electronic control gear at high frequency which both minimizes the cyclic variation of light output and changes its frequency so that it is no longer visible as flicker. Alternatively, in most industrial and many commercial buildings it is possible to connect successive luminaires to the three phases of the power supply, which eliminates most flicker and stroboscopic effects.

3.3.1.3 Radiation

Radiation is energy in transit that can be in the form of either electromagnetic waves or high speed particles. In broad terms, the electromagnetic spectrum can be divided into radiations with sufficient energy to ionize matter (ionizing) and radiations without sufficient energy to ionize (non-ionizing).

3.3.1.3.1 Ionizing radiation

In addition to background and medical sources of ionizing radiation, a small proportion of community is required to work with sources of ionizing radiation. Work-related doses vary depending on the work (radiologists in hospitals, dentists, uranium miners, students in research and education).

It is useful to further classify sources encountered within the workplace based on their form, because these forms influence the type of the hazard presented by the ionizing radiation. There are three forms of man-made ionising radiation:

- Irradiating apparatus refers to equipment that generates ionizing radiation, for example, X-ray machines, cyclotrons and neutron generators.
- Sealed sources and sealed source apparatus is any quantity of radioisotope whose physical form is so enclosed as to prevent the escape of any of the radioisotope (but not the radiation itself).

− Unsealed sources are usually in liquid or powder form and may readily escape into the environment if they are not carefully contained. They are most often used for scientific research.

External radiation hazard is the term used to identify radiation arising from sources outside the body, whereas the term **internal radiation hazard** is applied to sources of radiation deposited inside the body (e.g. when radioactive material is inhaled – inhaling contaminated air; ingested – taking radioactive material in through the mouth; injected – radioactive material entering the body via wounds or medical conditions such as eczema causing skin lesions; absorbed – through the intact skin by radioactive material penetrating through the intact skin).

Exposure standards that apply to external exposure to ionizing radiation are commonly known as **dose limits** based on international recommendations and are adopted into legislation by each state or territory. Dose limits are defined for radiation workers as well as for members of the public. A radiation worker is a person who is exposed to ionizing radiation as part of their work and the dose limits that apply to radiation workers are specifically for their work-related exposure, not for background or medical exposure to ionizing radiation. Background and medical exposure to ionizing radiation are not considered as part of the dose limitation for radiation workers or members of the public.

Dose limits for occupational exposure The occupational exposure of any worker should be controlled such that the following **external dose limits** are not exceeded:

− An effective dose of 100 mSv over five consecutive years;
− An effective dose of 50 mSv in any single year;
− An equivalent dose to the lens of the eye of 150 mSv in a year;
− An equivalent dose to the extremities (hands and feet) or to the skin of 500 mSv in a year.

For apprentices of 16 to 18 years of age who are training for employment involving exposure to radiation and for students of age 16 to 18 who are required to use sources in the course of their studies, the occupational exposure should be controlled such that the following limits are not exceeded:

− An effective dose of 6 mSv in a year;
− An equivalent dose to the lens of the eye of 50 mSv in a year;
− An equivalent dose to the skin of 150 mSv in a year;
− An equivalent dose to the extremities (hands and feet) of 150 mSv in a year.

Internal dose limits for ionizing radiation are defined as allowable limits of intake (ALI) separately for inhalation and ingestion.

The aim of any work with ionizing radiation should be to reduce the health hazards to a minimum. This should always be done in the planning stages of the work and should include minimizing both the internal and external radiation hazard.

Principles of control The following simple precautions should be adopted to reduce to minimum hazards from the use of radioactive materials:

1. Employ the smallest possible source of radiation.
2. Ensure the greatest distance between source and person.
3. Provide adequate shielding between source and person.
4. Reduce exposure time to a minimum.
5. Practice good personal hygiene where there is risk of absorption of radioactive material.
6. Personal sampling by use of film badge and/or thermal luminescent dose meter.

7. A dose of 15 mSv whole body in a year requires investigation of work exposure and control procedures. A cumulative dose of 75 mSv within five years requires further investigation of work, personal circumstances, dose history and advice regarding further exposure to ionizing radiations.

Basic terminology and definitions and biologic effects of ionizing radiation on humans see in Chapter Radiation and health hazards.

3.3.1.3.2 Non-ionizing radiation

At wavelengths at the extremities of the visible part of the electromagnetic spectrum, the radiation becomes progressively infrared (IR) at the longwavelength end and ultraviolet (UV) at the shortwavelength end. Both IR and UV radiation have been subdivided into three groups: A, B and C. The other components of the spectrum of non-ionizing electromagnetic waves are microwaves and laser radiation. The electromagnetic spectrum is shown in Figure 3.1.

Ultraviolet radiation (UV)

UV radiation is commonly divided into UV-A radiation (315 – 400 nm), UV-B radiation (280 – 315 nm), and UV-C radiation (100 – 280 nm). The sun is the major source of ultraviolet radiation although there are artificial sources such as electric arc lights, welding arcs, plasma jets, and special ultraviolet bulbs. The organs primarily affected by ultraviolet radiation are the **skin** and **eyes** since it has little ability to penetrate. Ultraviolet radiation is strongly absorbed by nucleic acids and proteins, and the effects in humans are largely chemical rather than thermal.

Long-term effects of ultraviolet exposure include an increased rate of aging of skin with degeneration of skin tissue and a decrease in elasticity. Late effects of ultraviolet radiation on the eye include the development of cataracts. The most serious chronic effect of ultraviolet exposure is skin cancer. Protection measures against ultraviolet radiation include administrative controls, equipment design, and personal protection. Personal protection includes the use of shields, goggles, and appropriate clothing, sunscreen cream or lotions.

Infrared radiation (IR)

Infrared radiation, of longer wavelength than visible light, is divided into IR A radiation (760 – 1,400 nm), IR B radiation (1,400 – 3,000 nm) and IR C radiation (3,000 – 3.10^6 nm). All objects above absolute zero radiate some infrared radiation. Objects of higher temperature

radiate to objects of lower temperature; the sensation of a hot stove results from this. Infrared radiation is the most important part of the spectrum for the production of **heat**. Infrared radiation causes dilation of the capillary bed of the **skin** and if strong enough can cause a burn. Infrared radiation can cause damage to the **eye** and is a cause of cataract development among glassblowers and others. In the eye, there is no warning and damage may be produced by amounts of energy which will not burn the skin. Mild exposure to infrared radiation can cause eye fatigue and headache.

Protection guides for IR exposure are designated primarily for protection against eye effects.

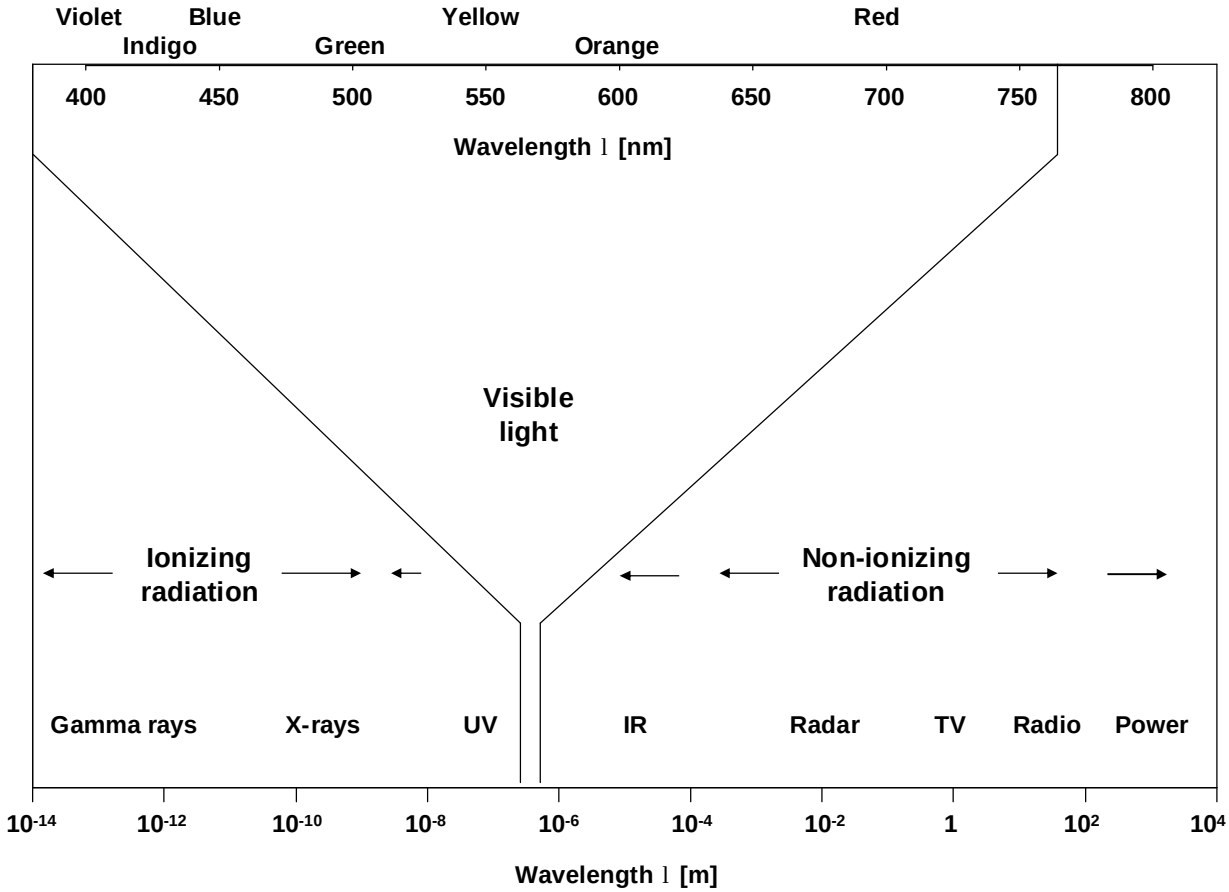

Figure 3.1 The electromagnetic spectrum (Source: Gardiner and Harrington, 2005)

Microwave radiation and electromagnetic fields

This is the electromagnetic radiation in the frequency range of 0 – 300 gigahertz (GHz). This radiation is emitted from a variety of electronic devices (heating devices, television receivers, and communications and radar units.

There are three frequency bands of radiation:

− Extremely low frequency (ELF) electromagnetic fields (EMFs) are in the 0 – 60 Hz frequency range;

− Low frequency electromagnetic fields are in the 60 Hz – 10 kHz frequency range;

− High frequency (radiofrequency and microwave (RF/MW) radiation) covers the 10 kHz – 300 GHz frequency band of the electromagnetic spectrum.

The military is a major user of RF/MW radiation for communications, radar, and electronic warfare. A multitude of industrial applications make use of the radiation's heating properties – for instance RF heaters and sealers are used to make products as diverse as loose-leaf plastic binders to car seats; other applications include laminating wood veneers. Microwaves are also used in hyperthermia for some medical treatment.

Microwave radiation is thought to be similar to infrared radiation, it causes localized heating of the skin (**thermal effects**), but penetration is deeper. Recently, however a number of other effects have been recorded. These apparent **non-thermal effects** due to the microwave radiation include changes in the cardiovascular, central and peripheral nervous system. It seems that some kind of cumulative effects can be produced. In the lens and in the eye repeated small doses may produce clinical effects.

The greatest need in the assessment of biological effects of microwave exposure is to determine the mechanism by which cell damage is produced, the biological tolerance of the most susceptible tissues, the cumulative effects of repeated small doses, and the safe levels of radiation intensity.

Laser radiation

Lasers emit a beam of **coherent** electromagnetic radiation of wave lengths in the range 0.3 – 10 micrometers, depending on the nature of material emitting the beam. Laser stands for *l*ight *a*mplification of *s*timulated *e*mission of *r*adiation. Lasers are used in industry, communications, surveying, construction, medicine, and electronics. There are many types of laser apparatus, but all are characterized by their ability to produce an intense, monochromatic, coherent beam in which all waves are parallel and all are in phase. There are three types of lasers: continuous, pulsed, and Q-switched, which are pulsed, but the beam is turned on and off at a rapid rate to produce a beam with higher peak power of shorter duration than the pulsed variety.

The main biological effects of laser radiation are due to **heating** of the tissues and are essentially local. There may also be non-thermal effects due to **photochemical reactions**. Non-thermal effects occur mainly with high power density, pulsed lasers. Burns may occur with exposure to lasers, either to the skin or to the eye.

The unprotected human **eye** is extremely sensitive to laser radiation and can be permanently damaged from direct or reflected beams. The site of ocular damage for any given laser depends on its output wavelength. Laser light in the visible and near infrared spectrum can cause damage to the retina, whereas wavelengths outside this region (that is, the ultraviolet and far infrared spectrums) are absorbed by the anterior segment of the eye, causing damage to the cornea and opacification of the lens. The extent of the damage is

determined by the laser irradiance, exposure duration, and beam size. As laser retinal burns may be painless and the damaging beam sometimes invisible, maximum care should be taken to provide protection for all persons in settings where a laser is in use. Threshold values have been proposed for a wide variety of laser equipment.

The other organ of concern, besides the eye, is the **skin**. Damage to the skin may range from a mild erythema to a surface charring and ultimately damage of deep parts. The organ of concern may also be the blood vessels or the underlying organs.

Laser radiation represents a specific workplace hazard to vision and requires an appropriate **eye protection**. If the eyes are not protected adequately when working with laser beams, severe damage can occur. The correct choice of lens density and color for goggles is based on the wavelength and power of the specific laser being used. Plastic goggles, for example, should not be worn by workers who might be exposed to direct laser beams or reflections. To ensure adequate protection, these workers should wear filter safety – glass goggles. In general, laser eye protection should be selected on the basis of how well it will protect against the maximum exposure anticipated. At the same time, the greatest amount of light possible should be allowed to enter the eye to ensure proper sight.

With the enormous expansion of laser use in medicine, industry, and research, every facility must formulate and adhere to specific safety policies that appropriately address eye and skin protection. Employers should undertake an adequate risk assessment and seek competent advice from a specialist who is familiar with the specific business. Risk assessment and accident prevention measures should take into account the individual workers' differences and the various jobs that are specific to the business in order to prevent vision injuries.

3.3.1.4 Noise

High noise levels in the workplace are a hazard to employees, are a physical stress that may produce psychological effects by annoying, startling, or disrupting the worker's concentration, which can lead to accidents. High levels can also result in damage to workers' hearing, resulting in hearing loss.

Advanced mechanization and other technological changes have created excessive noise conditions in different working and other conditions. While much is known about the adverse effects of noise on man, more information is still required before specifications for tolerable noise. Conditions can be made on a valid basis, especially in regard to combination with other physical, chemical and psychosocial factors.

3.3.1.4.1 Basic aspects of sound and noise

From the physiological aspect **sound** is defined as a mechanical wave motion transmitted through an elastic material medium such as air with a frequency in the range 16 – 20,000 Hz (audible to human ear). Mechanical wave motion below the frequency of audible sound waves is infrasound; above this frequency range is ultrasonics.

Noise means any unwanted, unpleasant or bothersome, annoyed or harmful sound.

To quantify sound exposure basic physical units are used:

- Acoustic (sound) pressure p [Pa].
- Acoustic velocity c [$m.s^{-1}$]; it is the speed at which the regions of sound producing pressure changes move away from the sound source.
- Frequency f [Hz]; Hertz is the name of international unit for the number of repetitions of similar exposure variations per second of time; this unit of frequency was previously called "cycles per second" (cps or c/s).
- Sound intensity I [$W.m^{-2}$]; it is the average rate at which sound energy is transmitted through a unit area normal to the direction of sound propagation.
- Sound pressure level (SPL) is often used in practice. It is a common logarithm of the ratio of the pressure of a sound wave relative to a reference sound pressure ($p_0 = 2.10^{-5}$ Pa). This relation is expressed on a decibel scale and defined by the formula:

$$SPL = 10\log\left(\frac{p}{p_0}\right)^2 \text{ [dB]}$$

The decibel [dB] is the common unit of measurement of sound pressure levels. The scale is logarithmic, so that an increase of 10 dB means a 10-fold increase in sound intensity, a 20 dB raise a 100-fold increase, and a 30 dB raise a 1,000-fold increase, etc.

The internationally adopted A-weighting is most commonly used, as it best corresponds to the response of the human ear. Sound pressure levels measured with the A-weighting filter are denoted as dB(A).

The equivalent sound level (L_{Aeq}) is defined as the level of noise that has the same average energy as the noise that is measured during a work day.

3.3.1.4.2 Effects of noise on man

The harmful effect of noise on human body was a relatively long time underestimated, mainly due to human health endangering not as directly as the other harmful substances in the workplace or in the environment. The effects of noise on man depend on:

1. **Noise character** – the most harmful effect has an impulsive noise, follows a continuous noise and/or fluctuating noise and the less harmful effect has an intermittent noise (because of not permanent effect to inner ear).

2. **Noise level** (according to Lehman's noise classification):

- Relative noise (up to 65 dB/A) – influences primarily mental functions.
- Absolute noise (over 65 dB/A):
  - The vegetative effects of noise – influences especially vegetative nervous system (in the range of 65 – 90 dB/A);
  - The hearing effects of noise – affects inner ear and hearing (in the range of 90 – 120 dB/A);

- The central nervous system effects of noise – in the range above 120 dB/A it can cause mechanical destruction of the inner ear, pain, and it can affect central nervous system (unconsciousness, dizziness, coma, etc.).

3. **Noise frequency** – the less harmful effects have the low-frequency noise (up to 50 Hz), the higher the noise frequency the higher its harmful effects.

4. **Noise duration** – noise has a cumulative effect, the longer the duration of exposure, the more frequent and the more harmful effects.

5. **Individual body susceptibility** varies among individuals and different people who are exposed to exactly the same noise for exactly the same period of time may suffer different degrees of hearing loss. Some people can tolerate high-intensity noise for a lifetime and not suffer any noticeable degree of hearing loss while other people may acquire a substantial hearing loss from exposure to much less intense noise. It depends on the type of higher nervous activity, genetic factors, age, sex, health status, life-style, etc.

The effects of noise on man could be auditory and/or extraauditory (whole-body):

Auditory effects of noise

The auditory effects of noise depend on wide variety of factors but they are mainly related to the duration, intensity, frequency of exposure, noise level, and susceptibility of the individual.

An important fact is that noise induced hearing loss is of neural type involving irreversible injury to the inner ear. Sensorineural cells of the organ of Corti are of neuroectodermal origin and their defects can be healed with reparatory compensation only by inferior tissue. Because of a terminal blood supply to cochlea, anatomical and functional impairments of microcirculation result in irreversible hair cells impairment.

Acute acoustic trauma is considered to be the result of the immediate noise effect. It normally results from high intensity explosive- or loud impact type impulsive noise, which can destroy the hair cells and other ear mechanisms after one or relatively few exposures. The lesion of the middle ear (eardrum perforation, middle ear bones dislocation, stapedius luxation), and mainly of the inner ear (reticular membrane rupture, break away of the organ of Corti from basilar membrane, which results in impairment of cochlea microhomeostasis with necrosis) occurs. These changes are permanent and result in **permanent hearing loss.**

Long-term effects of noise are more frequent. Temporary or permanent threshold shift may be due long-term exposure duration of higher noise levels at the workplace.

The first effect noticed when an ear is exposed to sounds above certain intensity and for a certain time is a reduction in the ear's sensitivity (elevated hearing threshold). This reduction in hearing is greatest immediately after the exposure and decreases gradually after the exposure has ended. If the noise has not been too loud or the exposure too long, hearing gradually return to its original level. This kind of hearing loss is known as **temporary**

threshold shift (TTS). This is caused by the hair cells in the hearing organ (cochlea) becoming reversibly desensitized.

If the noise is more intense than a certain value and/or the exposure time longer than a certain time, the resulting hearing threshold never returns to its original value and a **permanent threshold shift** (PTS) has occurred. PTS is the stable threshold shift that is experienced after recovery from TTS.

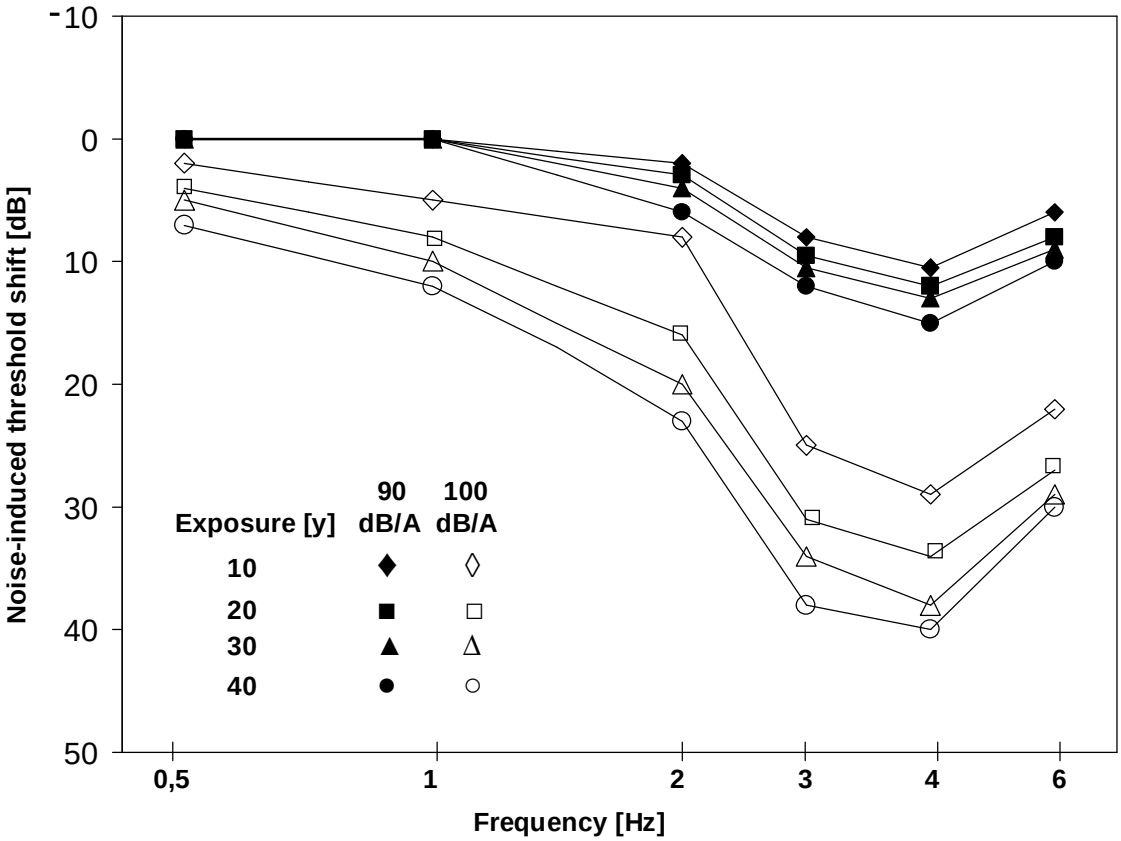

Figure 3.2 Median estimated noise-induced permanent threshold shift as a function of frequency for two exposure levels (90 dB/A and 100 dB/A) and four duration of exposure (10, 20, 30, and 40 years) (Source: Wallace, 2008)

The **noise-induced hearing loss** (NIHL) results from long-term regular exposure to loud noise, particularly higher pitched noises, and tend to reach a maximum level in the frequency range around 4 kHz after about 10 years of exposure (Figure 3.2). Impairment progresses in an irregular manner towards severe deafness, associated with very high levels of mean hearing loss. When the exposure time to noise is increased, or the level of the noise is increased, the magnitude of the hearing loss increases and the frequency range of the hearing loss widens. NIHL is not reversible as it arises from the destruction of the hair cells in the cochlea. The human ear does not have the ability to regrow hair cells and there is no medical treatment.

It is invariably found that the hearing threshold declines with age, more rapidly at higher frequencies, and more severely in men than in women. This decline known as **presbycusis**,

whether or not it is due to physiological aging or to wear and tear on the auditory system by the intensive noise and sounds of everyday living is an open question.

Non-auditory (non-specific) effects of noise

These effects arise as a stimulation of vegetative nervous system, reticular formation, cortical and subcortical brain centers. Noise acts as a stressor activating the mechanisms of stress reaction of the body. The most important are the reactions of cardiovascular system (changes in blood pressure, increasing of vascular peripheral resistance, changes in heart rate and some electrocardiographic anomalies), respiratory rate, gastrointestinal motility, and galvanic skin responses. Changes in the blood and other body fluids have also been reported (e.g. eosinophilia, hyperglycemia, hypoglycemia), as well as the effects on the endocrine system. Vegetative responses occur at low noise levels (35 – 70 dB) too, and they are independent on the subjective noise response.

Psycho-physiological effects of noise

At this level, noise mainly affects sleep and work performance. Noise may lead to sleep disturbance or awaking. Such responses show wide individual variation; some people are awakened by sounds of 40 dB/A, while others are roused only by sounds over 70 dB/A.

Noise may affect also the psychosomatic tasks performance. Depending on its intensity, duration, frequency, distribution, intermittence and significance, noise has been shown both to improve and to reduce work performance and both increase and decrease of reaction times. Work demanding to high degree of skill is particularly affected by noise.

Perhaps the most general reaction to noise is that of **annoyance**. Precisely what involves "annoyance" in response to noise is problematical. The annoyance is usually taken to include feelings of "bother", interference with activities, and minor psychosomatic symptoms such as headaches, tiredness, and irritability.

However annoyance is defined, there are wide inter-individual differences as to what constitutes an annoying sound because of the many non-acoustical considerations that enter into such judgments. There are some basic characteristics of sounds more annoying than the others. They include:

- Loudness – the more intense and consequently louder noises are considered more annoying;
- Pitch – a high pitch noise, i.e. one containing predominantly frequencies above 1,500 Hz, is more annoying than a low pitch noise of equal loudness;
- Intermittency and irregularity – a sound that occurs randomly or varies in intensity or frequency is believed to be more annoying than continuous and unchanging one;
- Localization – a sound which repeatedly tends to change in localization is less preferred than one which remains stationary;

− Inappropriateness to one's activity – an example is the difference in attitude to music when awake and when trying to sleep.

The effects of noise can be more harmful when the other negative factors at the workplace, such as higher temperature, humidity, vibrations and taking of ototoxic drugs occur.

3.3.1.4.3 Hearing conservation programs

Hearing conservation programs are based on understanding of the effect of noise on the ear, measurement of noise levels in the workplace and personal measurements (using dosimeters), and measurement of hearing (audiometry). Knowledge about noise standards and promotion of noise reduction at the source and promotion of personal protections (ear protectors) are also important factors in reducing the risk of acquiring NIHL as well as the employee training to acquaint employees with the hazards of noise exposure and the benefits of a hearing conservation program.

To reduce the risk of NIHL, recommendations of acceptable noise levels have been established and appear in the form of noise standards. The maximal permissible noise level and duration accepted in most industrial countries is **85 dB(A) for 8 hours a day, 5 days a week.**

The **limit levels** and **action levels** are given for hearing protection of employees. The highest permissible limit is 87 dB; this limit must not be exceeded in a workplace at all. The action levels are the sound level which when reached or exceeded necessitates implementation of activities to reduce the risk of NIHL. There are the higher action level (85 dB) and the lower action level (80 dB).

Main two types of **personal protection** are in common use: earmuffs, which are attached to a helmet or worn on a headband, and earplugs. Earmuffs can be removed more easily than earplugs and are therefore better suited for intermittent use as in situations when people are walking in and out of noisy areas (such as airports). On the other hand, earplugs are more practical for people who spend long periods of time in noisy environments.

Sounds that are not audible to humans because their frequencies are above or below our audible frequency range are known as **ultrasound** and **infrasound**, respectively. There is no evidence to indicate that exposure to sounds that are not audible can damage the ear, and there is little evidence that such sounds could have other untoward effects.

3.3.1.4.4 Effects of ultrasonic stimulation

Sounds whose frequencies are above the upper frequency limit are called ultrasonic. Ordinarily, ultrasonic sounds are defined as being in excess of 20,000 Hz.

Ultrasounds are rapidly attenuated when transmitted in air and, therefore, decrease rapidly in intensity with distance from the source. One of the best known effects of airborne

ultrasonic radiation is the production of heat on the body's surface. High intensity ultrasonic stimulation focused on specific areas of the human body will cause localized tissues and cellular damage which is attributed to the heating effect. This type of stimulation has been useful in experiments aimed at identifying the functions of various tissue and cells through selective destruction techniques. It also has implications for the removal of tumors that might not be otherwise reached with usual surgical procedures.

With the exception of experimental applications, present uses for ultrasound are believed to pose only a slight risk to the exposed individual. Future applications, however, may require higher intensity sources which can pose a more serious hazard to the operator, particularly if he has contact with the source or if the medium of ultrasonic transmission to the operator is other than air – for example, liquid or solid.

3.3.1.4.5 Infrasound effects

Exposure to low-frequency sounds (infrasound – in the frequency range of 1 – 16 Hz) of high intensity has been reported to cause various diffuse symptoms such as headache, nausea, and fatigue. The results of some experiments indicate that infrasound may give rise to a decrease in blood pressure, possibly mediated through stimulation of the vestibular part of the inner ear.

3.3.1.5 Vibration

Vibration is often closely associated with noise, but is frequently overlooked as a potential occupational health hazard. Vibration is defined as the oscillatory motion of a system around an equilibrium position. The system can be in a solid, liquid, or gaseous state, and the oscillation of the system can be periodic or random, steady state or transient, continuous or intermittent. Vibrations of the human body (or parts of the human body) are not only annoying; they also affect worker performance, sometimes causing blurred vision and loss of motor control. Excessive vibration can cause trauma when external vibrating forces accelerate some part or all of the body so that amplitudes and restraining capacities by tissues are exceeded. In the context of occupational medicine, mechanical vibration may affect humans at work through the mediation of anatomic structures and sensory receptors other than the organ of hearing mechanical spectrum.

Vibration originates from mechanical motion, generally occurring at some machine or series of machines. This mechanical vibration can be transmitted directly to the body or body part or it may be transmitted through solid objects to a worker located at some distance away from the actual vibration. Prolonged exposure to vibration causes health effects, disorders and/or disease. The risk of contracting any of these depends on the characteristics of the vibration, the part(s) of the body exposed and the duration of exposure.

The vibratory range of particular interest to man is 1 to 400 Hz, although it must be mentioned that the skin can detect vibrations in excess of 1,500 Hz in frequency.

Besides frequency, other features of vibration are displacement, velocity, and acceleration. Displacement refers to the distance between the normal resting position of an object and its position at a given time in its vibratory cycle. The maximum displacement of the object from its normal resting position is called the amplitude of vibration. The rate at which the velocity of the vibratory motion changes in direction and magnitude defines the acceleration of the motion. Acceleration has been the measure most frequently used to describe the magnitude of vibratory motion.

There are two types of vibration: whole-body vibration (affects, e.g., vehicle operators) and segmental vibration (occurs, e.g., in mining, stonecutting, and a variety of assembly operations).

Whole body vibration: If the vibration frequency is below 3 Hz, the whole body moves as a unit and the adverse effects experienced are of the type associated with motion sickness.

Subjective responses to this vibration include perception of motion, feeling of discomfort, apprehension, and pain. Changes in respiration, heart activity and peripheral circulation have been found but appear to be of a transient nature.

More is known about the results of **segmental vibration** affecting a part of the body or an organ (typically transmitted through hand to arm). The best known of the injurious effects of vibration, is associated with the use of hand-held power tools. Vibrations caused by these types of tools are usually found in the higher frequencies, such as 40–300 Hz. In this range vibrations may have ill effects on the blood vessels and nerve endings and blood circulation in the hands. The use of pneumatic picks, hammers, and drills has been found to lead to a condition called "dead hand" or "white fingers" or **Raynaud's syndrome**. After some months or years of exposure, the fine blood vessels of the fingers become increasingly sensitive to spasm especially after exposure to the cold or to vibration. Initially the whitening (blanching) of the fingers is localized to the tips of the fingers most exposed to the vibrating source, but with continued exposure it spreads to involve all fingers and the tips of the thumbs.

Exposure to vibration may also produce injuries of the joints and muscles in wrists and/or elbows and shoulders. Segmental vibration can also result in the loss of the sense of touch in the affected area. Some evidence suggests that decalcification of the bones in the hand can result from vibration transmitted to that part of the body. Muscle atrophy has also been identified as a result of segmental vibration. The symptoms and effects of segmental vibrations are aggravated when the hands are exposed to cold and/or the operator is a smoker.

Because the body acts as a mechanical system, it is subject to **resonance** in its various parts at various frequencies. When vibration occurs at or near any of these resonant frequencies the effect is greatly increased. The smaller the body member, the faster it can move and vibrate and so the higher the resonant frequency will be. For example, the head and shoulders resonate at a frequency of about 5 to 25 Hz, and the eyeball resonates in the range of about 30 to 80 Hz.

Standards for vibration in the workplace are expressed in terms of acceleration ($m.s^{-2}$) and duration of exposure and take into account the frequency of the vibration. There are limit levels and action levels for both whole body vibrations and segmental vibrations.

3.3.1.6 Abnormal air pressure

Abnormal air pressure may be considered to be any pressure either above or below normal sea level pressure (101.32 kPa). People are accustomed to small variations of atmospheric pressure. Decrease of pressure within the normal bounds may cause some unpleasant feelings. Extreme pressures in both directions (it means too high or too low) matters from the medical point of view, because they cause changes in partial pressures of gases in atmospheric as well as in alveolar air and influence their absorption by lungs and their solubility in blood and body fluids.

3.3.1.6.1 Low air pressure

When referring to the symptom complex developing as a result of exposure to high altitudes, dysbarism is the preferred term. The consequences of dysbarism result from the expansion of the gases within the body cavities and from the formation of the nitrogen bubbles in body tissues and fluids from gas which is normally in solution at sea level pressure. Upon traveling to high altitudes, the resultant reduction in barometric pressure allows the gases within the body to expand to a greater volume than occupied at sea level.

Low pressure is experienced by airplane pilots and travelers and by mountaineers. The barometric pressure sinks by about 10 mmHg that is 1.33 kPa for each 100 meters upwards. **Mountain sickness (high altitude sickness)** may occur at the height of 3,000 meters or less. It evokes lassitude, sleepiness, headache, nausea, bleeding from nose and ears, cold and cyanotic extremities and weak pulse. Dizziness and a shortness of breath are caused by the muscular exertion. Higher, the symptoms become aggravated and 4,500 meters is considered to be the greatest height at which it is safe to fly or to climb without facilities for the artificial administration of oxygen. At the less extreme heights, acclimatization takes place after a time. This results mainly in increased number of red blood cells and in hemoglobin amount and possibly also in increased oxygen-carrying capacity of hemoglobin. The prevention is aimed at rising the sturdiness and efficiency of organisms, the gradual acclimatization and technical equipment (oxygen apparatus, pressurized cabins of aircraft etc.).

3.3.1.6.2 High air pressure

It is experienced mainly by divers and those working in caissons or in deep mines. The pressure of the air increases by one atmosphere, that is 101.32 kPa for each 10 meters of descend in water. Symptoms such as headache, dizziness, pain in the ears accompanied by slowing of the pulse, dyspnoea, chest pain and sever cough occur when the pressure is increased.

Divers and caisson workers may suffer from pain in the joints if they return to the surface too quickly after working in deep water or under elevated air pressure. In these conditions, air contained in the body tissues, which was dissolved under high pressure, is released to form air bubbles (mostly nitrogen gas) in the joints and elsewhere to produce unpleasant symptoms. The **bends** is the name of the illness resulting. Mild cases affect the elbows, shoulders, ankles and knees. As the illness develops, the pain increases in intensity and the affected joint becomes swollen. Serious cases of the bends may affect the brain and/or the spinal cord. In cases of brain damage the patient may suffer visual problems, headaches, loss of balance, speech disturbances, deafness, nausea, vomiting and unconsciousness. Spinal cord damage may cause paralysis of the limbs, loss of sensation, pins and needles and pain in the shoulders and/or hips. The problem is obviated by reducing the rate of change of pressure to which the workers are subjected to a level at which the bubbles of gas do not form.

The treatment of compressed air illness or caisson disease is recompression, which leads to the solution of the nitrogen bubbles, followed by a slow decompression. The prevention resides in physiological decompression according to the decompression tables. The time to be devoted to decompression depends on the attained depth and on the time spent by the workers in depth. Important is also the selection of workers for the work in caissons. Healthy and sturdy men are demanded. Obese and hypertonic persons and those with vasoneurosis and ear-diseases are recommended not to work under these conditions.

3.3.1.7 Physical workload and mechanical hazards

Mechanical hazards or biomechanical hazards are the most commonly encountered hazardous exposure in most workplaces, and include sustained or repetitive exertion that exceeds the individual's capacity to recover. Force, frequency, and posture contribute to the workload and determine the frequency of adverse musculoskeletal outcomes.

Musculoskeletal disorders, in particular those affecting the back, neck and shoulders, are a major source of disability in many countries.

The pre-employment physical examination should include physical assessment and strength testing. If the results of these tests indicate that the employee is incapable of performing lifting operations required for his or her job classification, then he or she should not be hired for the job. Training involves recognition of the dangers of manual lifting, how to avoid unnecessary stress, and assessment of what a person can handle safely. Companies that provide back safety training report a significant decrease in back injuries. The best back injury prevention safety training includes training designed to help employees understand how to lift, bend, reach, stand, walk, and sit safely.

Engineering controls used to minimize lifting injuries include container design, handle and handhold designs, and floor-worker interface. Container design, obviously, would be employed in companies where lifting is a standard work activity – where standard items are manually lifted each workday on a continuous basis. From the manufacturing point of view, designing a container for manufactured product that is user-friendly and back-friendly is also

a goal. Designing containers that will protect products from damage during shipping and handling operations is important, and so is designing containers that protect handlers and customers from being injured by the products.

The actual weight of the load is only part of the potential risk. Traditional guidelines on acceptable weights have not taken into account all the other factors involved. These include whether the load is bulky or unwieldy; too big to allow a suitable grip or good vision; or unstable with an eccentric centre of gravity. All these factors will increase the risk to the handler.

Along with container design, environmental working conditions such as lighting, color, and labeling should be considered. Material handling system alternatives should also be looked at.

It can be determined two limits to assess safe lifting practice: an **acceptable lift** (sometimes called the action level) and a **maximum permissible lift** (MPL). After these two limits have been determined, the job can be classified into one of three risk categories:

1. **Acceptable**: If the weight of the lifted object is less than the action level, the job is considered acceptable (i.e., most of the workers in the workforce could perform the job with only a minimal risk of injury).

2. **Administrative controls required**: If the weight of the objects falls between the action level and the MPL, the job is assigned to this category, implying that some individuals in the workforce would have difficulty in performing the job. Because of their limited strength and increased risk of injury, action should be taken to protect these individuals.

3. **Hazardous**: If the lifted object weight more than the MPL, the job is considered hazardous. The only acceptable approach to resolving this situation is redesigning the job to eliminate or reduce lifting stresses.

Cumulative trauma disorders (CTDs) are injuries of the musculoskeletal and nervous systems that may be caused by repetitive tasks, forceful exertions, vibrations, mechanical compression (pressing against hard surfaces), or sustained or awkward positions. CTDs are also called repetitive motion disorders (RMDs); overuse syndromes, regional musculoskeletal disorders, repetitive motion injuries, or repetitive strain injuries.

These painful and sometimes crippling disorders develop gradually over periods of weeks, months, or years. Symptoms of CTDs may involve the back, shoulders, elbows, wrists, or fingers.

3.3.1.7.1 Worksite ergonomics

Considering the effects of ergonomic problems in today's workplace (e.g., reduction in work quality and productivity, increase in worker fatigue, poor work performance, increase in workers' compensation claims, etc.), the first and most obvious step in devising an organizational ergonomics program is to conduct a worksite hazard analysis to identify all hazards.

Once the worksite has been thoroughly surveyed and the hazards identified, hazard prevention and control measures need to be put in place. As with all hazards, the safety engineer either attempts to eliminate the hazard or to engineer it out. When this is not possible, other prevention and control measures must be adopted.

Ergonomics discovers and applies information about human behavior, abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, jobs, and environments for productive, safe, comfortable, and effective human use. Simply put, ergonomics considers the total physiological and psychological demand of a worker's job, rather than just productivity, safety, and health. Therefore the goal of ergonomics is to protect the worker, to minimize worker error, and to maximize worker efficiency – while providing a bit of comfort to the worker while he or she performs job tasks. An important ergonomic principle to remember (whether dealing with lower back disorders or any other environmental/workplace problem) is that equipment, technical systems, and tasks have to be designed in such a way that they are suited to every user.

To aid in reducing ergonomically related hazards in the workplace, employee participation is critical. Employee participation is normally increased whenever employees are properly trained on both program requirements and on those elements that make up the program. As with almost all safety and health provisions, training is an essential, required ingredient. Employees need to be aware of the organization's efforts, not only to reduce, eliminate, evaluate, and control ergonomic hazards, but also to be aware of the types of workplace situations and practices that lead to ergonomic problems.

3.3.1.8 The use of display screen equipment

Display screen equipment (DSE) is the term used to describe the electronic display equipment that forms part of a computer system. The regulations refer to workstations and users throughout. A workstation includes the desk, chair, DSE and the general space surrounding this assembly including the lighting. The scope of these regulations has been clearly defined and applies to any alphanumeric or graphic display screen regardless of the particular display process. The definition extends beyond the typical office visual display unit (VDU) and covers microfiche, lighted crystal displays and process equipment. The workstation also falls within the regulations. The definition includes an assembly of DSE with or without keyboard or software, and any accessories to the equipment such as telephone, printer, document holder, work chair, work desk or work surface. It also includes the immediate workplace environment.

The term "user" is applied to anyone for whom the use of DSE forms a significant part of his or her normal work. This has sometimes been difficult to interpret but it seems sensible to define a user as anyone to whom the following criteria apply:

- Employers must organize working practices so that work on DSE is regularly interrupted by breaks or other activities. It is becoming increasingly clear that, even with the

ergonomically best possible workplace, health problems may arise if workers undertake long periods of work within a 24-hour period and do not take regular breaks.

- Employers must ensure that new employees are given the right to have an appropriate eye and eyesight test before commencing work.
- Employers must ensure that current users are given the right to have an appropriate eye and eyesight test on request. Tests must be offered at regular intervals after starting work, and where user experiences eye problems which it is reasonable to conclude are caused by working with DSE.
- Employers must provide users with special corrective apparatus, i.e. spectacles suitable for the work being done, if their normal corrective appliances cannot be used and tests show that such provision is necessary.
- Employers must ensure that adequate health and safety training is given to an intended user before use of the workstation has commenced and to all users whenever the arrangements, including software, at their workstation are substantially modified.
- Employers must ensure that every user is given complete and comprehensible information about what has been done to meet the requirements of the regulations, about the entitlements to eye and eyesight testing, and training arrangements.

3.3.1.8.1 Some requirements for DSE worksite

Equipment should be provided to enable the operator to adjust to the **optimum working position**.

The **work surface** should be large enough to allow the comfortable arrangement of all equipment, and it should also be of a suitable height for DSE work with sufficient leg room. The use of a foot rest should be considered for short users.

Keyboard The correct height of a keyboard allows the operator's upper and lower arms to be at a 90-degree angle. If this angle is more than 15 % either way, one study estimates that as much as a 50 % loss of productivity may occur. The incorrect height can cause pain in the shoulders, back, arms, and wrists.

The keyboard should be positioned directly in front of the operator. Putting the keyboard to either side of the operator causes twisting of the upper body, this causes fatigue and pain of the neck, shoulders, and back.

Wrist rest The use of a wrist rest is imperative. The purpose of a wrist rest is to support the hands, wrists, arms, shoulders, and upper back. Without a wrist rest, employees may complain of pain and tension to parts of the body as mentioned. To increase productivity while enhancing the posture of employees, a wrist rest should be used.

Visual Display Terminal (VDT) The correct **height** of the VDT screen is very important. The top of the screen should be at eye level. If the screen is lower than the recommended height, the operator is forced to look downward, which causes fatigue, stress, and aches of the

neck, back, etc. Raising the height of the VDT terminal can be accomplished by placing unused books, files, etc., under the screen. Raising the screen allows the operator to sit with correct body posture.

Position The VDT should be directly in front of the operator. The document and keyboard should also be directly in front of the operator. This positioning eliminates considerably undue turning and twisting, which reduces fatigue, stress, strains, and pain of the eyes, neck, shoulders, back, and arms.

Distance The correct viewing distance should be 45 to 60 cm from the worker's face. Any operator who is closer or farther than the recommended distance could experience headaches, fatigue, and stress, and place undue stain on the eyes.

Brightness The VDT should have a brightness control knob. If reflective glare is on the screen, the brightness control can help relieve, reduce, or possibly eliminate the glare.

Chair The most important component of computer and desk set-up equipment is the chair. In many instances, several employees operate the same terminal. In light of this, the pneumatic-type chair is recommended because of its adjustability for height and it should have a base of five feet on rollers. The backrest should fit comfortably at the lower back (lumbar) to provide good back support. The backrest must be easily adjustable. The hardness of the seat and the absence or the presence of arms´ support is the sort of variables which it is worth considering.

Armrests were designed to support the arms, shoulders, and upper back. At first, most employees do not prefer arm rests. The usage of the footrest should reduce or eliminate aches and pains of the legs and feet and increase productivity.

The **document** should not be to the side lying flat on the desk. This position causes operators to consistently turn their head and refocus their eyes, which places undue stress on the eyes, neck, shoulders, and upper back. Headaches are a common result. To eliminate these symptoms, place the document to the side of the screen at the same height as the VDT. The purchase of a document holder is highly recommended.

DSE worksite environment Background noise should be kept to a minimum. Heating and ventilation should be kept at a suitable level. Lighting can enhance or hinder an employee's work environment. There are many concerns pertaining to this subject, such as type of lighting, location of lighting, and location of VDT. Computer environments are different from the standard office environment – the lighting and arrangements of the VDT terminal must be controlled to eliminate reflective glare. General light levels should be 300–500 lx. In some cases where lower level general lighting is preferred, individual desk lights may be appropriate.

Workstations should be sited at right angles to windows and where necessary natural light should be controlled by blinds or curtains. The intensity of work at the screen as well as its timing can be significant in the development of health problems. It is essential that managers

control levels of screen work. A ten-minute break away from the screen every hour or a fifteen-minute break every two hours has been recommended.

3.3.1.8.2 Health effects

Effects on the eyes Using DSE does not damage the eyes or the eyesight, nor does it cause deterioration in existing eye conditions. However, pre-existing eyesight defects may be highlighted by the intense visual effort that such work entails. Frequent changes in the required focal length for the visual task (from document holder to screen to keyboard) may show up more sluggish eyesight accommodation in older operators, resulting in symptoms of eye fatigue such as sore eyes and headaches. Similarly, eyesight correction may be required to read the screen, which is at a different distance from the normal reading position. Eye fatigue may also result from poor positioning or glare. The requirement for eye and eyesight tests within the regulations addresses these issues.

Glare is undoubtedly a nuisance and troublesome factor to the operator. The majority of VDT screens will have some type of nuisance glare. When glare appears on the CRT, the operator should adjust their eyes and reposition him- or herself to reduce or eliminate the glare. Constantly eyes refocusing and body repositioning to avoid glare causes stress, fatigue, and aches of the head, eyes, neck, shoulders, back, and arms.

Fatigue and stress The relationship between the operator and the display screen is often more intense than that experienced in typewriting. The speed of operation and the lack of natural breaks (such as changing the paper) may be influential here. In many operations there is less operator control of speed of response – the machine may seem to be working the operator. Systems of work should ensure that relaxation periods are inevitable.

Determining the average workload is important. A heavy workload could cause fatigue, stress, and possible cumulative trauma disorders of the wrist and fingers. Breaks are essential to employees to reduce or eliminate cumulative trauma disorders, fatigue, and stress. If the workload is heavy, it is recommend a fifteen-minute break every hour.

Radiation There is a continually expressed anxiety that display screens emit damaging ionizing and non-ionizing radiation. Exhaustive tests have shown that emission levels are well below national and international safe limits and there is no risk.

Work-related upper limb disorder There is no doubt that work with DSE can cause upper limb symptoms. Attempts have been made to group symptoms under various titles such as repetitive strain injury (RSI) and work-related upper limb disorder (WRULD).

Sitting in a fixed and often unsuitable position for long periods, undertaking repetitive finger, hand or wrist movements, particularly if there are time or other pressures to finish the work, can result in pain and stiffness in the neck, shoulders and arms. Generally, these symptoms disappear with rest, but in certain cases, where symptoms are ignored and pain is “worked through”, more disabling and long-term symptoms may develop and be labeled as some form of WRULD.

It will be clear that the term WRULD includes a number of conditions, some of which such as tenosynovitis and carpal tunnel syndrome can be diagnosed by objective tests; others may be less amenable to objective evaluation and can be diagnosed on symptomatology alone.

Training of operators in the early identification of symptoms is essential. This can result in early intervention both in terms of treatment and correction of unsatisfactory work practices and conditions. The use of DSE increases daily in the workplace, thereby potentially putting more employees at risk. Consideration of risk factors at the planning and development stage can avoid long-term problems.

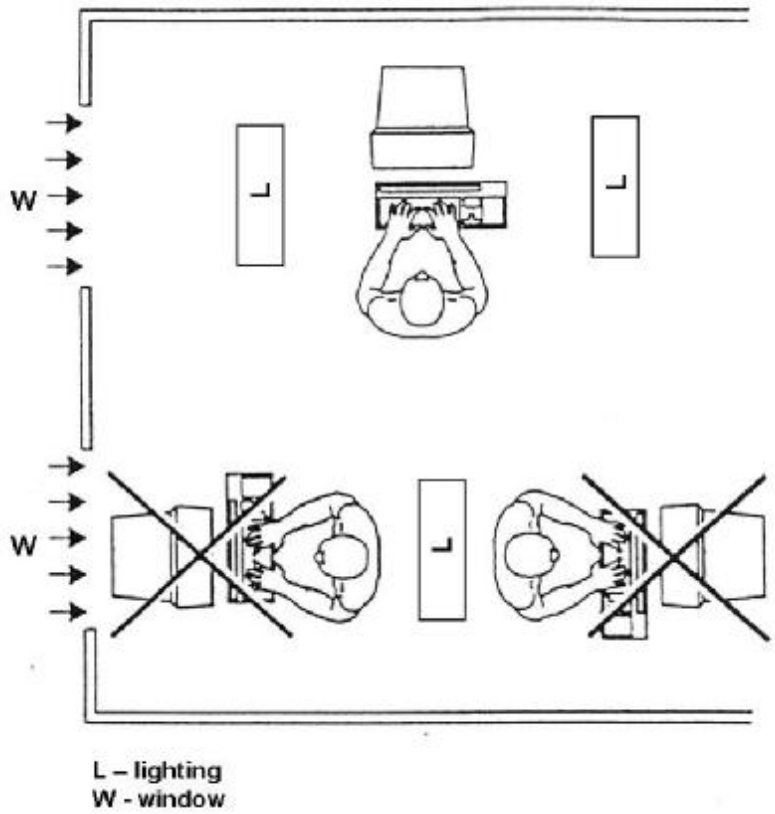

Figure 3.3 Appropriate and non-appropriate position of display screen equipment in the room

3.3.1.8.3 Risk reduction

To a great extent, problems seem to arise because operators are not using their equipment correctly, do not have appropriate software and are not taking reasonable breaks. The single most common problem is inappropriate seating or seating used inappropriately. Figures 3.3, 3.4 show the correct position for working with DSE. Unsuitable positioning may develop because the height of the seat has not been, or cannot be, adjusted; the operator's feet do not touch the floor because he or she has short legs and there is no foot rest; the operator's vision is not suitably corrected for screen work; or there is not enough desk space. Risk reduction should be addressed in five ways:

− Training in good practice;
− Repositioning of equipment and chair adjustment;

− Provision of equipment such as foot rest, document holder;
− Appropriate lighting;
− Work redesign.

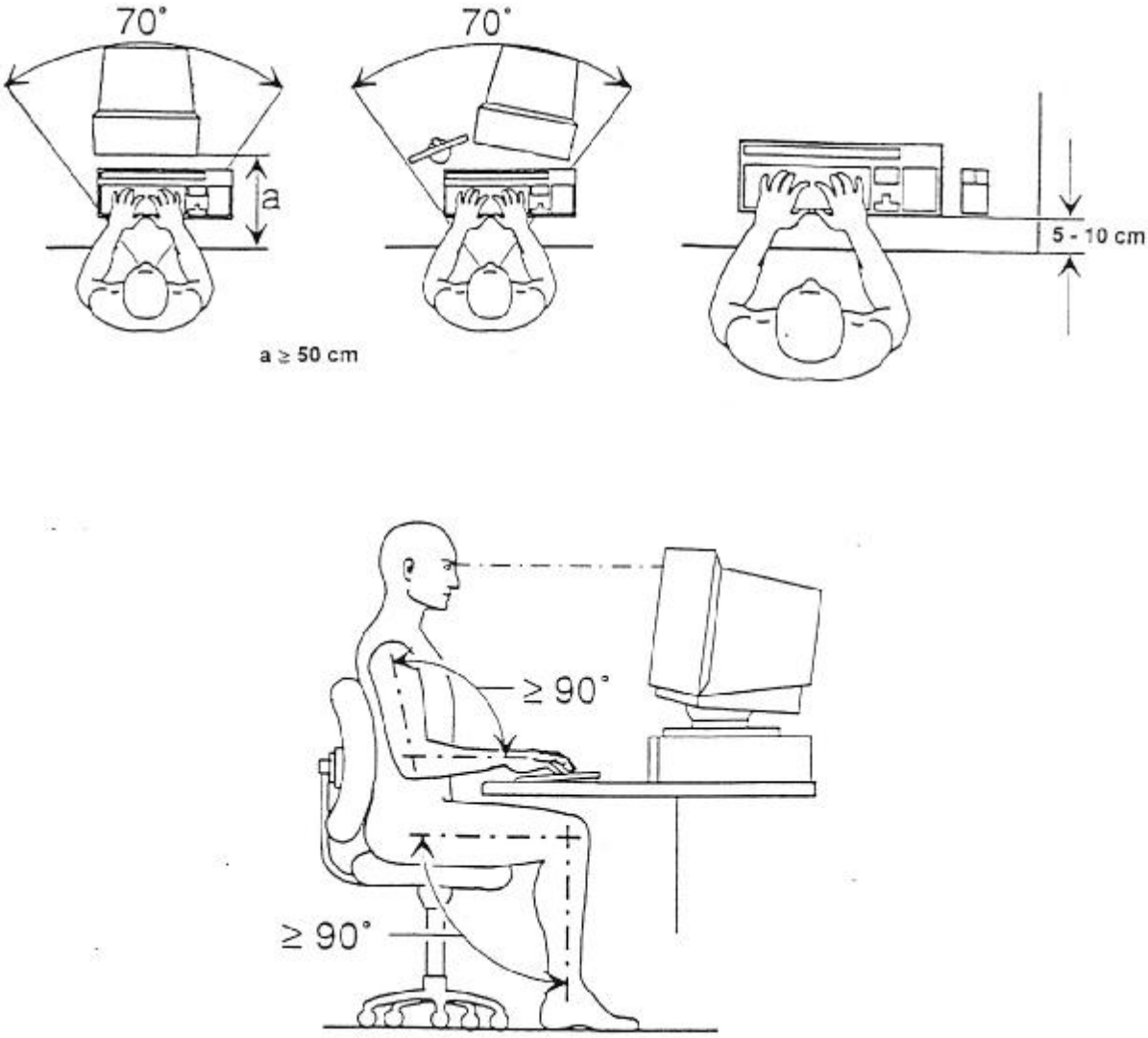

Figure 3.4 Ergonomic requirements for display screen equipment worksite

3.3.2 Chemical occupational hazards

Occupational chemical risk factors are those chemical compounds to which a worker is exposed in the course of his work and that may produce harmful effects when taken into the organism in doses exceeding the capacity of the body to deal with them. The number of chemical substances used mostly in industry today is vast and their biological effects are so diverse that it is unlikely that a common principle will be found that sufficiently reflects the relationship between the chemical properties of a substance and its biological effects.

Chemical hazards consist of synthetic or naturally occurring chemicals that come in contact with the skin, respiratory tract, or gut (or, rarely, through inoculation). Chemicals may exert toxic effects by interacting with a receptor site in these organs, by interacting with

receptor sites elsewhere in the body following absorption, or both. Toxic substances, also called toxicants or xenobiotics, may be absorbed, distributed, stored, metabolized, and excreted. Adverse outcomes from exposure may be enhanced or reduced by metabolic transformation, which primarily acts to promote excretion of the toxicant.

Chemical **exposure** is defined as contact with a chemical by an organism. It may be acute, subacute, or chronic in duration, and outcomes may be transient, persistent, cumulative, or latent. In addition to producing irritant, sensitizing or organ-specific damage, specific chemical exposures may cause genetic damage that may lead to adverse reproductive outcomes or they may induce or promote changes that lead to cancer.

There is no such state as absolute safety in the use of chemicals since all chemicals are toxic to a degree depending on the dose. The **toxicity** of a substance is its potential to cause harm on contact with body tissues. In order to effect proper controls to protect workers, it must not only be understood the basics of exposure sensitive industrial occupations and the processes involved but also associated exposure hazards. Materials used and exposure times are also important considerations.

Effects of chemicals may be acute, i.e. of rapid onset and short duration; or chronic, i.e. of gradual onset and prolonged. They may be local, occurring at the site of contact only, or general following absorption. Toxic substances may disturb normal cell function, damage cell membranes, interfere with enzyme and immune systems, RNA and DNA activity. Pathological response may be irritant, corrosive, toxic, fibrotic, allergic, asphyxiant, narcotic, anaesthetic and neoplastic.

Exposures to toxic chemicals can be in the form of liquids, gases, mists, fumes, dusts, and vapors. Generally, toxic agents are classified in terms of their target organs, use, source, and effects.

3.3.2.1 Exposure to toxic chemicals

The amount of a toxin that reaches the target tissue is dependent upon four factors: absorption, distribution, metabolism, and excretion. These four in combination govern the degree of toxicity, if any, from chemical exposure.

Other factors affecting toxicity include:

- The inherent potential of a substance to cause harm.
- Rate of entry and route of exposure; that is, how fast is the toxic dose is delivered and by what means.
- Metabolism in the body (bio-transformation) and its half-life.
- Age, which can affect the capacity to repair damage.
- Previous exposure, which can lead to tolerance, increased sensitivity, or make no difference.

− State of health, medications, physical condition, and life style. Pre-existing disease can result in increased sensitivity.

− Host factors including genetic predisposition and the sex of the exposed individual.

Portals of entry For humans, there are three primary routes of chemical exposure, in order of importance:

− Inhalation (i.e., through breathing) – dusts, mists, gases, fumes, vapors, etc.

− Skin contact (i.e., by touching) – direct absorption (pesticides, phenol); action on eye and mucous membranes (acids, irritating effects of vapors); corrosive action on the skin (acids, alkalis, phenols); solvent defatting of skin (toluene, methylene chloride); photosensitising agent to skin (creosote, bitumens); and allergenic action on skin (nickel, chromium).

− Ingestion (i.e., by eating).

Absorption of a poison depends on its physical state, particle size and solubility. Of the substances entering the lung some may be exhaled, coughed up and swallowed, attacked by scavenger cells and remain in the lung or enter the lymphatics. Soluble particles may be absorbed into the blood stream. The skin is protective unless abraded when soluble substances can penetrate to the dermis, as they may also do via the hair follicles, sweat and sebaceous glands, and then be absorbed into the blood stream. In pregnancy, harmful substances in the mother's body may cross the placenta to affect the unborn baby.

Metabolism Most substances absorbed will be carried by the blood stream to the liver where they may be rendered less harmful by a change in their chemical composition. However, some may be made more toxic, e.g. naphthylamine which is responsible for bladder cancer and tetra-ethyl lead which is converted into the tri-ethyl form and is toxic to the central nervous system.

Excretion The body eliminates harmful substances in the urine, lungs and less commonly the skin. Some are also excreted in the faeces and milk. The time taken to reduce the concentration of a substance in the blood by 50 % is known as its biological half-life. Similarly, the time for a 50 % fall in concentration of a substance or its metabolite in urine or breath, after cessation of exposure, is its half-life in that medium. This is important in the design of screening tests.

In the human body, the different effects and severities of hazardous materials are vast in number. In simple terms these effects can be described in terms of **where and when they affect the body**.

A. Where:

1. Local effects are adverse effects on the particular tissue which has been exposed to the hazardous substance. Examples include:

− Corrosives that can severely damage the eyes or skin;
− Organic solvents that can induce dermatitis on exposed hands;
− Gases (chlorine, ammonia) that can intensely irritate the respiratory tract.

2. Systemic effects are adverse effects on one of the several systems of the body after absorption of the hazardous substance. For example:

- Lead affects the nervous system, blood, kidneys and reproductive functions;
- Organophosphorus insecticides affect the nervous system.

B. When:

1. Acute effects are short lasting and develop during or soon after exposure. These can include irritant, acute poisoning or reproductive effects, for example:

- Gases (e.g. ammonia) immediately irritate the eyes and respiratory tract;
- Excessive exposure to toxic organic solvents can induce rapid narcotic effects (e.g. headache, dizziness, incoordination, unconsciousness);
- High exposure to some metal fumes produces a rapid onset of metal fume fever;
- Miscarriage from the acute effect of a substance on the developing foetus.

2. Chronic indicates that the adverse effects are long lasting, if not permanent. Onset may be soon after exposure, or it may be delayed many years. Some well-known chronic health effects are:

- Asbestosis and silicosis following excessive exposure to asbestos and quartz respectively;
- Lung cancer following exposure to dusts containing arsenic;
- Chronic dermatitis from exposure to chromium-containing cements;
- Lung cancer and mesothelioma from asbestos exposure;
- Damage to the DNA structure of sperm and ova, and reduced fertility (suppression of sperm production), for example, from lead exposure.

There are some toxic substances with chronic effects:

PCBs belong to a family of organic compounds known as chlorinated hydrocarbons. Most PCBs were sold for use as dielectric fluids (insulating liquids) in electrical transformers and capacitors. When released into the environment, PCBs do not easily break apart and form new chemical arrangements (i.e., they are not readily biodegradable). Instead they persist for many years, and bioaccumulate and bioconcentrate in organisms. Exposure to PCBs in humans can cause chloracne (a painful, disfiguring skin ailment), liver damage, nausea, dizziness, eye irritation, and bronchitis.

Vinyl chloride Most vinyl chloride is used to make polyvinyl chloride (PVC) plastic and vinyl products. Acute (short-term) exposure to high levels of vinyl chloride in air has resulted in central nervous system (CNS) effects, such as dizziness, drowsiness, and headaches in humans. Chronic (long-term) exposure to vinyl chloride through inhalation and oral exposure in humans has resulted in liver damage. Cancer is a major concern from exposure to vinyl chloride via inhalation, as vinyl chloride exposure has been shown to increase the risk of a rare form of liver cancer in humans. Vinyl chloride has been classified as a Group 1 human carcinogen (i.e. confirmed human carcinogen).

3.3.2.2 Carcinogens

A **carcinogen** is an agent which may produce cancer (uncontrolled cell growth), either by itself or in conjunction with another substance. A chemical is considered to be a carcinogen if it has been evaluated by the International Agency for Research on Cancer (IARC) and found to be a carcinogen or potential carcinogen. A **potential** or **suspect carcinogen** is an agent

which is suspected of being a carcinogen based on chemical structure, animal research studies, or mutagenicity studies. IARC classifies carcinogens in the following manner:

1. Carcinogenic to humans with sufficient human evidence; **confirmed human carcinogen**. The agent is carcinogenic to humans based on the weight of evidence from epidemiologic studies.

2A. Probably carcinogenic to humans with some human evidence; **potential human carcinogen.**

2B. **Possibly carcinogenic** to humans with no human evidence.

3. Agents **not classifiable** as to its carcinogenicity to human.

4. Probably **not carcinogenic** to humans.

Human data are accepted as adequate in quality but are conflicting or insufficient to classify the agent as a confirmed human carcinogen; or, the agent is carcinogenic in experimental animals at doses, by routes of exposure, at sites, of histologic types, or by mechanisms considered relevant to worker exposure. The 2B is used primarily when there is limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals with relevance to humans.

3. Sufficient evidence of carcinogenicity in experimental animals.

Some carcinogens are as follows:

Coke oven workers who have been exposed to high levels of polycyclic aromatic hydrocarbons have a near threefold increased risk of lung cancer. Other carcinogens are arsenic, cadmium, chrome, nickel and paint spray, exposures that occur across a wide range of occupations. Exposure to certain hexavalent, but not trivalent, chrome salts increases the likelihood of contracting lung cancer.

3.3.2.3 Mutagens

A substance or material, that causes change in the genetic material of a cell. Some substances interact with genetic material, causing either point mutations, chromosomal damage, or interference with meiosis, mitosis, or cell division. A variety of tests can measure these effects and new genetic techniques allow sequencing of genes and detection of changes at specific codons.

Mutagen classification:

- **Category 1 – confirmed human mutagen** Substances known to produce heritable genetic defects.
- **Category 2 – potential human mutagen** Substances that should be regarded as if they are mutagenic to humans, for which there is sufficient evidence, based on long-term animal studies and other relevant information, to provide a strong presumption that human exposure may result in the development of genetic mutations.

− **Category 3 –** substances that cause concern owing to possible mutagenic effects but for which available information is not adequate to make satisfactory assessments.

3.3.2.4 Classifications of toxic materials by physical properties

Gas is a form of matter that is neither solid nor liquid. In its normal state at room temperature and pressure, it can expand indefinitely to completely fill a container. A gas can be changed to its liquid or solid state under the right temperature and pressure conditions.

Vapor is the gaseous phase of a material which is ordinarily a solid or a liquid at room temperature and pressure. Vapors may diffuse. Evaporation is the process by which a liquid is changed into the vapor state and mixed with the surrounding air. Solvents with low boiling points will volatize readily.

Aerosol is a group of liquid or solid particles suspended in a gaseous medium, usually in the range of 0.001 to 100 μm in size.

3.3.2.4.1 Aerosols in the workplace

Naturally and artificially produced aerosols are found in ambient and industrial air environments and vary greatly in size, density, shape and chemical composition. The term **particle** implies a small discrete object, and **particulate** indicates that the material has particle-like characteristics. For a proper assessment of the toxic hazard, the size of the aerosol's particles is important (see below).

Dust usually comprises solid particles generally greater than 0.5 μm in size, formed by crushing or other mechanical forces on a parent material. Dust is found everywhere, including all workplaces, and has remained one of the most intractable of workplace problems since metal ores were first mined. Operations carried out in today's industrial workplaces – mining, crushing, sieving, milling, grinding, planing, sawing, sanding, machining, pouring – all contribute to particle generation. Particles generated in one workplace can become airborne dusts that are carried into other working locations. While many of these dusts are relatively harmless, causing only transient irritation, some give rise to lung fibrosis, others to carcinoma, bronchitis, asthma or other lung disorders.

Fume is an aerosol consisting of small solid particles and is produced as the result of condensing vaporised materials, usually metal, and represents particles less than 0.05 μm in size, even though these particles generally agglomerate. Smelting, thermal cutting and welding operations all produce fume.

Mist or **fog** is a liquid form of aerosol comprised of liquid droplets with sizes ranging from 0.01 to 10 mm. Examples of mists are oil mists, chemical mists, and water mists contaminated with various chemicals.

Smog is an aerosol consisting of solid and liquid particles, created generally by the action of sunlight on various vapours.

Smoke is a solid or liquid aerosol which is the result of incomplete combustion, and most smoke particles are sub-micrometre in size.

There are a lot of kinds of aerosols that might be encountered in the workplace. One major source is from naturally occurring and synthetic manufactured materials of **inorganic mineral origin**. Coal, quartz-bearing rock and toxic metal dusts (e.g. lead) commonly associated with mineral extraction and processing industries are all significant sources of workplace dust. Many metal manufacturing and processing industries give rise to dusts and fumes of **toxic metals** (lead, zinc, copper, arsenic). Today, many people are potentially exposed to dust from **construction and demolition activities**. **Asbestos** can still be present in some "asbestos-free" friction materials manufactured overseas (e.g. brake linings), despite the ban on all types of asbestos importation. Workers are potentially exposed to asbestos fibre in the asbestos removal industry. **Synthetic mineral fibres** used in insulation and fire rating provide another source of workplace dust exposure, but they are not toxic like asbestos, except that various specific types of synthetic mineral fibres are classified as "possibly carcinogenic to humans".

Naturally occurring organic dusts are common in some workplaces. Rural workers are exposed to natural dusts of grain. Sugar mill workers may be exposed to dust from bagasse, which is the waste cane after sugar has been extracted. Downstream processing industries expose workers to dusts containing wood, cotton, paper, felt, fur, feathers and pharmacologically active plant materials. Within industrial manufacturing processes, it can be encountered **manufactured dusts** from a range of plastic polymers – epoxies, polyvinylchloride, acrylates, polystyrene, etc. They are found in industries as diverse as foundries, plastic pipe manufacture, packaging, surface coating industries and dental laboratories. The wide spectrum of dusts and the ways they occur in different workplaces provide a constant challenge to devise various strategies for their control.

The two factors important for assessing the impact of inhaled aerosols in the workplace are:

− chemical composition of the aerosol;
− particle size.

Composition and **particle size** are important in the way an inhaled aerosol affects the worker, because together they govern how much of a material actually enters the body, where it finally deposits and what sort of toxic effect it can exert.

In some cases, the toxic effect caused by the inhaled particles or dust occurs quickly (e.g. within a few hours). In other cases, the effect of inhaling the aerosol may be a chronic effect and not appear for many years following exposure. It then becomes difficult to make an association between the inhaled aerosol and its effect. This long latency period has often made it difficult to establish causal links between particular aerosol exposures and disease. Of course, it can also lead to a false sense of safety in dealing with such aerosols.

Particle size is important for two reasons:

1. Particle size determines how long a particle remains airborne and hence how far an aerosol cloud will disperse in a workplace before settling. This factor may influence choice and effectiveness of control strategies.

2. The effects on health that many aerosols exert depend on their site of deposition. The site of deposition depends largely on the size of a particle, or more correctly, its aerodynamic settling velocity. Large particles (up to several hundred micrometers in diameter) settle in the nose and throat and may cause their effects at these sites. Smaller particles between 5 and 10 μm are collected in the upper airways (the bronchi and bronchioles) from where they can

be cleared by the mucociliary escalator (cilia beating in an upward direction). The very small particles, termed **respirable dusts** and generally smaller than around 1 – 5 μm in dimension, penetrate right to the alveolar gas exchange region of the lung, from where they are only very slowly cleared. Particles as small as < 0.5μm are generally not deposited (see Figure 2.1).

Only rarely in practical situations – usually under controlled laboratory conditions – do aerosols consist of particles of all one size. Such aerosols are referred to as **monodisperse**. More generally, however, in workplaces and elsewhere, aerosols consist of populations of particles having wide ranges of sizes, and so are termed **polydisperse**. For these, particle size within an aerosol needs to be thought of in statistical terms.

3.3.2.4.2 Dusts in occupational environment

Dusts are generated by mechanical processes such as grinding or crushing. Dusts range in size from 0.5–50 μm. Dust is hazardous when deposited anywhere in the respiratory tree including the nose and mouth. Common workplace dusts are either inorganic or organic. **Inorganic dusts** are derived from metallic and nonmetallic sources. Nonmetallic dusts can be silica bearing – that is, in combined or free silica as crystalline or amorphous form. **Organic dusts** are either synthetic or natural. Natural organic dust can be animal or vegetable derived.

Examples of organic and inorganic dust are:

- Sand (inorganic, nonmetallic, silica bearing, free silica, crystalline);
- Beryllium (inorganic, metallic);
- Cotton (organic, naturally occurring, vegetable).
- Also dusts can be **classified** on the basis of their health effects as follows:
- Fibrogeneous aerosols (e.g. crystalline silica, graphite, bituminous coal, coke);
- Potential fibrogeneous aerosols (e.g. amorphous silica, bentonite);
- Innocuous or non-specific effect aerosols (e.g., iron oxide, limestone, basalt, magnesite, cement; may also be considered as nuisance dusts);
- Sensitizers (e.g., many hardwood dusts, cotton, wool, coat, flour);
- Fibrous aerosols (e.g. asbestos, manmade mineral fibres).

Particle shape can have a significant bearing on effects, for example on the way in which particles behave in the air, and how they behave after they have been deposited in the respiratory tract.

Particle shape falls into a number of categories and these include:

- Spherical particles (e.g. glassy spheres condensing out of some high-temperature processes);
- Regular or isometric, non-spherical, angular particles which have no preferred dimension or whose aspect ratio cannot be said to be substantially different from unity (e.g. most dusts, including coal dust);
- Platelet particles (e.g. some dusts, such as mica);
- Fibrous or acicular particles which are long, thin, needle-shaped particles (e.g. asbestos and manmade mineral fibre dusts);
- Fractal particles, complex aggregates of much finer primary particles (e.g. fumes and smokes).

The motion of airborne particles The physical processes governing the motion of airborne particles are highly relevant to the transport and deposition of particles in ventilation ducts, deposition onto workplace surfaces, inhalation into and deposition inside the human respiratory tract, sampling and filtration, and so on.

Pneumoconiosis The term pneumoconiosis literally means “dusty lungs” and, as such, conveys no connotation of harm. For medical purposes, however, the term should be confined to mean permanent alteration of lung structure following the inhalation of mineral dust, and the tissue reactions of the lung to its presence. The dusts that are most harmful to the lungs are silica (or quartz), coal dust and asbestos. This broad group of conditions generally affects the lung interstitium rather than the airways and therefore results in a restrictive defect on lung function testing.

Silicosis Crystalline silica (SiO_2) is a major component of the earth’s crust and is responsible for causing silicosis. This is probably the oldest of all the occupational diseases and follows exposure to fine crystalline silicon dioxide or quartz. In the past, the disease was common in many industries including mining, quarrying, the pottery industry, iron and steel foundries and sand blasting. Inhalation of silica leads to the formation of small nodules of fibrotic tissue (around 1 mm in diameter), which increase in size and coalesce as the disease progresses. These nodules are seen on a chest radiograph as small, round opacities scattered predominantly in the upper parts of the lung, and may be present before any symptoms of breathlessness appear.

The term **coal miner`s pneumoconiosis (anthracosis)** refers to a blackish pigmentation of the lungs caused by deposition of carbon particles and may be observed with no evident pathologic changes at autopsy. The condition was in the past observed in the lungs of city dwellers that have had no industrial exposure.

3.3.2.4.3 Fibrous particles

Typical example for fibrous particles is asbestos and manmade mineral fibre dusts. Fibres of respirable size are those which are smaller than 3 μm in diameter, usually longer than 5 μm and have aspect ratios of at least 3:1 length to width.

Asbestos is the name given to a group of naturally occurring minerals widely used in certain products, such as building materials and vehicle brakes, to resist heat and corrosion. Asbestos includes chrysotile, amosite, crocidolite, tremolite asbestos, anthophyllite asbestos, actinolite asbestos, and any of these materials that have been chemically treated and/or altered. Typically, asbestos appears as a whitish, fibrous material which may release fibers that range in texture from coarse to silky; however, airborne fibers that can cause health damage may be too small to be seen with the naked eye. The inhalation of asbestos fibers by workers can cause serious diseases of the lungs and other organs that may not appear until years after the exposure has occurred. Exposure to asbestos can cause:

− asbestosis;
− lung cancer;

− mesothelioma (cancer affecting the membranes lining the lungs and abdomen);
− cancers of the esophagus, stomach, colon, and rectum.

Pulmonary and pleural **asbestosis** is found only in asbestos workers who have been exposed to high fibre concentrations over a long period of time. It is the classical disease of the asbestos miners, millers, weavers and those involved in processing fibre in large quantities (e.g. manufacturing brake linings or asbestos cement products). Asbestosis is associated with fibrotic changes in the lung (which may become extremely severe and can often progresses to disability and death) and with the development of cancer (see below). The development of pulmonary fibrosis, or asbestosis, mainly follows exposure to white asbestos (chrysotile), although blue (crocidolite) and brown (amosite) asbestos are also fibrogenic. The patient complains of increasing shortness of breath and often a dry cough.

Many individuals exposed to asbestos die from **lung cancer**. It was observed among workers heavily exposed to any type of asbestos, and a greatly increased risk of lung cancer occurred when heavily exposed asbestos workers were also heavy smokers, as smokers are at higher risk of developing some asbestos-related diseases. Smokers who are exposed to asbestos are at a very much greater risk of developing lung cancer than are people who only smoke or only have asbestos exposure.

Mesothelioma (pleural tumours) is a rare disease, occurring most often among those exposed to asbestos (almost entirely in those who have been exposed to blue asbestos – crocidolite) but also quite rarely in some unexposed people. Its latency period is usually 30 to 40 years and typically follows exposures which are substantial, but in some cases thought to have been caused by brief but intense exposures of a few months or less. The greatest risk of mesothelioma may be associated with the ability of an asbestos mineral or product to produce durable and long (> 10 μm) fibres.

Talcosis. Pure talc is hydrated magnesium silicate, similar in chemical composition to asbestos. Numerous investigations have shown that prolonged inhalation of talc will result in the production of significant lung damage even though there is no silica present. The histopathologic examination usually reveals the presence of mild or moderate peribronchial and perivascular fibrosis with dilatation of many small bronchi and bronchioles. In more advanced cases the fibrosis may be extensive.

Potential occupational exposures include cosmetic workers, paint makers, paper makers, pottery makers, rubber cable coaters, rubber fire makers, talc millers, talc miners, and talcum powder makers.

Byssinosis occurs in individuals who have experienced exposure to heavy air concentrations of cotton dust. The exact mode of action of cotton dust is unknown, but one or more of the following factors may be important in the pathogenesis of the disease: toxic action of microorganisms adherent to the inhaled fibers, mechanical irritation from the fibers and allergic stimulation by the inhaled cotton fibers or adherent materials.

Pulmonary siderosis is a benign pneumoconiosis resulting from the deposition of inert dust in the lung. In general there is neither fibrosis no emphysema associated with this conditions unless, as often occurs, there is concomitant exposure to silica dust.

Farmer's lung is a disease entity produced by the inhalation of dust arising from moldy silage. The pathogenesis of this disease remains obscure. Available evidence indicates that the pulmonary reaction (dyspnoea, cough, interstitial fibrosis and diffuse obstructive emphysema) is due a mechanical irritation, or the production of hypersensitive state by the molds or their disintegration products.

3.3.2.5 Exposure standards

The exposure standard (ES), or the national exposure standard, is one of the most important tools used to help assess the risks associated with a range of workplace hazards. In many workplaces there are likely to be times when workers are exposed to a vapour or a dust or some other contaminant in the air. The ES is a guide to upper levels of exposure to a contaminant for unprotected workers. Relevant workplace measurements of exposure are compared with the ES to determine whether the prevailing exposure is likely to be a risk to health, and whether controls (or additional controls) need to be implemented.

Hazardous chemicals in the workplace have been encountered since antiquity. But it has really only been since the early 1940s, with major advances in medicine and technology, that there have been significant efforts to quantify the risks of workplace hazard exposures and to develop numerical values for maximum “allowable” concentrations for atmospheric contaminants in the workplace.

The **dose-response relationship** defines the potency of a toxin and it is the most fundamental and pervasive concept in toxicology. To understand the potential hazard of a specific toxin (chemical), it has to be known both the type of effect it produces and the amount, or dose, required to produce that effect. The relationship of dose to response can be illustrated as a graph called a **dose-response curve** (Figure 3.5). The dose is represented on the x-axis and the response is represented on the y-axis. An important aspect of dose-response relationships is the concept of **threshold**. For most types of toxic responses, there is a dose, called a threshold, below which there are no adverse effects from exposure to the chemical. This is important because it identifies the level of exposure to a toxin at which there is no effect.

Some other substances show the **non-threshold dose-response relationship**. It is a typical response for some chemical substances like carcinogens and/or mutagens (Figure 3.5).

Older occupational health standards were based on **threshold limit values**. In this system, maximum exposure limits were usually set based on the level of a contaminant known to produce acute effects, allowing some margin for safety and considering what was readily achievable by employers. Unfortunately, such limits do not protect against long-term chronic or subclinical effects on the body, such as changes in blood chemistry, liver function, or the reaction time of the central nervous system. In addition, these values were derived mainly for

healthy, young, adult white males, not for the diverse makeup of working populations. In addition, these values were not designed to address the problem of irreversible health problems such as cancer.

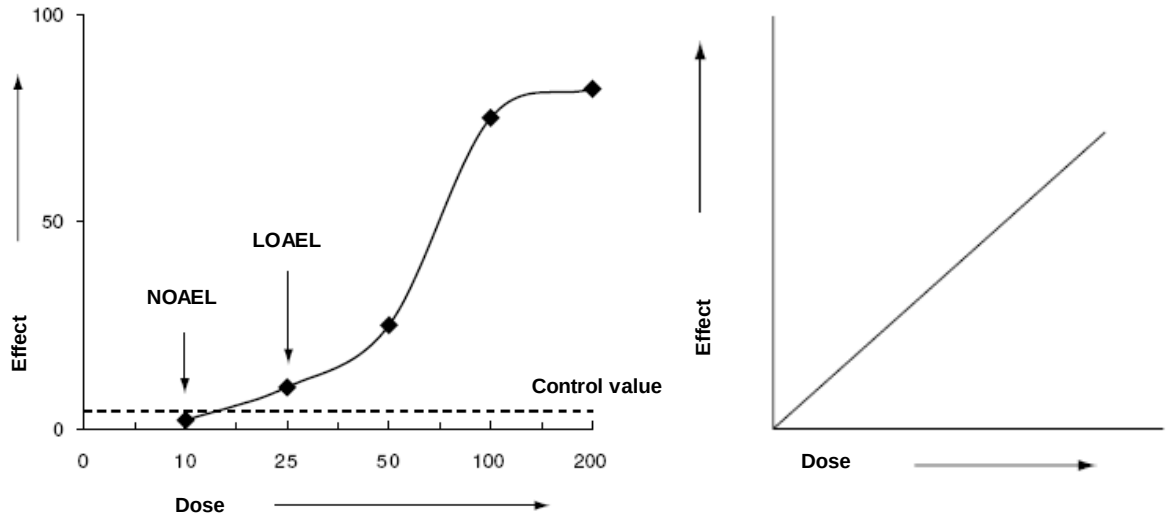

Figure 3.5 Characteristics of dose-response curves for threshold (left) and non-threshold (right) toxicological effects (Source: Gardiner and Harrington, 2005)
NOAEL – the no observed adverse effect level
LOAEL – the lowest observed adverse effect level

Permissible exposure limits (PELs) are now used as health standards. PELs are based on consideration of the health effects of hazardous substances.

Permissible exposure limit (PEL) is defined as the time-weighted average concentration of an airborne contaminant that a healthy worker may be exposed to 8 hours per day or 40 hours per week without suffering any adverse health effects.

Short term exposure limit (STEL) is the time weighted average concentration to which workers can be exposed continuously for a short period of time (typically 15 minutes) without suffering irritation, chronic or irreversible tissue damage, or impairment for self-rescue.

Peak limitation means a maximum or peak airborne concentration of a particular substance determined over the shortest analytically practicable period of time which does not exceed 15 minutes.

Standards alone will not guarantee healthful, safe working conditions. Enforcement inspections to determine whether compliance exists are essential. Training and education of workers and employers is also necessary. Government cannot provide direct, constant enforcement of employee protection; this effort must be assisted by employer and employee participation.

There are a number of **practical limitations** to using exposure standards (ES). These include:

- ES do not represent “no effect” levels which guarantee protection for all workers.
- ES are not intended as fine dividing lines between safe and unsafe working conditions.
- ES should not be used as a measure of relative toxicity.
- ES consider only uptake of the chemical by inhalation and consequently are only valid where significant skin absorption cannot occur.
- ES should not be used as the basis for air quality standards for nonoccupational exposures.

Exposure standards have only been assigned for about 700 of the more commonly used and better studied workplace hazardous substances. Most substances used in workplaces do not have an ES. It is important to recognize that the lack of an ES does not mean that a chemical is safe or will not cause adverse health effects if exposure is sufficiently high. Consequently it is good policy (and a responsibility under occupational health and safety legislation) to keep exposures to all substances as low as is practicable regardless of whether or not they have an ES.

Exposure standards almost invariably apply to the **airborne concentration of a pure substance**. In the real world, however, the working environment is quite likely to contain two or more airborne contaminants and in some cases may contain a **complex mixture** of many substances. The application of exposure standards in such situations always requires a good knowledge of the toxicology of the substances involved; even with such knowledge, however, the interpretation of results can be fraught with difficulty. Compliance with the overall exposure standard for the mixture occurs when the sum of all elements is less than or equal to 1.

Other interactive effects for mixtures of chemicals, such as **synergism** (where the overall health effect is greater than the sum of the individual effects) or **potentiation** (where one chemical has no direct effect but increases the adverse effect of another) are possible. In practice, only a very small number of these types of interactions are known. The classic example of a synergistic effect is the increased risk of lung cancer among cigarette smokers who have also been exposed to asbestos.

Exposure standards tend to change regularly because they are (or should be) the subject of regular review to ensure that the standards reflect the current scientific and technical knowledge about the health effects that may occur following exposure to the substance. As the knowledge about the substance grew and it was found that it can cause nerve damage (peripheral neuropathy), the standard was progressively reduced. The trend of further reductions in exposure standards for many substances is likely to continue in the future.

3.3.2.6 Permissible exposure limits for aerosols

Permissible exposure limit (PEL) values for dust with non-toxic effects are based on **mean concentration** ($mg.m^{-3}$) over an 8-hour work shift, which should prevent the impairment of respiratory organ function. For aerosols with fibrogeneous effects there are also permissible exposure limit values for **respirable fraction** (i.e. mass proportion of particles $\leq$ 5 μm).

As the various kinds of asbestos can cause malignant tumors in humans and there is a non-threshold dose-response relationship, for this reason PEL values cannot be assigned. To provide a limit value for setting up practicable protective and control measures at the workplace **technical exposure limits** (TEL) are designated. Employee exposure to asbestos must not exceed 0.1 fibers per cm^3 of air, averaged over an 8-hour work shift. Short-term exposure must also be limited to not more than 1 fiber per cm^3 of air, averaged over 30 minutes. In general industry, exposed employees must have a preplacement physical examination before being assigned to an occupation exposed to airborne concentrations of asbestos. The physical examination must include chest X-ray, medical and work history, and pulmonary function tests. Subsequent exams must be given annually and can involve cythological sputum examination and also some others at the discretion of the physician.

There is a range of **legislation** relating to chemicals in workplaces. Employers must somehow comply with all this legislation. With regard to the workplace, critical legislation has been introduced in the past decades relating to workplace safety and the environment. This has placed pressure on employers and workplace managers to manage chemicals better.

There are really only four approaches to chemical control. These approaches apply equally well at the national, industry, company or workplace levels. It is important to recognize that most, if not all, chemical substances can be handled and used safely, providing that:

- The hazards are known and understood;
- Correct handling and use procedures are in place and adhered to;
- The correct equipment to handle and use chemicals is available, used and maintained;
- Workers are informed about hazards and trained in correct procedures and prompt action is taken to control and minimise problems that do arise.

This requires systems to ensure that hazards are identified, risk assessment procedures are in place, the right controls are used, and emergency procedures are in place. In turn, this requires good management. The risk management approach of establishing organizational considerations, identifying chemical hazards, assessing risks, control risks and evaluating management activities has become the *de facto* means of managing workplace hazards.

3.3.2.7 Workplace control

The methods commonly used to control workplace air contamination at their point of origin are **local exhaust ventilation** (it consists essentially of four parts, as follows: hoods and enclosure, air ducts, collector, and exhaustor), wet methods (the use of water or other suitable liquid at operations producing dust and fumes) and good housekeeping.

The object of **general or dilution ventilation** is to dilute the contaminated air of a workroom with a sufficient quantity of clean air to reduce the atmospheric concentration of the contaminant to a safe level.

Isolation In many instances, some operations or machines which liberate large amounts of contaminants require the isolation of the offending operations and machines.

The substitution of a nontoxic for a highly toxic material is one of the most effective methods of controlling the atmospheric health hazard.

Respiratory protective devices may be divided in to two major classifications: air-purifying respirators, and supplied-air respirators. They are used effectively on jobs such as abrasive blasting, point chipping, handling with used storage battery plates, cadmium oxide manufacture, and use of pigments and dyes, and like that.

Maintenance, housekeeping, and the education of the worker are interdependent. It is impossible to have good maintenance unless the housekeeping (general cleanliness and orderliness) is good and the worker has been informed of the need for the control measures and the proper operation there of.

3.3.2.8 Biological monitoring of workers

Monitoring the worker's health directly, instead of the surrounding workplace environment, is another way of checking on the quality of the work environment. Biological monitoring involves the measurement of workplace agents or their metabolites in biological specimens, usually blood or urine, for the purpose of monitoring the level of exposure and absorption. It is a common adjunct to medical monitoring or screening.

The list below outlines some of biological monitoring strategies in increasing order of relevance to occupational disease:

1. **Airborne monitoring –** measures potential or actual exposure, but does not allow measurement of individual absorption, tissue distribution and excretion of chemicals; does not allow for individual susceptibility to chemical effects.

2. **Biological monitoring –** allows an estimate of body burden, taking into account individual work practices; may enable the routes of exposure to be determined; provides some evidence of compliance with exposure and safety standards.

3. **Biological-effect monitoring –** indicates that sufficient exposure has occurred to cause a change in function of cells or tissues; it takes into account individual susceptibility; may also be applied to non-chemical exposures (e.g. ionizing radiation). Intervention in the workplace that results in a decline in the measured index suggests a reduction in risk.

4. **Health surveillance –** allows the early detection of disease. This may allow an intervention to be made which will stop or reverse the disease process so that the disease outcome will be less severe than if intervention had not occurred.

Biological tests can provide information on the uptake of the substance by the worker, whereas air testing cannot. For example, blood cyanide tests on workers in the cyanide manufacturing industry can indicate whether workers need to be removed from further cyanide exposure. In some cases, such as industries where workers are exposed to lead, measurement of blood lead concentrations or urinary markers of lead absorption and effect may be legislative requirements. In other cases, biological monitoring programs provide additional information of the exposure and absorption patterns of chemicals.

Although **blood sampling** is invasive, blood is one of the most often sampled tissues, since it is readily accessible. There is also a large body of accumulated data that has been

published relating to blood samples collected from workers in a wide range of industries. Chemicals such as solvents, metals, pesticides and gases have all been measured in blood samples.

Urine is the most commonly collected fluid. It is easy to collect, and collections before and after work allow determination of workplace contribution to the measured index. Sampling may be repeated throughout the work week to follow time courses of chemical appearance and elimination, and to identify specific duties associated with increased chemical absorption. It has also been used for a large range of chemicals and their metabolites, ranging from solvents and gases, to metals, pesticides, plastics and others.

Hair sampling has been used mostly for analysis of metals that are deposited in the hair shaft as it grows.

Exhaled air is usually used for volatile compounds, such as solvent vapours.

An understanding of the pharmacokinetics of the chemical concerned is required to determine an appropriate **sampling regime**. Chemicals of short half-life (under 3 hours) must be sampled within a very short time of the exposure before blood or urine concentrations fall significantly. This is usually at the end of the daily work shift. These data usually represent only recent exposures. Chemicals with a longer half-life (3–20 hours) may be sampled at the end of the week of work shifts, and the measured index reflects exposure over a week or more. Chemicals with half-lives that are very long (weeks to years) may be sampled at any time, as the measured index reflects long-term exposures.

Biological exposure index (BEI) is estimated from the relationship observed between a particular biological monitoring measure (such as urinary chemical concentration) and the corresponding airborne chemical concentrations. It indicates the expected biological monitoring value if worker exposure occurs at about the exposure standard (ES).

Biological-effect monitoring provides independent confirmation of whether workplace exposures result in changes to physiological or biochemical function, even where workplaces comply with the relevant ES. Biological-effect monitoring allows the examination of particular cell or tissue endpoints that indicate some response to workplace chemical exposure. **Biomarkers** are now considered by many to be early indicators of effects, including adverse effects. The distinction between measuring some early biomarkers of disease and carrying out health surveillance is not always clear. Biological-effect monitoring usually refers to a variety of assays based on biochemical or chromosomal changes, or changes in the amount or character of particular proteins, enzymes or nucleic acids.

Biochemical methods include measures of enzyme activities that are either inhibited or enhanced (induced) by chemical exposure. Biological-effect monitoring requires several factors to be taken into account, similar to those important in biological monitoring procedures, including the selection of appropriate tissues, the specific test to be used, the sampling regime, and how data will be interpreted. Generally, results may be used for comparison before and at intervals after employment, or with other individuals and groups with different duties or different degrees of potential exposure.

Health surveillance within an enterprise often involves analysis of the information gathered in baseline or pre-placement examinations and periodic screening testing. In addition, administrative records such as health insurance data, work absence records, workers' compensation claims, or worksite "incident reports" may provide insight into the health of the workforce. Records from poison control centers and from emergency room visits have been used for population-based occupational injury surveillance as well. Population-based workforce data can be analyzed for rates of disease or injury, so areas of unusual occurrence within an enterprise, a community, or a country can be identified and investigated. Some conditions such as silicosis are so characteristically occupational that all cases should be investigated. These are known as sentinel events.

3.3.2.9 Smoking in the workplace

There can be little doubt that smoking in the workplace is an issue with which management must engage. There are two types of tobacco smoke: mainstream smoke, inhaled and exhaled by the smoker, and sidestream smoke which is released directly into the atmosphere from the cigarette. This contains a higher concentration of the tobacco chemicals, including known carcinogens. Sidestream smoke forms the greater part of environmental tobacco smoke (ETS).

Lung cancer, as well as other forms of cancer is more common in smokers. However, cardiovascular disease, including heart attacks, remains the major cause of death in smokers. Other health effects of ETS are recognized including irritation and discomfort of the mucous membranes, exacerbation of adult asthma and increased incidence of heart disease.

There is no doubt that the risk associated with the hazards presented by passive smoking must be assessed and reduced. The nature of the industry or work may make smoking particularly dangerous: for example, the risk of contracting lung cancer in a smoker who is also exposed to asbestos dust is around 55 times greater than that of an ordinary non-smoker, since the effects of asbestos and tobacco smoke chemicals appear to be cumulative. Specific factors such as these may be strong motivators.

Smoking in the workplaces is nowadays strictly prohibited in the most European countries.

3.3.3 Biological occupational hazards

Although the nature of biological hazards is totally different from inanimate hazards such as dusts, vapours and chemicals, a number of control solutions are remarkably similar.

The human body does have some defense mechanisms. Whether or not ill health occurs depends on the concentration (usually numbers of micro-organisms) to which the worker is exposed, the virulence (toxicity) of the micro-organism and the resistance of the individual. Medical treatment is often available and effective.

Biologic hazards include **exposures to living organisms** and may or may not be communicable (readily transmitted to others). Viruses, bacteria, fungi, rickettsia, Chlamydia, protozoa, helminths, and now prions have been demonstrated to produce occupational and environmental illnesses. Toxins, which are large organic molecules elaborated by living organisms, may be included under the grouping of biologic hazard, but more often are listed with chemical hazards. Workers at higher risk of exposure to biologic hazards include:

- Those who work with people (health-care workers, child-care workers, laboratory workers – i.e. blood-borne viruses, hepatitis B virus, hepatitis C virus, HIV, tuberculosis);
- Those who work with animals (agricultural workers, laboratory workers, zookeepers), they may be exposed to zoonoses, diseases transmitted from animals to man under natural conditions (i.e. diarrhoeal diseases, brucellosis, Q Fever, erysipelothrix, lyme disease, psittacosis, bovine tuberculosis, anthrax, leptospirosis);
- Those exposed to unfamiliar pathogens through travel (business travelers, migrant workers, military – i.e. malaria, travellers' diarrhea, hepatitis);
- Those who work or live in large groups (military recruits, college students);
- Those who move soil (construction workers, farmers).

Microbiology laboratory workers have an increased risk of occupationally acquired infection, although this risk is declining. Assessment should include measures to prevent or control exposure to infection. When there is infection risk, the use of preventative measures must be considered. When assessing the occupational risk of infection in laboratory workers, a number of factors need to be considered; what pathogens are likely to be involved, the local epidemiology of disease, the nature of material handled and the frequency of contact with infected material. The local laboratory facilities need to be looked at, as well as the availability of containment measures. When there is a vaccine to prevent infection, its safety and efficacy should be taken into account. However, vaccination should never be a substitute for good laboratory practice.

The **types of micro-organisms** and similar life forms most often present in occupational environment are: bacteria, fungi, viruses, parasites, and prions.

Classification of micro-organisms:

Micro-organisms are categorized into different risk groups, according to the risk they pose and the control procedures required containing them.

Risk group 1 – low individual and community risk, a micro-organism that is unlikely to cause human or animal disease (e.g. brewer's yeast).

Risk group 2 – moderate individual risk, limited community risk, a pathogen that can cause human or animal disease, but is unlikely to be a serious hazard to laboratory workers, the community, livestock, or the environment; laboratory exposures may cause infections, but effective treatment and preventive measures are available, and the risk of spread is limited. Examples are *Staphylococcus aureus*, *Legionella* bacteria, hepatitis viruses etc.

Risk group 3 – high individual risk, limited community risk, a pathogen that usually causes serious human or animal disease and may present a serious hazard to laboratory workers. It could present a risk if spread in the

community or the environment, but there are usually effective preventive measures or treatment. Specialized training is required to work with these micro-organisms. Examples are *Brucella* bacteria, Hantaan viruses.

Risk group 4 – high individual and community risk, a pathogen that usually produces life-threatening human or animal disease, represents a serious hazard to laboratory workers and is readily transmissible from one individual to another. Effective treatment and preventive measures are not usually available. Specialized training is required to work with these micro-organisms. Examples are Lassa, Ebola, Marburg viruses.

In addition to containing or destroying micro-organisms, several other approaches are used in **controlling the risk of infection** or other disease from these agents. They include:

- Administrative controls, which include pre-employment medical screening, regular physical and medical checks, temporary job reassignment for pregnant workers, and maintenance of medical records.
- Restricting access to approved workers where micro-organisms are manipulated.
- Standard work practices, which include prohibiting eating and drinking in the workplace, proper personal hygiene and disinfection procedures, using special protective clothing which is not worn outside the workplace.
- Disinfection or decontamination on a programmed basis of all floors, equipment, safety cabinets, laboratory benches.
- Vaccination programs when working with certain infectious agents, for example hepatitis A and B viruses, bacteria causing tetanus, tuberculosis, Q-fever, etc.
- Placarding with approved biohazard warning signs.
- Training of staff in the hazardous nature of micro-organisms, including safe handling and disposal procedures.

3.3.4 Psychosocial occupational factors

The work environment only represents one part of the total environment of human beings, but a very important part of the societal structure surrounding the individual. Psychological and physiological reactions that underlie the association between the psychosocial work environment and health are founded on interplay between individual and environment. Interest in the psychosocial aspects of the working environment has increased rapidly in recent years. Psychosocial factors are beginning to be incorporated as part of occupational medicine in many countries.

Psychosocial factors in work are gaining importance. They are related to changing attitudes and values towards work and also to the technical and organizational development of work. Computerization, automatization and the switch over to information production will lead, in all sectors, to reductions in manual work and to work of an increasingly abstract nature, largely based on sensual perception and activities of the central nervous system.

In addition to the positive effect on health (e.g. reduction in excessive physical load, decrease of occupational hazards), such changes in work patterns are bound to have some negative effects. The central nervous system and the senses of workers will become

increasingly stressed. Psychological monotony may increase and social contact at work may decrease dramatically. Educational requirements will increase and employees will be forced to adapt the changing nature of work by moving from one job to another through their working life. In some spheres, work will become an impersonal "dialogue" between the employee and computer.

Psychosocial factors can be classified into three closely interrelated categories: **work organization**, **general working conditions** and **type of work**.

Human factors include endogenous factors, such as age, sex, genetic factors, past psychological conditions, vulnerabilities, capacities and expectation and exogenous factors, such as family life, and society.

Health effects can be positive when they involve adaptation, coping, and qualification, or negative when stressors are beyond human tolerance.

All above mentioned factors are closely connected with the term of **stress**. Problems associated with “occupational stress” are now recognized as a central issue for those concerned with health and safety in the workplace. Perhaps because of the inherent subjectivity involved in its investigation, however, this is a field that excites considerable controversy and presents a variety of challenges.

The **effects of stress** on individual workers are usually considered in terms of:

1. **Effects on mental health**. A number of research studies have demonstrated a relationship between exposure to work-related stressors and mental health problems, typically in terms of an increase in symptoms of anxiety and depression. These problems may also be expressed as a range of non-specific physical symptoms such as headache, excessive fatigue, gastrointestinal problems and musculoskeletal pain.

2. **Effects on physical health**. Stress has been implicated as a contributory factor in a number of physical conditions, for example, gastrointestinal disorders, cardiovascular disorders, immune system disturbance, diabetes, etc.

3. **Effects on behaviour**, although clearly these different aspects may frequently overlap or interact.

Causes of stress may be considered under a number of headings:

- The person – lack of physical and mental fitness to do the job; inadequate training or skill for the particular job; poor reward and prospects; financial difficulties; fear of redundancy; lack of security in the job; home and family problems; long commuting distances.
- Work demand – long hours; shift work; too fast or too slow a pace; boring repetitive work; isolation; no scope for initiative or responsibility.
- Environment – noise; heat; humidity; fumes; dust; poor ventilation; diminished oxygen; confined space; heights; poor house-keeping; bad ergonomic design.

- Organization – poor industrial relations, welfare services and communications; inconsiderate supervision; remote management.

Work organization This includes such factors as workload, work pace and work schedule. In modern workplaces, these tend to be cited very frequently as sources of stress. Essentially, this refers to a situation in which there are numerous different competing demands such that many tasks remain half completed, awaiting further attention, or are completed unsatisfactorily with workers often attempting to carry out two or more tasks at the same time. The converse of this situation, which can be an equal source of stress, is the experience of routine, monotonous work that requires skills well below the capabilities of the worker.

Working hours With the advent of the 24-h society, the requirement for shiftwork and unsocial hours is increasing. A substantial body of research has indicated the potential for adverse health effects associated with shiftwork, including persistent fatigue, anxiety and depression, as well as longer term effects such as increases in coronary heart disease. It is generally accepted that shiftwork, particularly when this involves night work or rapidly rotating shifts, is a physiological and psychological stressor.

Although shiftwork is in many cases carried out by a "survivor" population who have successfully adapted to this form of working time, certain groups remain vulnerable, notably those with pre-existing health complaints, those requiring regular medication and also older workers who appear to become less tolerant to shiftwork with increasing age. In addition to shiftworking, concerns have focused on the potential adverse effects of long working hours, which have also been linked to an increased risk of cardiovascular complaints and deterioration.

Role Included here are positions involving tasks that are too difficult as a result of inadequate training, producing errors, negative feedback and time spent correcting mistakes. Other examples include the experience of excessive responsibility, unclear requirements, role ambiguity and situations in which differing and conflicting expectations emanate from different parts of the organization (role conflict).

Interpersonal relationships If there is no relationship of mutual trust and respect between the manager and the member of his team, the subordinate is likely to feel under pressure. These may be characterized by poor communication, distrust and conflict, or social isolation. Alternatively, relationships may be too demanding in terms of social exchanges and create feelings of lack of privacy. Associated with this, emotional contagion of anxious or depressed feelings can occur spontaneously in some circumstances.

Job overload One of the commonest causes of stress at work is overload: too much to do in too little time (quantitive overload) or work which is qualitatively beyond the individual's capacity (qualitative overload). Where there is quantitive overload the problem will be compounded if the employee has little or no control over the load. Machine-paced work has long been recognized as a source of pressure. This applies not only to process workers but also to those working with display screen equipment who are dependent on the timescale which the electronics can achieve. It is common for an employee to perceive that he is

overloaded but be unable to find any solution, or at least any solution not perceived as making him vulnerable to management censure.

Underload, although less common, may cause great anxiety where there are to be job losses or where the individual loses self-esteem because he is not making a worthwhile contribution.

Therefore, the management of stress essentially involves:

1. A recognition of the problem;
2. An assessment of the nature and scale of the problem;
3. The development of intervention strategies for control.

Added to this is a requirement for on-going evaluation of the situation to monitor the effectiveness of any policies that have been implemented.

Burn-out syndrome Close contact with other human beings brings human suffering into focus. In the health care sector, the workers have to take an active, inescapable part in the suffering of others. On the one hand this is stimulating and enables the expansion of coping ability. On the other hand, the close exposure to suffering increases the risk that the worker may develop "burn-out". Burn-out has been described as the psychological equivalent of a battery that is not chargeable any more. The worker is not able to become normally engaged in work. Three different components of burn-out have been described:

- **Emotional exhaustion**, the inability to experience normal feelings – this results in lack of any kind of emotional reaction to situations that normally arouse depression, anger, anxiety or joy.
- **Depersonalization**, the feeling that one is profoundly changed as a person, not the same as one was used to being.
- **Lack of personal accomplishment**, the feeling that the person cannot achieve anything. Emotional exhaustion is more often found in women and the other two components more often in men.

There are many questionnaires available for the exploration of the psychosocial work environment. **Standardized questionnaires** have to be supplemented with questions that are specific to the work site and the occupation that is being explored. A great advantage of the standardized questionnaires is that it is possible to compare the collected information with that obtained from large reference groups – which may provide answers regarding the relative level of difficulties in the work site studied.

There are also three general categories of approaches and strategies which can be applied:

- improve job content and organization in order to control psychosocial risk factors at work;
- monitor changes in work situation, workers` health and their relationship, and
- increase awareness, inform, train, educate.

3.3.5 Specific groups of workers

3.3.5.1 Women workers

In the past, little research in occupational health has concerned women. However, the rise in the number of women in the labor force has sensitized public health practitioners, workers, and scientists to the necessity to include women's concerns in their occupational health activities.

Women and men differ, on average, on almost all anthropometric dimensions: height, weight, body segment length, sitting height, etc. Their physical strength also differs. A number of hormonal and physiological sex differences have been found or suggested that may lead to differences in susceptibility to disease, including occupational disease. A number of studies have found a difference in symptoms between women and men workers even after controlling for workplace exposures to risk factors for musculoskeletal or toxic effects.

Women's social roles affect their movements in and out of employment. Thus, the "healthy worker effect" (defined as a tendency for workers to be healthier than the general population) manifests itself in specific ways with women workers. Their reproductive health may affect their employment status, so that reproductive ill health may be more characteristic of working women than those not working. Women's most common self-reported health problems are musculoskeletal problems, headaches, allergies including skin problems, and hypertension. Women are also much more likely than men to report psychological distress. Workplace conditions are relevant to all these conditions.

It has been adopted a directive aimed at improving the health and safety of pregnant workers, those who have recently given birth and those who are breast-feeding. Under this comprehensive amendment a special risk assessment is required with respect to women who fulfill the above conditions. Where a risk is demonstrated, the hours of work or working conditions should be altered to avoid the risk where it is reasonable to do so. If it is not possible to remove the risk and alternative work is not available then the employee must be suspended with continued remuneration.

The hazards which must be assessed may be chemical, physical or microbiological:

Chemical hazards The area which has probably caused most concern is that of chemical hazard to reproduction. Several groups of chemicals have been implicated in causing reproductive impairment (i.e. lead, cytotoxic drugs, anaesthetics, etc.).

Physical hazards – i.e. ionizing radiation, some non-ionizing radiation (ultraviolet), noise, etc.

Microbiological hazards Chicken pox (varicella), rubella and cytomegalovirus infection during pregnancy can have an adverse effect on the fetus. Pregnant women should avoid exposure to these infections.

3.3.5.2 Youth workers

Youth work is defined as employment of children less than 18 years of age. Employment in any hazardous occupation is prohibited for anyone less than 18 years old. Thus, no one under age 18 may work in mining, logging, brick and tile manufacture, roofing, excavating, or as a helper on a vehicle or on power-driven machinery. As in all injury interventions, the best approach to prevention includes a combination of education, engineering, and policy and enforcement options, and includes the necessity for surveillance in order to measure how any of these alone and in combination are working.

3.3.5.3 Older workers

In some developed countries, there will be more workers in older age groups because of later retirement, economic necessity, longer life expectancies, and the aging of the population. There are concerns that normative aging changes and underlying chronic medical conditions may affect older workers' ability to carry out their work. Needed research areas include improved data (including data on costs of occupational injury and illness in older workers); targeted research on exposures, effects of chronic underlying health conditions; and identification and evaluation of interventions (including public policies, job design, training, accommodations, and worksite health promotion.

3.3.6 Work related health damage

3.3.6.1 Occupational diseases

Occupational diseases or diseases caused by work exposures may occasionally result from single massive exposures but usually result from exposures to the causative agent over a period of time.

Time factor The disease may take some time to develop, ranging from minutes to years. Some health effects appear long after exposure has ceased. Consequently it is important to recognize that workplace exposure to hazardous substances can be equated to accidents occurring over a long timespan. The typical timespan for asbestos-related diseases, for example, may be 15 years for asbestosis, 20 years for lung cancer, and 30 years for mesothelioma.

Damage factor In occupational disease, tissue damage may or may not occur where the causative agent is applied. For example, inhaled quartz dust has a direct effect on the lungs, but inhaled solvent vapours may produce effects on the liver or on the brain such as headache or drowsiness. In addition, subtle changes which are not obvious to the worker may occur to body functions. For example, small amounts of lead produce changes to blood formation even though the person remains quite well, whereas absorption of larger amounts will cause frank illness.

Dose factor Disease may be caused by a single large exposure or many small exposures to a workplace hazard. The likelihood of disease depends on the dose received. There may be

some threshold dose, below which there is no adverse effect, which will vary depending on the hazard. It will be very small for highly hazardous agents, and large for those of lower hazard (Figure 3.6). Different doses can provoke different responses in the case of exposure to dusts, metals, gases and vapours. The dose to which a worker is exposed affects the interpretation of risk and the kinds of controls it should be used.

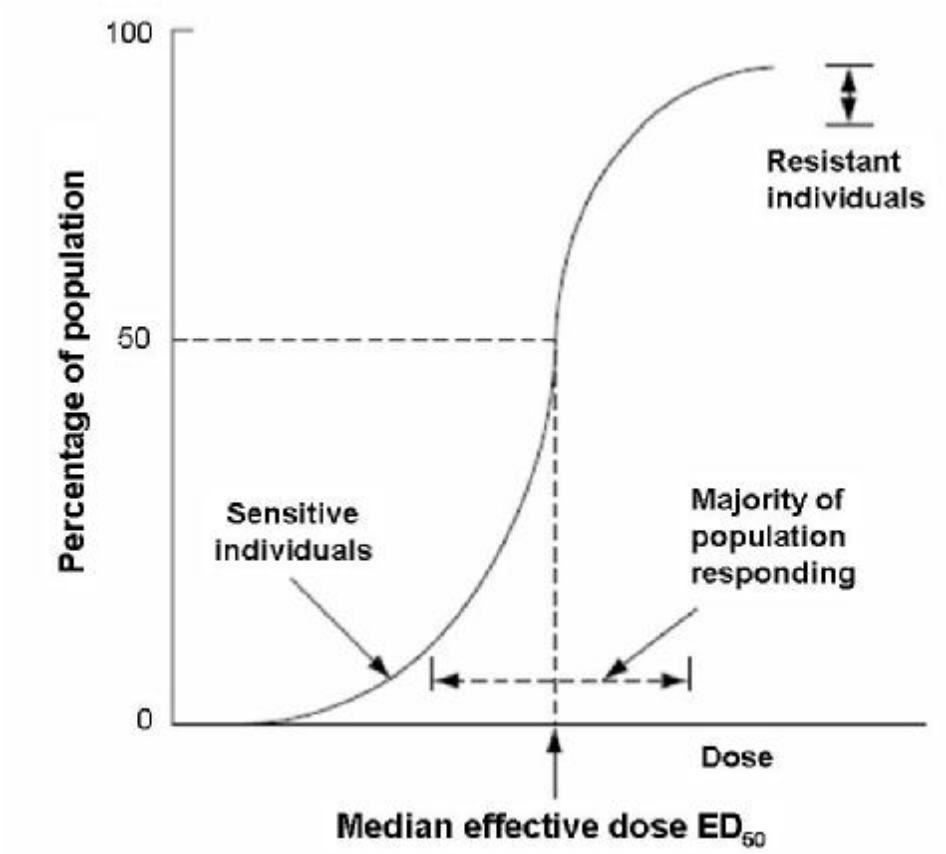

Figure 3.6 Typical dose-response curve (Source: Gardiner and Harrington, 2005)

Because of these three factors, **time**, **damage** and **dose**, the link between cause and the resulting occupational disease may not be immediately obvious. Therefore, to prevent disease, or to detect minor change early before the worker becomes ill, it is essential to have knowledge of the conditions in the workplace which make it a risk to health. Detection and prevention of disease require an understanding of a wide array of work situations and knowledge of the effects that various hazardous agents can have on workers.

The prevention of occupational diseases continues to be an important issue for occupational health professionals. In addition work-related diseases (e.g. low back pain, hypertension etc.) will constitute an increasing challenge. Their multiple etiologies complicate the identification of the causes, which only partly have occupational origin.

3.3.6.2 Occupational injuries

Occupational injuries are defined as any damage to the body by energy transfer during work with a short duration between exposure and the health event (usually less than 48 h).

Occupational injuries are distinct from occupational diseases in that they are caused by acute exposure in the workplace to physical agents such as mechanical energy, electricity, chemicals, and ionizing radiation, or from the sudden lack of essential agents such as oxygen or heat. Examples of events that can lead to worker injury include motor vehicle crashes, assaults, falls, being caught in parts of machinery, being struck by tools or objects, and submersion. Resultant injuries include fractures, lacerations, abrasions, burns, amputations, poisonings, and damage to internal organs.

Accident results from both environmental hazards and human factors. The contributing **environmental factors** include the layout of the workplace, unsatisfactory machine guards, inadequate maintenance of equipment, defective lighting, excessive noise and vibration, unsuitable floors, etc. **Human factors** involve poor adaptation to the industrial mechanized environment, the attitude towards work, and incorrect methods of work. In addition, the physical and physiological capacities of the worker may not meet the job requirement (e.g. visual activity may be inadequate), the worker may suffer from hearing loss or other forms of incapacitation, his psychological state (alertness), may be unsatisfactory, failure to observe safe practices and to make proper use of personal protective equipment.

Other occupational health damages are occupational poisoning, mental health disorders, non-specific health damage, and occupational health jeopardizing.

3.3.6.3 Health damage prevention strategies

Occupational health surveillance can contribute to improved prevention of occupational disease and injury. Health examinations at work are the “inputs” for programs aimed at early identification of adverse effects to reduce disease in individuals and for programs of surveillance designed to identify new hazards, track trends, and evaluate the adequacy of interventions for groups of workers.

Hazard surveillance is another significant element in comprehensive occupational disease and injury prevention efforts. The development and conduct of any successful program that includes health examinations must address critically important ethical issues including those of worker autonomy and confidentiality. The results of health examinations and hazard information, thoughtfully analyzed, can help target preventive interventions. Surveillance systems can contribute to prevention but do not, in themselves, prevent disease or injury. This is done through the recognition and control of hazardous exposures at work.

After an offer of employment is made, but before or soon after work is initiated, workers may undergo selective or comprehensive **health examinations**. Ethically and legally, these examinations may not be used to exclude the worker from employment but may be used to guide proper placement for the worker, identify educational and training needs, assist in the selection of personal protective equipment, and identify necessary work-station design or other kinds of accommodations needed for workers with disabilities. These examinations are more likely to take place when known hazardous exposures are anticipated, and some are mandated by legal health standards.

Medical screening examinations attempt to identify health effects from work exposures at an earlier stage than they would ordinarily be detected by the worker without the examination. In general, after a positive screening test is confirmed, available, acceptable interventions must be able either to reverse the detected abnormality or to reduce the severity of the outcome. Screening is intended to benefit the screened individuals. Screening programs may also indirectly benefit other similarly exposed workers if the detection of work related health effects trigger an investigation of the workplace and efforts to reduce hazardous exposures or change unsafe working conditions. If large groups are tested periodically, the resulting data can be analyzed to identify group trends as part of a surveillance program.

Screening examinations may include administration of questionnaires, physical examinations, and clinical tests such as tests of pulmonary or liver function. Screening examination should be voluntary and are intended to benefit the individual worker who is screened. Therefore, the screening tests used in these one-time or periodic examinations should be evaluated to ensure that the tests are effective for screening objectives and pose minimal risk.

Some standards mandate medical examinations as part of a comprehensive approach to prevention. For example, people exposed to asbestos or cotton dust in general industry must be offered periodic pulmonary examinations; lead-exposed workers must undergo periodic blood lead analyses; and workers exposed to excessive noise must be offered periodic audiometry. Examinations either focus on the primary “target organ” of the toxin, as with asbestos, or involve biological monitoring as with lead.

Prevention strategies Over the years, a number of models for occupational injury prevention have evolved. There are prominent and complementary approaches that use a systematic approach to identify points of intervention, and a hierarchy of controls, with an emphasis on controls that minimize the role of human behavior.

A comprehensive approach to worker injury prevention efforts inevitably includes all tiers of the control hierarchy to achieve maximum worker protection. In most work environments, a combination of engineering controls, administrative controls, and PPE will be required to have a complete and effective injury prevention program.

4. RADIATION AND HEALTH HAZARDS

4.1 IONIZING RADIATION

Radiation has always been a natural part of our environment. Natural radioactive sources in the soil, water and air contribute to our exposure to ionizing radiation, as well as man-made sources resulting from mining and use of naturally radioactive materials in power generation, nuclear medicine, consumer products, military and industrial applications.

Naturally occurring ionizing radiation originates both from outside the body in the form of cosmic radiation from natural radioisotopes in the environment, and from inside the body from natural radioisotopes deposited from food, drink and air.

During the present century, mankind has been subjected to increasing levels of ionizing radiation from man-made sources, such as X-ray equipments, nuclear weapons, the nuclear fuel cycle, and artificial radioisotopes used for medical and other purposes.

Ionizing radiation may be divided into two main groups: electromagnetic radiations of short wave length and high energy (e.g. X-rays and gamma rays), and particulate radiations, which vary in mass and charge (e.g. electrons, protons, neutrons, alpha particles, and other atomic particles). Some of them – alpha particles, beta particles (electrons), and protons are electrically charged, whereas others (neutrons) have no electric charge.

Ionizing radiation, impinging on a living cell, collides randomly with atoms and molecules in its path, giving rise to ions and free radicals and depositing enough localized energy to damage genes, chromosomes, or other vital macromolecules. The distribution of such events along the path of the radiation – that is, the quality or **linear energy transfer** (LET) of the radiation – varies with the energy and charge of the radiation, as well as the density of the absorbing medium. Along the path of an alpha particle, for example, the collisions occur so close together that the radiation typically loses all of its energy in traversing only a few cells, whereas along the path of an x-ray the collisions are far enough apart so that the radiation may be able to traverse the entire body (Table 4.1).

The common characteristic of all types of radiation referred to, whether electromagnetic or corpuscular, is that particles are responsible for the ionization they ultimately produce. The interested reader is encouraged to consult the reviews in physics.

4.1.1 Basic terminology and definitions

The following terminology covers some aspects of the characteristics, measurement, and effects of radiation. **Radioactivity** is the property of spontaneous disintegration possessed by certain unstable types of atomic nuclei (called radionuclides). The disintegration is

accompanied by the emission either alpha- or beta-particles and/or gamma rays. Natural radioactivity is due to the disintegration of naturally occurring radionuclides. The rate at which radionuclides disintegrate is not influenced by any chemical changes, any normal changes of temperature or pressure, or by the effects of electric or magnetic fields. However "induced" or "artificial" radioisotopes of most elements can be formed by bombardment with particles (e.g. neutrons) or photons in a nuclear reactor or accelerator.

Table 4.1 Differences among various types of ionizing radiation in penetrating power in tissue (Source: Upton, 2008)

Type of radiation	Source	Range in tissue
alpha	^{210}Po 5.3 MeV	Range 0.037 mm
beta	^{14}C 0.154 MeV maximum energy	Maximum range 0.29 mm (typically less)
beta	^{32}P 17.1 MeV maximum energy	Maximum range 8 mm (typically less)
gamma	^{125}I 0.035 MeV	Average distance to collision 33 mm
gamma	^{60}Co 1.33 MeV	Average distance to collision 164 mm.

Alpha particles are particles with two neutrons and two protons that are emitted spontaneously during the radioactive decay of radionuclides of high molecular weight. They do not penetrate matter easily because of their large size and double-positive charge. Alpha particles can be stopped by a piece of paper and, thus, generally will fail to penetrate the skin. If inhaled or ingested, however, alpha particles produce a high degree of ionization in immediately adjacent tissues. Alpha particles irradiate the body's cells and may act as carcinogens or initiate other adverse health effects.

Beta particles have the mass of one electron and vary greatly in their ability to penetrate tissues, depending on initial energy and density of matter. As beta particles traverse matter, they lose energy and velocity and the lost energy is emitted as photons or electromagnetic radiation. Only modest thicknesses of commonly available materials are sufficient to stop beta radiation completely. Beta decay can refer to release of either an electron (negatively charged) or a positron.

Gamma rays represent an electromagnetic radiation emitted as packets of energy (photons) during the nuclear decay of certain radionuclides. Gamma rays are the most highly penetrating type of radiation; they can pass through the body with great ease. When they interact with tissue, they can produce adverse effects, even though their source is external to the body.

X-rays are electromagnetic radiation and are similar to and have the same properties as gamma rays. They are of considerable importance in medicine. X-rays are produced

artificially in an evacuated tube by acceleration of electrons from a heated element to a metal target with voltages in excess of 16 kV.

Neutron radiation is a neutron emitted by an unstable nucleus, in particular during atomic fission and nuclear fusion. Apart from a component in cosmic rays, neutrons are usually produced artificially. Neutrons, due to their electrical neutrality, can be very penetrating and when they interact with mater or tissue, they cause the emission of beta and gamma radiation.

Cosmic radiation is a mixture of many different types of radiation, including protons, alpha particles, electrons and other various high energy particles. All these particles interact strongly with the atmosphere.

Quantities and dose units of ionizing radiation are in the Table 4.2.

To describe a dose (the amount of energy deposited in the body when a beam of radiation is absorbed there) the units of gray and sievert are used.

Gray (Gy) is defined in terms of the amount of energy absorbed in a given weight of body tissue. It is an SI measure of absorbed dose of ionizing radiation, the energy in joules absorbed by one kilogram of irradiated material. The gray unit replaced in scientific nomenclature an older cgs unit rad.

Sievert (Sv) is a unit taking into account the biological damage that might result from the absorbed energy. 1 Sv = the dose in grays multiplied by an appropriate RBE (relative biologic effectiveness) quality factor. The quality factor takes into account the relative biological hazard of the different types of particles (Table 4.2). Thus 1 Sv of any type of radiation represents the dose that is equivalent in biologic effect to 1 Gy of gamma rays. The corresponding cgs unit is the rem.

Table 4.2 Quantities and dose units of ionizing radiation (Source: Upton, 2008)

Quantity being measured	**Definition**	**Dose unit***
Absorbed dose	Energy deposited in tissue	Gray (Gy)
Equivalent dose	Absorbed dose weighted for the relative biological effectiveness of the radiation	Sievert (Sv)
Effective dose	Equivalent dose weighted for the sensitivity of the exposed organ(s)	Sievert (Sv)
Collective effective dose	Effective dose applied to a population	Person - Sv
Committed effective dose	Cumulative effective dose to be received from a given intake of radioactivity	Sievert (Sv)
Radioactivity	One atomic disintegration per second	Becquerel (Bq)

* The units are those of the International System, introduced in the 1970s to standardize usage throughout the world. They have largely supplanted the earlier units; namely the rad (1 rad = 100 ergs/g = 0.01 Gy); the rem (1 rem = 0.01 Sv); and the curie (1 Ci = 3.7×10^{10} disintegrations per second = 3.7×10^{10}Bq).

For the purpose of describing an amount of radioactive material, the rate at which radiation is emitted by called activity is used. Becquerel (Bq) represents derived SI unit of

activity (radioactive). 1 Bq equals the quantity of radioactivity in which there is one atomic disintegration per second. It replaces the old cgs system unit the curie.

Equivalent dose is equal to the absorbed dose multiplied by a factor that takes into account the ways in which a particular type of radiation distributes energy in tissue so that we can allow for its relative effectiveness to cause biological harm. For gamma rays, X rays, and beta particles, this radiation-weighting factor is set at 1, for alpha particles, the factor is set at 20, values of the radiation weighting factor for neutrons of various energies range from 5 to 20 (Table 4.3). It is expressed in a unit called the sievert, symbol Sv.

Table 4.3 Radiation weighting factors
(Source: ICRP, 1991; Council Directive 96/29/EURATOM; Government regulation of Slovak Republic No 345/2006)

Radiation type	**Radiation weighting factor, w_R***
Photons	1
Electrons and muons	1
Protons >2 MeV	5
Alpha particles, fission fragments, heavy nuclei	20
Neutron energy <10 keV	5
Neutron energy 10 to 100 keV	10
Neutron energy >100 keV to 2 MeV	20
Neutron energy ≥2 to 20 MeV	10
Neutron energy >20 MeV	5

* Radiation weighting factor, w_R weights the absorbed dose for the relative biological effectiveness of different types of radiation and is independent of the type of tissue.

Effective dose is the equivalent dose weighted for the sensitivity of the exposed organ (s). It is measured in sievert (Sv). Table 4.4 lists some tissue-specific weighting factors. The list of organs most at risk includes gonads, breasts, red bone marrow and lungs. With the help of weighting factors we can calculate for irradiation of the single organ with equivalent dose to standard characteristic – effective dose. The effective dose accounts for the fact that the same equivalent dose to different tissues of the body may present different degrees of risk to the individual. The effective dose caused by irradiation of a particular tissue is numerically equal to the uniform whole-body dose that is expected to have the same probability of cancer or genetic effects as associated with the partial-body irradiation.

Collective effective dose is the quantity used to express the total radiation dose to groups of people or a whole population. It is obtained by adding, for all exposed people, the effective dose that each person in that group or population has received from the radiation source of interest. The effective dose from all sources of radiation is on average 2.8 mSv in a year. Since the world population is about 6,000 million, the annual collective effective dose to the whole population is about 17,000,000 man Sievert, symbol man Sv.

The uptake, distribution, and retention of an internally deposited radionuclide vary, depending on the physical and chemical properties of the element in question. Once deposited, the amount of radioactivity remaining in situ decreases with time as a result of both physical

decay and biological removal. The physical half-lives of the different radionuclides vary, from less than a second in some to billions of years in others. Biological half-lives also vary, tending to be longer with radionuclides that localize in bone (e.g., Ra, Sr, Pt) than with those that are deposited predominantly in soft tissue (e.g. I, Cs, T). For ^{131}I, it is 8 days; ^{137}Cs, 30 years; ^{14}C, 5,730 years, ^{239}Pt, 24,000 years and ^{238}U, 4,470 million years. In successive half-lives, the activity of a radionuclide is reduced by decay to ½, ¼, 1/8 of its initial value. As the amount of a radionuclide decreases, the radiation emitted decreases proportionately.

Table 4.4 Tissue weighting factors used in the calculation of an effective dose (Source: ICRP, 1991; Council Directive 96/29/EURATOM; Government regulation of Slovak Republic No 345/2006)

Tissue or organ	**Tissue weighting factor w_T**
Gonads	0.20
Red bone marrow	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Liver	0.05
Oesophagus	0.05
Thyroid	0.05
Skin	0.01
Bone surfaces	0.01
Remainder	0.05
Whole body total	**1.00**

Calculation of effective dose

Consider a circumstance in which a radionuclide causes exposure of the lung, the liver, and the surfaces of the bones.

Suppose that the equivalent doses to the tissues are, respectively, 100, 70, and 300 mSv.

The effective dose is calculated as (100 x 0.12) + (70 x 0.05) + (300 x 0.01) = 18.5 mSv.

The calculation shows that the risk of harmful effects from this particular pattern of radiation exposure will be the same as the risk from 18.5 mSv received uniformly throughout the whole body.

4.1.2 Radiation sources and levels

Life has evolved in the continuous presence of natural background radiation. The major sources of natural background radiation to which the human population is exposed are (a) cosmic rays, which originate in outer space; (b) terrestrial radiations, which emanate from the thorium, uranium, radium, and other radioactive constituents of the earth's crust; (c) internal radiation, which is emitted by the ^{40}K, ^{14}C, Ra, and other radionuclides normally present in living cells; and (d) Rn and its daughter elements which are inhaled in indoor air (Figure 4.1).

In addition to natural background radiation, populations in the modern world are exposed to radiation from various artificial sources as well. The largest such source is the use of x-rays in medical diagnosis. Lesser sources include (a) radioactive minerals in building materials,

phosphate fertilizers, and crushed rock; (b) radiation-emitting components of TV sets, video display terminals, smoke detectors, and other consumer products; (c) radioactive fallout from nuclear weapons and nuclear accidents; and (d) radionuclides released in the production of nuclear power.

Additional doses of radiation are received by workers in various occupations, depending on their particular work assignments and working conditions. Radiation accidents have been another source of exposure for workers and members of the public.

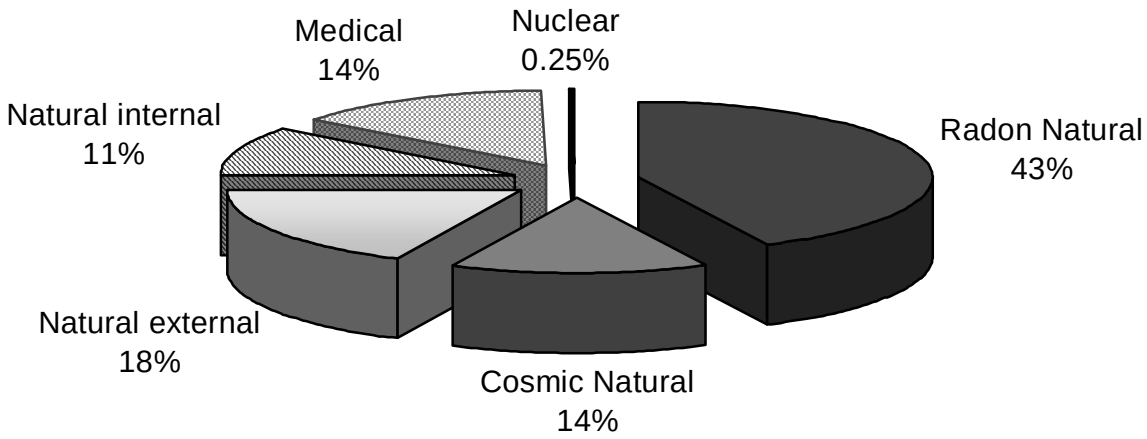

Figure 4.1 Average radiation exposure from all sources (annual effective dose = 2.8 mSv) (Source: UNSCEAR, 2000, Report to the General Assembly)

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) regularly publishes data on doses from all sources. The results of the review published in 2000 are in the Figure 4.1. The annual dose, averaged over the population of the world, is about 2.8 mSv in total. Over 85 % is from natural sources with about half coming from radon decay products in the home. Medical exposure of patients accounts for 14 per cent of the total. All other artificial sources (fallout, consumer products, occupational exposure, and nuclear industry) account for less than 1 % of the total value (Table 4.5)

Radon is a significant contributor to the dose incurred from background radiation. Radon contributes to the problem of indoor air pollution. It is discussed more fully later in the text. **Cosmic radiation** consists of galactic cosmic rays, intermittent solar particle radiation, and the secondary particles that result mainly from the interaction of the galactic cosmic rays and the atmosphere. The atmosphere absorbs not only ultraviolet radiation but also cosmic radiation. It acts as an effective shield, reducing the cosmic radiation dose by perhaps three orders of magnitude. On earth, most of the cosmic radiation consists of secondary particles. **Medical exposures** represent more than 90 % of the dose received from man-made sources and it is mostly from medical and dental diagnostic procedures. Because of the wide variations in the techniques used in the large number of different types of radiological examinations, exact estimates of the collective effective doses are difficult.

Table 4.5 Average annual doses to the world population from all radiation sources (Source: UNSCEAR, 2000; IAEA, 2004)

Source	Dose [mSv]
Natural	
Cosmic	0.4
Gamma rays	0.5
Internal	0.3
Radon	1.2
Artificial	
Medical	0.4
Atmospheric nuclear testing	0.005
Chernobyl	0.002
Nuclear power	0.0002
Total (rounded) mSv	**2.8**

4.1.2.1 Radiation from nuclear tests fallout

Nuclear tests caused large quantities of radioactive substances to be injected into the stratosphere, from where they have continued to fall back to earth until the present time.

Those substances that decay rapidly have largely vanished. but radioisotopes, such as ^{90}Sr and ^{137}Cs, are still falling today in small quantities.

Regarding the nuclear power plant accidents the major two have occurred at nuclear power plants. These were at Three Mile Island (TMI) and Chernobyl, but off-site releases of radionuclides were many orders of magnitude less from TMI than those from Chernobyl.

The immediate area of the accident (with a radius of up to a few tens kilometers) is referred to as the "near field”. Urgent action such as sheltering, evacuation. and decontamination of individuals may be necessary. Administration of stable iodine tablets may also have to be part of emergency response where radioiodines are released in significant quantities.

Radionuclides can spread over very large areas – referred to as the "far field". Food control and other appropriate authorities will need to consider effects on food availability and trade.

4.1.2.2 Radiation from radioactive contamination by other sources

Four main groups of uses might in the future be considered as sources of environmental contamination, namely: nuclear power reactors and other reactors, reprocessing plants and "hot" laboratories, medical application of radioisotopes. Nuclear reactors and reprocessing plants are the most important. Medical application involves mainly short-lived isotopes. Their extent is limited by the amounts of radioactivity acceptable to patients and the number of applications, which in turn depends on the number of potential patients. Other applications are too limited in scope at the present time.

4.1.2.3 Radiation from radioactive consumer goods and from electronic devices

"Small sources" of radiation include the luminous dials and wrist watches, and alarm clocks, shock-fitting X-ray fluoroscopes, television sets, and the continually increasing number of applications of radioactive substances. Altogether they contribute not more than 1-2 % of the natural background radiation.

4.2 BIOLOGICAL EFFECTS OF IONIZING RADIATION

Most adverse health effects of radiation exposure may be grouped in two general categories:

1. deterministic (non-stochastic, threshold) effects (harmful tissue reactions) due in large part to the killing/ malfunction of cells following high doses; and

2. stochastic (non-threshold) effects, i.e. cancer and heritable effects involving either cancer development in exposed individuals owing to mutation of somatic cells or heritable disease in their offspring owing to mutation of reproductive (germ) cells.

Consideration is also given to effects on the embryo and fetus (ICRP, 1991).

Radiation exposure can be short-term (as in an industrial accident or atomic explosion) or long-term (as in household radon or occupational exposure to cosmic radiation among airline employees). Acute exposure can produce immediate effects (the acute radiation syndrome), chronic disease, or diseases such as cancer that become apparent only after a latency period of many years (Table 4.6).

The process of ionization in human tissues may alter the atoms and molecules of the cells to the extent of irreparable damage or death. The clinically relevant aspect of exposure is to determine the relationship between dose and response.

Effects of ionizing radiation on humans can be divided into somatic effects from short- or long-term exposure and genetic effects, including reproductive effects and cancer (Table 4.6).

Tab. 4.6 Immediate and late effects of radiation exposure

<table>
<tr><th>Immediate</th><th colspan="3">Late</th></tr>
<tr><th colspan="3">Somatic</th><th>Genetic</th></tr>
<tr><td>Acute radiation syndrome
Acute local impairment</td><td colspan="2">Late impairments other than cancer</td><td rowspan="2">Cancer</td><td rowspan="2">Genetic effects</td></tr>
<tr><td colspan="3">Fetal impairment</td></tr>
<tr><th colspan="3">Nonstochastic</th><th colspan="2">Stochastic</th></tr>
</table>

Radiation doses of different sizes, delivered at different rates to different parts of the body, can cause different types of health effect at different times.

4.2.1 Acute radiation syndrome

The acute radiation syndromes are divided into the hematopoietic, gastrointestinal, and central nervous (CNS) syndromes. The first two syndromes are caused by depletion of stem cells. In the two latter syndromes, damage to the vasculature plays a role, and in the CNS syndrome the principal damage is to membranes. It is important to understand that the syndromes are not discrete: the damages to gut, bone marrow, and vasculature interact. The clinical signs and symptoms are characteristic of both the organ system that is most affected and the doses absorbed (Table 4.7).

Table 4.7 Major forms and features of the acute radiation syndrome (Source: UNSCEAR, 1988; Upton, 2008)

Time after irradiation	**Cerebral form (> 50 Sv to brain)**	**Gastrointestinal form (10 – 20 Sv to intestines)**	**Hematopoietic form (2 – 10 Sv to bone marrow)**	**Pulmonary form (> 6 Sv to lungs)**
First day	Nausea Vomiting Diarrhea Headache Disorientation Ataxia Coma Convulsions Death	Nausea Vomiting Diarrhea	Nausea Vomiting Diarrhea	Nausea Vomiting
Second week		Nausea Vomiting Diarrhea Fever Erythema Prostration Death		
Third-sixth weeks			Weakness Fatigue Anorexia Fever Hemorrhage Epilation Recovery or Death	
Second-eighth months				Cough Dyspnea Fever Chest pain Respiratory failure

In each of the forms, anorexia, nausea, and vomiting typically occur within minutes or hours after irradiation, to be followed by a symptom-free interval that lasts until the onset of the main phase of the illness.

At Hiroshima more than half of the blast survivors living in Japanese-style homes within 0.6 miles of the atom bomb epicenter succumbed from radiation illness. Acute exposure in excess of 50 Sv can produce cerebral damage leading to confusion, convulsions, coma and death.

4.2.2 Chronic deterministic effects

The main effects are thyroid damage, sterility and cataracts. Other effects include growth and development effects and life shortening. Examples of deterministic effects are the induction of temporary and permanent sterility in the testes and ovaries; depression of the effectiveness of the blood forming system, leading to a decrease in a number of blood cells; skin reddening, desquamation and blistering, possibly leading to a loss of skin surface; induction of opacities in the lens and visual impairment (cataract); and inflammation processes that may occur in any organ. Some effects are indirect and they result from deterministic effects on other tissues. For example, radiation that leads to the inflammation and fibrosis of blood vessels may result in damage to the tissues served by those blood vessels

4.2.3 Health effects other than cancer

Somatic effects of radiation on humans are changes that affect the individual and can range from cellular to whole organism and can be sublethal or lethal. Somatic chromosome abnormalities can be found in the general population at low levels but are numerous in cancer cells. The most vulnerable tissues are those with the most rapid cell turnover.

Chromosomal and DNA aberrations The chromosomal aberrations and DNA damage can also occur in somatic cells. Any cell can be killed by a large enough dose of radiation. but a dose of only 1 to 2 Sv is sufficient to cause human cells to cease to divide.

Immune response The cells involved in the immune response exhibit a broad range of radiosensitivities. Some lymphocytes are exceedingly radiosensitive, but plasma cells and macrophages are very resistant. In general, irradiation inhibits the immune response and radiation victims frequently succumb to infection. Recent experiments with animal models have demonstrated that radiation exposure can also be associated with augmentation of the immune system. This so called „radiation hormesis“ is the unproven theory that a low level of ionizing radiation (i.e. near the level of Earth's natural background radiation) helps "immunize" cells against DNA damage from other causes (such as free radicals or larger doses of ionizing radiation), and decreases the risk of cancer. The theory proposes that such low levels activate the body's DNA repair mechanisms, causing higher levels of cellular DNA-repair proteins to be present in the body, improving the body's ability to repair DNA damage. This assertion is very difficult to prove in humans (using, for example, statistical cancer studies) because the effects of very low ionizing radiation levels are too small to be statistically measured. Therefore, the idea of radiation hormesis is considered unproven by regulatory bodies. The internationally accepted hypothesis is that the dose-response relationship for stochastic effects of ionizing radiation (cancer) is linear also for low doses all

the way to zero (linear – no threshold – LNT hypothesis), i.e. that any radiation has a detrimental effect, however small.

Growth and development Injurious effects of ionizing radiation on the developing brain have been found in the atomic-bomb survivors who were exposed in utero and show a dose-dependent increase in the incidence of severe mental retardation if exposure occurred at gestational age of 16 – 25 weeks. Analysis of the epidemiological data shows the maximal sensitivity of the brain occurs between 8 and 15 weeks of gestation.

Cataracts Cataract formation, or opacification of the lens of the eye, results from the irradiation to the lens in excess of 0.6 to 1.5 Gy. Although detectable damage to the lens can occur from a dose as low as 1 Gy, the threshold for vision-impairing cataracts under conditions of recurrent or protracted exposure is thought to be at least 8 Sv.

Fertility and sterility The estimated threshold dose equivalent for temporary sterility in the human testis is 0.15 Sv; for permanent sterility it is 3.5 Sv when received as a single dose. The corresponding threshold dose for permanent sterility in the adult human ovary is 2.5 to 6.0 Sv in a single exposure and 6.0 Sv when received in a protracted exposure.

4.2.4 Cancer

The cause of radiation-induced cancer is complex and incompletely understood. The risk of such cancer depends on the type of radiation, the age and sex of the exposed person, the magnitude of the dose to the target organ, the quality of the radiation, the nature and timing of exposure, the presence of other carcinogens or promoters, and individual characteristics of the exposed person. Because the most common cancers attributed to radiation also occur in unexposed people, it continues to be a challenge to identify whether a particular cancer was caused by excess radiation or any other environmental factor.

Cancers of various types have been observed to increase in frequency with the dose of ionizing radiation in atomic bomb survivors, radiotherapy patients, early radiologists, radium dial painters, uranium miners, and other irradiated human populations. Mostly lung cancer, leukemia, female breast cancer and cancer of thyroid gland are discussed.

Lung cancer Results from the Japanese atomic bomb survivors and from several groups of patients with acute high-dose exposures show elevated risks of lung cancer associated with external low-LET radiation. The large influence of smoking on lung cancer risks is to be of great importance in determining radiation-induced risks. There is a suggestion that the joint effect of low-LET radiation and smoking is closer to an additive than a multiplicative relationship. The UNSCEAR 2000 report summarized the results of various epidemiological studies of underground miners and people exposed in residences and concluded there was a strong evidence for an association between lung cancer and exposure to radon daughters.

Leukemia The frequencies of all major types of leukemia, except chronic lymphocytic leukemia, have been observed to increase with dose after exposure of the whole body or a major part of the hemopoietic system. In A-bomb survivors and other irradiated populations,

the increases have appeared within 2 – 5 years after exposure; have been dose-dependent, averaging approximately 1 – 3 cases per 10,000 persons per year per Sv to the bone marrow over the first 25 years after irradiation; and have persisted for 15 years or longer, depending on the type of leukemia, age at irradiation, and other variables.

Breast Cancer The incidence of breast cancer has appeared to increase in proportion to the radiation dose in women surviving A-bomb irradiation, women given radiotherapy to the breast, women fluoroscoped repeatedly and women employed as radium dial painters. In all four groups, the excess did not become evident until at least 5 – 10 years after irradiation, depending on age at the time of exposure, and it has persisted for the duration of follow-up.

Thyroid Gland Dose-dependent excesses of thyroid cancer have been observed in A-bomb survivors, patients treated with x-rays for various benign conditions in childhood, Marshall Islanders and others exposed during childhood to radioactive fallout from nuclear weapons tests, and children exposed to radionuclides from the Chernobyl accident. The cancers have consisted mainly of papillary carcinomas and have typically been preceded by a latent period of 10 years or longer, after which their frequency has remained elevated for the duration of follow-up. Children appear to be several times more susceptible to the induction of such tumors than adults, and females several times more susceptible than males.

Information about risk factors for cancers and risk assessments are assessed periodically by UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) and by the International Commission on Radiological Protection (ICRP) in order to determine the most appropriate risk estimates also for the purpose of developing recommendation for protection. The IAEA (International Atomic Energy Agency) develops its radiation safety standards taking account of the advice of UNSCEAR and ICRP.

4.3 EXAMPLES OF RADIATION EXPOSURE

Hiroshima and Nagasaki

Much of what is known about radiation damage is derived from follow-up studies of the victims of the Hiroshima atomic blast. Many significant reproductive and cancer findings have been reported in the literature. The two atomic-bomb blasts in August 1945 killed more than 100,000 people by several mechanisms including flash burns caused by thermal radiation. More than 80,000 survivors are enrolled in a Life span study and many epidemiological studies have documented the non-threshold linear dose-response relationship between radiation and cancer and other diseases.

Three Mile Island

The near-meltdown at the Three Mile Island nuclear plant near Harrisburg, Pennsylvania, in March 1979 captured the nation's nuclear accident imagination and dealt a severe blow to the nuclear industry's safety image. A minor failure in the feedwater system, coupled with a faulty pressure-relief valve, allowed the loss of coolant and depressurization of the reactor.

Faulty diagnosis and delayed corrective action led to ever core damage. Radioactive gases (Xe, Kr) escaped into the atmosphere. The subsequent human exposure was considered to be low although the anxiety and outrage were substantial.

Chernobyl

The accident of 26 April 1986 at the Chernobyl nuclear power plant, located in Ukraine about 20 km south of the border with Belarus, was the most serious ever to have occurred in the nuclear industry. It caused the deaths, within a few days or weeks, of 30 power plant employees and firemen (including 28 with acute radiation syndrome) and brought about the evacuation, in 1986, of about 116,000 people from areas surrounding the reactor and the relocation, after 1986, of about 220,000 people from Belarus, the Russian Federation and Ukraine. Vast territories of those three countries (at that time republics of the Soviet Union) were contaminated, and trace deposition of released radionuclides was measurable in all countries of the northern hemisphere. Radionuclides were found in many foods over a period of months in many countries.

In the Chernobyl accident alone, enough radioactivity was released to result in a collective committed effective dose to the Northern Hemisphere of 600,000 man Sv (60,000,000 person-rem).The large amounts of radioactive iodine (> 600 PBq) that were released in the accident have since been implicated in an increase in the incidence of thyroid cancer in Belarus and the Ukraine. Following the first few weeks after the accident, when

^{131}I was the main contributor to the radiation exposures, doses were delivered at much lower dose rates by radionuclides with much longer half-lives. Since 1987, the doses received by the populations of the contaminated areas came essentially from external exposure from ^{134}Cs and ^{137}Cs deposited on the ground and internal exposure due to the contamination of foodstuffs by ^{134}Cs and ^{137}Cs. Other, usually minor, contributions to the long-term radiation exposures include the consumption of foodstuffs contaminated with ^{90}Sr and the inhalation of aerosols containing plutonium isotopes.

Estimated collective effective doses received during the 1986-1995 time period by the inhabitants of the contaminated areas of Belarus, the Russian Federation and Ukraine were about 24,200 manSv from external exposure and 18,400 manSv from internal exposure, for a total of 42,600 manSv and an average effective dose of 8.2 mSv.

A majority of the studies completed to date on the health effects of the Chernobyl accident are of the geographic correlation types that compare average population exposure with the average rate of health effects or cancer incidence in time periods before and after the accident. As long as individual dosimetry is not performed no reliable quantitative estimates can be made. The reconstruction of valid individual doses will have to be a key element in future research on health effects related to the Chernobyl accident.

4.4 HEALTH PROTECTION OF CITIZENS FROM ACCIDENTAL RELEASE OF RADIOACTIVE SUBSTANCES

The INES (The International Nuclear and Radiological Event Scale) is a worldwide tool for communicating to the public in a consistent way the safety significance of nuclear and radiological events. The INES Scale explains the significance of events from a range of activities, including industrial and medical use of radiation sources, operations at nuclear facilities and transport of radioactive material.

Events are classified on the scale at seven levels: Levels 1 – 3 are called "incidents" and Levels 4 – 7 "accidents". The scale is designed so that the severity of an event is about ten times greater for each increase in level on the scale. Events without safety significance are called “deviations” and are classified Below Scale – Level 0 (Table 4. 8). Since 1990 the scale has been applied to classify events at nuclear power plants, and then extended to enable it to be applied to all installations associated with the civil nuclear industry. By 2006, it had been adapted to meet the growing need for communication of the significance of all events associated with the transport, storage and use of radioactive material and radiation sources. The current version of the INES manual was adopted 1 July 2008.

INES classifies nuclear and radiological accidents and incidents by considering **three areas of impact**: *People and the Environment* considers the radiation doses to people close to the location of the event and the widespread, unplanned release of radioactive material from an installation. *Radiological Barriers and Control* covers events without any direct impact on people or the environment and only applies inside major facilities. It covers unplanned high radiation levels and spread of significant quantities of radioactive materials confined within the installation. *Defence-in-Depth* also covers events without any direct impact on people or the environment, but for which the range of measures put in place to prevent accidents did not function as intended.

Supranational and national agencies have published recommendations for handling the physical and medical problems arising from nuclear accidents. In developing principles for emergency planning, International Commission on Radiological Protection (ICRP) recognizes number of actions to provide protection for members of the public following a radiological attack corresponding to the phases of responding to the event. International Commission on Radiological Protection (ICRP) recognized three phases after a serious accident.

The early phase extends from the recognition of a potential release of radioactive material to the general environment to a few hours into the release. Countermeasures such as sheltering indoors, the issuing of stable iodine tablets and the evacuation of the local residents likely to be at risk may be indicated.

The intermediate phase extends from a few hours to a few days after the onset of the accident. It is assumed that virtually all the release to the atmosphere has occurred and that significant amounts of radioactive material have been deposited on the ground. Measurements and assessments will have been made. Countermeasures such as the control of foodstuffs and the relocation of nearby residents may be indicated.

Table 4.8 General description of INES levels (Source: IAEA, 2009)

INES level	People and environment	Radiological barriers and control	Defense-in-depth
Major accident level 7	Major release of radioactive material, widespread health and environmental effects, implementation of planned and extended countermeasures *(Chernobyl, 1986)*		
Serious accident level 6	Significant release of radioactive material, planned countermeasures *(Kyshtym, Russia, 1957)*		
Accident with wider consequences level 5	Limited release of radioactive material, planned countermeasures, several deaths *(Windscale, Pile, UK, 1957;Goiania, Brasil, 1987)*	Severe damage to reactor core, release of large quantities of radioactive material, significant public exposure *(Three Mile Island, USA, 1979)*	
Accident with local consequences level 4	Minor release of radioactive material, implementation of planned countermeasures, local food controls, at least one death from radiation *(Tokaimura, Japan, 1989; Fleurus, Belgium, 2006)*	Fuel melt or damage to fuel resulting in release of core inventory, release of radioactive material, probability of significant public exposure *(Saint Laurent des Eaux, France, 1980)*	
Serious incident level 3	Exposure in excess of ten times the statutory annual limit for workers, non-lethal deterministic health effect from radiation *(Yanango, Peru, 1999)*	Severe contamination in an area, a low probability of significant public exposure *(Sellafield, UK, 2005)*	Near accident at a nuclear power plant, no safety provisions remaining, lost or stolen highly radioactive sealed source *(Vandellos, Spain, 1989*)
Incident level 2	Exposure of a member of the public in excess of 10 mSv, exposure of a worker in excess of the statutory annual limits *(Atucha, Argentina, 2005; USA, 2005)*	Radiation levels in an operating area > 50 mSv/h, contamination within the facility *(Cadarache, France, 1993)*	Failures in safety highly radioactive sealed orphan source, inadequate packaging *(Sweden, 2006; France, 1995)*
Anomaly level 1			Overexposure, minor problems with safety, low activity lost or stolen radioactive source
No safety significance (below scale/level 0)			

The recovery phase commences with the first measures to return to normal living conditions and to withdraw the early and intermediate countermeasures. A substantial decontamination program over a prolonged period may be required.

During an emergency exposure situation, other measures are also likely to be considered. These include public warning, information, advice and basic counseling, dealing with their own national citizens in another affected country, comprehensive psychological counseling, medical management, and long-term follow up.

Intervention levels in emergency exposure situations are expressed in terms of avertable dose, i.e. a protective action is indicated if the dose that can be averted is greater than the corresponding intervention level. The standards provide the values which can be taken as starting points for the judgment required for decisions to select levels for emergency exposure situations.

These values have been developed by IAEA and summarized in Table 4.9.

Table 4.9 Recommended generic intervention levels for urgent protective measures (Source: The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, 1996)

Protective action	**Generic intervention level (dose avertable by the protective action)**
Sheltering	10 mSv in a period of no more than two days
Temporary evacuation	50 mSv in a period of no more than one week
Iodine prophylaxis	100 mSv (absorbed dose due to radioiodine)*

* For children WHO recommends 10 mSv

The generic optimized intervention levels recommended for temporary relocation and permanent resettlement are given in Table 4.10. The recommended generic action levels for foodstuffs are presented in Table 4.11.

Table 4.10 Recommended generic intervention levels for temporary relocation and permanent resettlement (Source: The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, 1996; IAEA, 2004)

Actions	**Avertable dose**
Initiating temporary relocation	300 mSv in a month
Termination and temporary relocation	10 mSv in a month
Permanent relocation	1 Sv in lifetime

Table 4.11 Generic action levels for foodstuffs (Bq/kg) (Source: The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, 1996; IAEA, 2004)

Important radionuclides	**Milk, infant foods and drinking water [Bq/kg]**	**Food for general consumption [Bq/kg]**
^{90}Sr		100
^{131}I	100	
^{239}Pt	1	10
^{137}Cs	1000	1000

They are based on, and consistent with, the Codex Alimentarius Commission's guideline levels for radionuclides in food moving in international trade following accidental contamination, but it is limited to the nuclides usually considered relevant to emergency

exposure situations. These levels apply where alternative food supplies are readily available. Where food supplies are scarce, higher levels may apply but must be justified. These levels are intended to be applied to food prepared for consumption and would be unnecessarily restrictive if applied to dried or concentrated food prior to dilution or reconstitution.

4.5 SYSTEM OF RADIOLOGICAL PROTECTION

In its 1990 recommendations, ICRP, subdivided its system of protection into *"practices"* and *"intervention"*. The three well-known principles of justification, optimization of protection and dose limits applied to practices. **Justification** (no practice shall be adopted unless its induction produces a positive net benefit) in the sense of doing more good than harm, and **optimization** (all exposures shall be kept as low as reasonably achievable, with economic and social factors being taken into account, dose constraint) of protection also applied to intervention, but **dose limits** (the effective dose to individuals shall not exceed the limits recommended for the appropriate circumstances) did not.

ICRP now considers that it is a better to define three categories of exposure situations, namely: *planned exposure situations* which involve the deliberate introduction and operation of sources; *emergency exposure situations*, which require urgent action in order to avoid or reduce undesirable consequences; and *existing exposure situations*, which include prolonged exposure situations after emergencies.

ICRP also concludes that the slight differences in nominal detriment coefficients between those derived in the new recommendations and those given in its 1990 recommendations are of no practical significance and therefore has not significantly changed the dose limits. The limits are reproduced in Table 4.12.

Table 4.12 Recommended dose limits in planned exposure situations (Source: ICRP, 1991; Council directive 96/29/EURATOM)

Type of limit	**Occupational, mSv in a year**	**Public, mSv in a year**
Effective dose	100 mSv in a consecutive five year period, subject to a maximum effective dose of 50 mSv in any single year	1 (exceptionally, a higher value of effective dose could be allowed in a year provided that the average over 5 years does not exceed 1 mSv in a year)
Equivalent dose to the lens of the eye	150	15
Equivalent dose to skin	500	50
Equivalent dose to hands, forearms and feet and ankles	500	-

Additional restrictions apply to the occupational exposure of pregnant women. If a female worker has declared that she is pregnant, ICRP has recommended that the level of protection for the embryo/fetus should be broadly similar to that provided for members of the public.

The optimization of protection also includes a constraint on the procedure, in the form of restrictions on doses or risks to people to prevent inequitable exposures from radiation. For workers, the value of the dose constraint should be chosen so as to reflect the annual value of dose that can reasonably be reached in a particular industry or procedure; it maybe be a small fraction of the dose limit. For members of the public, a typical constraint, 0.3 mSv in a year, can be used as a planning value for a new source of radiation exposure.

4.5.1 Dose limits

The dose limits specified apply to exposures attributable to practices.

The dose limits are not relevant for taking decisions on whether and how to apply intervention, but workers undertaking intervention shall be subject to the relevant requirements.

The dose limits are not relevant for the control of potential exposures.

Dose limits for occupational exposure

The occupational exposure of any worker shall be controlled such that the following limits are not exceeded (Table 4.12):

- an effective dose of 100 mSv over five consecutive years, subject to a maximum effective dose of 50 mSv in any single year;
- an equivalent dose to the lens of the eye of 150 mSv in a year;
- an equivalent dose to the extremities (hands and feet) or to the skin of 500 mSv in a year.

For apprentices of 16 to 18 years of age who are training for employment involving exposure to radiation and for students of age 16 to 18 who are required to use sources in the course of their studies, the occupational exposure shall be controlled such that the following limits are not exceeded:

- an effective dose of 6 mSv in a year;
- an equivalent dose to the lens of the eye of 50 mSv in a year;
- an equivalent dose to the extremities or the skin of 150 mSv in a year.

Dose limits for members of the public

Exposure of members of the public attributable to a practice shall not exceed the following limits which shall apply to the estimated average doses to the relevant critical groups (Table 4.12):

- an effective dose of 1 mSv in a year;
- in special circumstances. an effective dose up to 5 mSv in a single year provided that the average dose over five consecutive years does not exceed 1 mSv per year;
- an equivalent dose to the lens of the eye of 15 mSv in a year;

− an equivalent dose to the skin of 50 mSv in a year.

The dose limits set out in this part shall not apply to individuals knowingly and willingly helping (other than as part of their employment/occupation) in the support and comfort of patients undergoing medical diagnosis or treatment. However, the exposure of such comforters and careers should be constrained so that it is unlikely that their actual exposures exceed 5 mSv during the period of the patients' diagnostic examination or treatment.

4.5.2 Radiation to occupationally exposed persons

With the exception of mining, average doses from most types of occupational exposure from artificial sources, including the nuclear industry, are now below about 2 mSv in a year. Doses in the health professions – medical, dental and veterinary – are generally very low, but there are still matters of concern. Some clinical procedures with diagnostic radiology require the physician to be at risk of appreciable exposure.

Doses to aircrew from cosmic rays depend on the routes flown and the amount of flying time. On the average, the annual dose is around 3 mSv, but it could be twice as much for long flights continually at high altitudes. By the nature of the radiation and the operations, such doses are unavoidable.

Many people who are exposed to radiation at work wear personal monitoring devices (or dosimeters) such as small photographic film or some thermoluminescent material in a special holder (See chapter Occupational hygiene).

4.5.3 Radiation to patients from medical uses of radiation

The major part of medical radiation exposure comes from the use of X-rays in diagnosis. From these sources the per capita annual effective dose equivalent is likely to be no lower than 0.4 mSv and may be as high as 1mSv.

Overall, diagnostic practices with radiopharmaceuticals remain small in comparison with the use of x rays; the annual numbers of nuclear medicine procedures and their collective dose are only 2 % and 6 %, respectively, of the corresponding values for medical x rays. However, the mean dose per procedure is larger for nuclear medicine (4.6 mSv) than for medical X rays (1.2 mSv).

The need for such analysis is heightened by a number of underlying factors that could affect the practice of radiology, in terms of both the type and frequency of procedures carried out and the associated levels of dose to individual patients (Table 4.13)

4.6 MONITORING REQUIREMENTS AT NORMAL RADIATION LOAD AND AT ENDANGER

Information on radiation required by the system that protects the population and environment from radioactive materials and ionizing radiation (radiation protection) comes from several sources, among them the Radiation Monitoring Network (RMN).

The task of RMN is to monitor spatial and temporal distribution of the activity of radionuclides and doses of ionizing radiation on the national territory. Under normal radiation situation, the purpose of the monitoring is to establish long-term trends and identify in time any variations from these trends. In extraordinary situations, the task of RMN is to assess the radiation situation on the national territory and provide background information for deciding on countermeasures to protect the population. RMN is focused, in particular, on the following artificial radionuclides: ^{3}H, ^{137}Cs, ^{90}Sr, $^{239+240}Pt$, ^{85}Kr in the atmosphere, ^{137}Cs, ^{90}Sr and ^{3}H in food, and ^{137}Cs in the human body. Since last two years, ^{14}C (which is of both artificial and natural origin) has been also monitored.

Table 4.13 Guidance reference levels for medical exposures. Exposures for diagnostic radiological procedures for a standard size adult patient – radiography (Source: IAEA, 1996)

Examination	**Entrance surface dose per radiograph [mGy]**	
Lumbar Spine	AP	10
	LAT	30
	LSJ	40
Abdomen, intravenous urography and cholecystography	AP	10
Pelvis	AP	10
Hip joint	AP	10
Chest	PA	0.4
	LAT	1.5
Thoracic spine	AP	7
	LAT	20
Dental	Periapical	3
Skull	AP	5
	PA	5
	LAT	3

PA = Posterior-anterior projection LSJ = Lumbo-sacral-joint projection
LAT = Lateral projection AP = Anterior-.posterior projection

The Radiation Monitoring Network is a controlled system of technically, professionally and personally equipped workplaces, organizationally linked to the needs of monitoring of the radiation situation and the collection of data on the territory of the Slovak Republic, created by the Public Health Authority in cooperation with central governmental bodies according to Act No 355/2007 Coll. on Protection, Support and Development of Public Health that implements European Council Directive 96/29/Euratom into national legislation.

The Radiation Monitoring Network ensures:

a) Measuring of certain parameters in specified elements of the environment in the system of points of measurement according to a time schedule;

b) Evaluation of irradiation of the population and the contribution to the irradiation caused by activities leading to irradiation in a normal radiation situation;

c) Basis for systematic directing of irradiation of the population;

d) Data on radioactive contamination of the environment necessary for deciding on the execution and termination of interventions and measures for the limitation of irradiation in case of a radiation threat;

e) Data on the level of irradiation for informing the population and for international exchange of information on the radiation situation on the territory of the Slovak Republic.

Monitoring requirements at normal ionizing radiation load and at radiation threat in Slovak Republic are presented in Tables 4.14, 4.15.

4.7 RADIOACTIVE WASTES

Radioactive waste means any material which contains or is contaminated by radionuclides and for which no use is foreseen.

Different stages of the nuclear fuel cycle produce radioactive wastes. There are also other radioactive wastes. These come from medical, industrial and research activities involving radioactive materials.

Exempt waste contains only very limited amounts of radionuclides and it does not need to be treated differently from ordinary non-radioactive waste.

Low/intermediate-level waste consists of items such as paper, clothing and laboratory equipment, contaminated soil and building materials, more active materials used in the treatment of gaseous and liquid effluents or the sludge that accumulate in the cooling ponds**.** They do not occur in a form that is immediately suitable for disposal; they have to be mixed into an inert material such as concrete, bitumen or resin. Safe disposal is ensured by preventing significant transfer of radionuclides into the environmental pathways that might lead to excessive human exposures. Among the most likely options is a repository deep underground in good geological conditions.

High level radioactive waste This radioactive waste is characterized by heat generation and a long half-life (e.g. produced by a reprocessing of nuclear fuel). These wastes need to be deposited in deep underground stable rock formations with multiple engineered barriers to prevent their leakage to the environment, over a period of thousands of years, which would be considered unacceptable today.

There has been considerable discussion of the criteria to be used in judging the acceptability of waste disposal methods both from radiological protection point of view and from the wider social perspective. The consensus is that the people in future generations should be protected to the same degree as they would be at present. A second requirement is to apply the principle that all exposures should be as low as reasonably achievable once economic and social factors have been taken into account.

The environmental hazards of ionizing radiation will be probably higher in the future and result in an increased population exposure. Accurate quantitative assessment of the total risk to individuals as well as communities thus requires increasing and continuous attention.

Table 4.14 Monitoring requirements at normal ionizing radiation load
(Source: Government Ordinance No. 524/2007 Coll. on Radiation Monitoring Network)

Monitoring item	**Measurement unit**	**Measurement procedure, followed radionuclide**	**Minimal number of places**	**Minimal number of measurements per year**
External irradiation	Input of spatial dose equivalent	Continuous measurement and evaluation	20	Continuously, hourly and ten minutes averages
External irradiation	Spatial dose equivalent	Continuous measurement, periodic evaluation, TLD	50	4
Aerosols in the air	Volumetric activity of radionuclides	Continuous extraction, periodic evaluation, gammaspectrometric measurements (including ^{7}Be and ^{137}Cs), analysis ^{90}Sr	1 up to 2	52, natural radionuclides and ^{137}Cs, Quarterly ^{90}Sr
Atmospheric fall-out	Surface activity of radionuclides	Continuous extraction, periodic evaluation, gammaspectrometry	3	12, monthly
Soil, grass and other ground cover	Surface activity of radionuclides	Gammaspectrometric measurement	5	1
Surface water	Volumetric activity of radionuclides	Gammaspectrometric measurement (^{137}Cs), pertinently total betaactivity, ^{40}K, ^{3}H	5 (2)	1 – 4 (12)
Drinking water	Volumetric activity of radionuclides	Natural radionuclides, ^{3}H, ^{90}Sr, ^{137}Cs	3 (10)	12 (4)
Waterworks sludge and river sediments	Mass activity of radionuclides	Gammaspectrometric measurement	1 (2)	1
Milk	Volumetric activity of radionuclides	Gammaspectrometric measurement (^{137}Cs), ^{90}Sr	5 (1)	4 (12)
Pork meat, beef, lamb, poultry, deer, fish, eggs	Mass activity of radionuclides	Gammaspectrometric measurement (^{137}Cs), ^{90}Sr	1	1
Wheat, barley, oat, corn	Mass activity of radionuclides	Gammaspectrometric measurement (^{137}Cs), ^{90}Sr	4	1
Potatoes, leafy, root and fruit vegetable, fruits	Mass activity of radionuclides	Gammaspectrometric measurement (^{137}Cs), ^{90}Sr	4	1
Forest fruits, mushrooms	Mass activity of radionuclides	Gammaspectrometric measurement (^{137}Cs), ^{90}Sr	2	1
Flour, rice, vegetable oils and fat, mixed daily food	Mass activity of radionuclides	Gammaspectrometric measurement (^{137}Cs), ^{90}Sr	2	2
Internal contamination of persons by radionuclides	Activity of radionuclides in the body	Gammaspectrometric measurement (^{137}Cs)	5	1
Internal contamination of persons by radionuclides	Activity of radionuclides in daily urine	Gammaspectrometric measurement (^{137}Cs)	5	1

Table 4.15 Monitoring requirements at radiation threat
(Source: Government Ordinance No. 524/2007 Coll. on Radiation Monitoring Network)

Monitoring item	**Measurement unit**	**Measurement procedure, followed radionuclide**	**Frequency of measurements, number of measurements**
External irradiation	Input of spatial dose equivalent	Continuous measurement and evaluation	Hourly and ten minutes averages, immediate averages
	Input of spatial dose equivalent	Monitoring on the route in the field	Immediate values, short-term averages
	Input of spatial dose equivalent and surface contamination	Aeromonitoring on the route	Immediate values
	Spatial dose equivalent	Continuous measurement, TLD	Evaluation daily and monthly, according to needs
Aerosols in the air	Volumetric activity of radionuclides	Continuous extraction, on stationary places, or short-term extractions, gammaspectrometric measurement, other analyses according to needs	Evaluation: urgent, periodic daily, according to needs
Atmospheric fall-out and precipitation	Surface and volumetric activity of radionuclides	Continuous extraction, periodic evaluation, gammaspectrometric measurement, other analyses according to needs	Daily, up to weekly evaluation
Iodine in gaseous form	Volumetric activity of ^{131}I	Continuous or periodic extraction, gammaspectrometric measurement	Evaluation according to conditions, several times a day, up to daily frequency
Surface radioactive contamination of soil, surfaces and vegetation	Surface and volumetric activity of radionuclides	Local extractions, other analysis according to needs	According to the accident extent and needs
Surface water	Volumetric activity of radionuclides	One-shot or repeated extractions, gammaspectrometric measurement (^{137}Cs), ^{3}H, pertinently other analyses according to needs	Daily up to weekly evaluation, according to the accident extent and needs
Drinking water	Volumetric activity of radionuclides	One-shot or repeated extractions, gammaspectrometric measurement (^{137}Cs), ^{3}H, pertinently other analyses according to conditions	Daily up to weekly evaluation, according to the accident extent and needs
Milk	Volumetric and mass activity of radionuclides	Gammaspectrometric measurement, other analyses according to conditions	Daily up to weekly evaluation, according to the accident extent and needs
Pork meat, beef, lamb, poultry, deer, fish, eggs	Volumetric activity of radionuclides	Gammaspectrometric measurement, other analyses according to conditions	Weekly, according to the accident extent and needs
Wheat, barley, oat, corn	Volumetric activity of radionuclides	Gammaspectrometric measurement, other analyses according to conditions	At the harvest, according to the accident extent and needs
Potatoes, leafy, root and fruit vegetable, fruits	Volumetric activity of radionuclides	Gammaspectrometric measurement, other analyses according to conditions	At the harvest, according to the accident extent and needs
Forest fruits, mushrooms	Volumetric activity of radionuclides	Gammaspectrometric measurement, other analyses according to conditions	At the harvest, according to the accident extent and needs
Tea and medicinal herbs	Volumetric activity of radionuclides	Gammaspectrometric measurement, other analyses according to conditions	At the harvest, according to the accident extent and needs
Fodder plants	Volumetric activity of radionuclides	Gammaspectrometric measurement, other analyses according to conditions	At the harvest, according to the accident extent and needs
Imported foodstuffs	Volumetric activity of radionuclides	Gammaspectrometric measurement, other analyses according to conditions	According to needs
Mixed daily food	Volumetric activity of radionuclides	Gammaspectrometric measurement, other analyses according to conditions	According to needs
Internal contamination of persons with radionuclides	Activity of radionuclides in the body and in the daily urine	Gammaspectrometric measurement, other analyses according to conditions	At the harvest, according to the accident extent and needs

4.8 RADON

Radon poses an environmental risk because of its carcinogenic properties, but the interest in radon extends considerably beyond the issues of exposure to it, its estimated effects, and the means of preventing exposure. Radon is a major contributor to the ionizing radiation dose received by the general population.

First, exposure to radon is predominantly naturally occurring rather than generated by human polluters, even though there are certainly instances in which excess radon exposure results from improper disposal of radioactive waste or, as in underground mines, insufficient industrial hygiene practices.

Second, radon exposure is predominantly an indoor problem in private dwellings and in this regard shares many characteristics with other indoor air contamination issues.

Finally, as a recently discovered hazard, the radon problem may be a harbinger of other chemical and physical agents for which the scope of population can only be appreciated as a result of new technology that increases the sensitivity and decreases the difficulty and expense of performing of widespread measurements.

4.8.1 Physical and chemical properties

Radon itself is an odorless, colorless, chemically non-reactive gas. It is in the decay chain of ^{238}U, one of the major natural sources of radioactive isotopes on earth. Given that the half-life of ^{238}U is approximately 9 billion years, this isotope, generated when the planet was formed, is still present on earth in considerable quantities.

The gaseous and non-reactive characteristics of the noble gas radon result its easy diffusion through air, it is also soluble in water. When formed in soil and rock from the decay of its parent isotope, ^{226}Ra, radon can diffuse from its source. Radon in the ambient air has a stable concentration throughout the world. but the soil gas tends to enter and accumulate in enclosed structures, including mines and buildings, as a result of a combination of diffusion and air-pressure differentials. Because the half-life of ^{222}Rn is about 4 days and because it is not chemically very reactive, radon gas itself is very likely to be exhaled after inhalation without having irradiated lung tissue. In contrast, the first few products in the decay chain after radon gas (often called radon daughters or progeny) are short-lived and chemically very reactive isotopes of polonium, lead, and bismuth. These species impart the specifically carcinogenic risk to the population. The polonium decay emits alpha particles, which are highly damaging but penetrate only several cell layers; thus only cells in the immediate vicinity of the radioactive decay are affected. The long-term decay products at the end of the decay chain, such as ^{210}Po and ^{210}Pb, present smaller radiation doses to the body than do the short-lived daughters because the overall biologic residence of ^{210}Pb is shorter than the radioactive half-life.

Because radon itself is more inexpensively and reliably measured than its short-lived decay products, it is measured as a surrogate for the more hazardous daughters or progeny. Radon is usually discussed as if it were the hazardous agent.

4.8.2 Exposure and distribution

For the average person, the major source of exposure is from indoor air, although miners working underground at some locations are also at risk. Radon usually enters the home from the soil beneath the foundation; well water used for domestic supply can also be a source. If buildings are well ventilated this accumulation of radon will not be marked. However, in many, mostly colder, countries, buildings are constructed with more emphasis on retaining heat and preventing draughts. They are often poorly ventilated and radon concentrations indoors can be higher than outdoors. Radon concentrations in buildings depend on local geology and vary between countries, different parts of a country and even from building to building in the same area. Results of indoor radon concentrations in OECD countries see on Table 4.16.

Table 4.16 Indoor radon concentrations in OECD countries (Sources: UNSCEAR, 2000; WHO, 2007, 2009; Vicanova et al., 2006)

Indoor radon levels [Bq/m^3]			
Country OECD	**Arithmetic mean**	**Geometric mean**	**Geometric standard deviation**
Australia	11	8	2.1
Austria	99	15	NA
Belgium	48	38	2.0
Canada	28	11	3.9
Czech Republic	140	44	2.1
Denmark	59	39	2.2
Finland	120	84	2.1
France	89	53	2.0
Germany	49	37	2.0
Greece	55	44	2.4
Hungary	82	62	2.1
Iceland	10	NA	NA
Ireland	89	57	2.4
Italy	70	52	2.1
Japan	16	13	1.8
Luxembourg	110	70	2.0
Mexico	140	90	NA
Netherlands	23	18	1.6
New Zealand	22	20	NA
Norway	89	40	NA
Poland	49	31	2.3
Portugal	62	45	2.2
Republic of Korea	53	43	1.8
Slovakia	87	41	2.2
Spain	90	46	2.9
Sweden	108	56	NA
Switzerland	78	51	1.8
United Kingdom	20	14	3.2
USA	46	25	3.1
Worldwide average	39		

NA: Not Available

Although building materials such as brick and concrete do produce radon, the main source of high indoor levels is the ground. When radon gas enters the atmosphere from the ground, it disperses in the air, so concentrations out of doors are low. When the gas enters a building, predominantly through the floor from the ground, the concentration of activity builds up within the enclosed space.

The atmospheric pressure inside homes tends to be slightly lower than outside, and radon is drawn into the home mainly through gaps and cracks in the floor. The uranium content of the ground and its permeability to radon, the design and quality of the floor, and the living habits of the occupants combine to determine the radon levels. High values are therefore more likely to occur where geology is unfavorable, as for example around granite masses or on uraniferous shale, but levels in adjacent homes may differ markedly. The implication is that measurement is always required to determine whether a particular home is adversely affected by radon.

4.8.3 Health effects

Lung cancer is the primary threat from radon. Historically the excess lung cancers observed in underground mines were principally small-cell and squamous (epidermoid) types. Rates of other histologic types have since been observed to be elevated as a result of occupational radon exposure and consistent patterns have also been seen in some of the residential studies to date, but with much variation among studies. The fact that the small-cell and squamous types of lung cancer are also those most frequently induced by tobacco smoking makes the interaction of smoking and radon even more difficult to disentangle.

Recent studies on indoor radon and lung cancer in Europe, North America and Asia provide strong evidence that radon causes a substantial number of lung cancers in the general population. Current estimates of the proportion of lung cancers attributable to radon range from 3 to 14 %, depending on the average radon concentration in the country concerned and the calculation methods. The analyses indicate that the lung cancer risk increases proportionally with increasing radon exposure.

Radon is the second cause of lung cancer after smoking. Most of the radon-induced lung cancer cases occur among smokers due to a strong combined effect of smoking and radon.

4.8.4 Protection and prevention

Addressing radon is important both in construction of new buildings (prevention) and in existing buildings (mitigation or remediation). The primary radon prevention and mitigation strategies focus on sealing radon entry routes and on reversing the air pressure differences between the indoor occupied space and the outdoor soil through different soil depressurization techniques. In many cases, a combination of strategies provides the highest reduction of radon concentrations.

Since the mid-1980s, trends in technology and costs of radon testing and remediation have made it possible for buildings with excess radon to be discovered and remediated to the current guideline at costs feasible for most households and agencies.

The best approach is to prevent radon entering from the ground by drawing radon-laden air from under the floor and discharging it to the atmosphere. A small sump, duct, and fan should be installed, but gaps in the floor should be closed for best results. With new homes, suspended solid floor with good underfloor ventilation and some antiradon detailing are likely to be successful. None of these measures is expensive in comparison with the value of homes, and the cost per unit of collective dose avoided is negligible compared with the cost assigned to artificial radiation.

Several countries are using the ICRP guidelines of 200 $Bq.m^{-3}$ for new housing and 400 $Bq.m^{-3}$ at 50 percent equilibrium, for existing housing.

A national reference level for radon represents the maximum accepted radon concentration in a residential dwelling and is an important component of a national programme. For homes with radon concentrations above these levels remedial actions may be recommended or required. When setting a reference level, various national factors such as the distribution of radon, the number of existing homes with high radon concentrations, the arithmetic mean indoor radon level and the prevalence of smoking should be taken into consideration. In view of the latest scientific data, WHO proposes a reference level of 100 Bq/m^3 to minimize health hazards due to indoor radon exposure. However, if this level cannot be reached under the prevailing country-specific conditions, the chosen reference level should not exceed 300 Bq/m^3 which represents approximately 10 mSv per year according to recent calculations by the International Commission on Radiation Protection.

5. NUTRITION AND HEALTH

Human nutrition may be defined as the process of meeting human health needs in the context of basic human personal needs by nutritional means. Food as a basic life-support material supplies the body with certain essential chemicals that enable to do its work. We need have energy for work and physical activities, and we must build body cells and tissues. The essential nutrients are water, carbohydrates, proteins, fats, vitamins and minerals. The list of nutrients essential or otherwise useful to human physiology is long, complex, and probably incomplete, includes the more than 40 distinct substances (Table 5.1). They must be obtained from food sources, because the body does not produce them or produces them in amounts too small to maintain growth and health. Their dietary or metabolically-induced deficiency causes recognizable symptoms that disappear when the nutrients are replaced.

Non-essential nutrients, produced and created in the body, do not need to be obtained from food sources. An individual needs are varying amounts of essential nutrients.

Hygiene of nutrition is an interdisciplinary medical branch, which participates at provision of a nutritionally adequate and hygienic diet and confers major health benefits including:

− Elimination of dietary deficiency diseases;
− Reduction of acute and chronic foodborne diseases;
− Improvement in overall nutritional status, including increased childhood growth rates;
− Increased resistance to bacterial and parasitic infectious diseases.

Over the course of evolution, human beings (and their primate predecessors) adapted progressively to a wide range of naturally occurring foods, but the types of foods and the mix of nutrients (in terms of carbohydrates, fats, and proteins) remained relatively constant throughout the ages. Food supply was often precarious, and starvation frequent.

The agricultural revolution, approximately 10,000 years ago, brought profound changes. The ability to produce and store food became more widespread, and some foods were preferentially cultivated.

The industrial revolution in developed countries in the last 200 years has introduced radical changes in methods of food production, processing, storage, and distribution. Recent technological innovations, along with increased material well-being and life-style have allowed the exercise of dietary preferences and have led to major changes in the nutritional composition of the diet in developed countries. It is estimated that the per capita consumption of fat and sugar (refined carbohydrates) has increased 5 – 10 fold in England over past 200 years, while the consumption of complex carbohydrates (including cereal grains) has declined substantially. Compared with the scale of human history and biological evolution, these developments represent dramatic and extremely rapid changes in population food supply.

Human health needs in the context of nutrition are as follows:

- **Developmental stages of men (age groups' needs)** have their special needs and nutritional requirements. Different conditions with special nutritional needs are also in women during pregnancy or breast-feeding.
- **Load factors** in individual life situations are caused by physical, mental, or emotional stress which have a profound effect on the nutritional conditions.
- **Health status,** a person's degree of health or disease, actual situation as each person perceives it, influences nutritional or food modification needs.
- **Personal needs** Although food and water are essential for survival, we do not eat to sustain our physical body alone. Food has many meanings and helps us to meet a number of personal, social and cultural needs.

Table 5.1 Essential dietary components

1. Energy sources	Carbohydrate, fat, protein, alcohol
2. Essential amino acids	Izoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine, histidine
3. Essential fatty acids	Linoleic, linolenic, arachidonic, eicosapentaenoic acid
4. Vitamins	
Water-soluble	Ascorbic acid (C), thiamin (B_1), riboflavin(B_2), pantothenic acid (B_3), pyridoxine (B_6), folacin, niacin (PP), biotin (H), cobalamin (B_{12})
Fat-soluble	Vitamin A, vitamin D, vitamin E, vitamin K
5. Minerals	
Major minerals [g]	Calcium, chlorine, magnesium, sodium, phosphorus, potassium, sulphur
Trace elements [μg]	Iron, iodine, zinc, copper, manganese, chromium, cobalt, selenium, molybdenum, fluorine
6. Fiber	
7. Water	

5.1 NUTRITIONAL VALUE OF FOOD

Nutritional, physiological, and health human needs consist in intake of macronutrients (carbohydrates, proteins, fats) and micronutrients (vitamins, minerals, trace elements). Daily intake of macronutrients ranges in tens up hundreds grams, (represent 80 – 90 % of a dry part of food), micronutrient daily intake is in milligrams or micrograms.

Nutritional value (i.e. energy and biological value) of food are quantitative and qualitative nutritional demands of human body.

5.1.1 Energy need and energy balance

Energy is that force (power) that enables the body to carry out its life-sustaining or metabolic activities. The energy provided by foods is measured in kilocalories (kcal) or joules (J). This is the amount of heat required to raise l kg of water l °C. One kcal equals 4.184 kilojoules (kJ); one megajoule (MJ) equals 239 kcal.

The average kilocalorie value of the energy nutrients (fuel factors): l g of carbohydrate yields 4 kcal, l g of protein yields 4 kcal, l g of fat yields 9 kcal and l g of alcohol yields 7 kcal.

Energy is available in four basic forms for life processes: chemical, electrical, mechanical, and thermal. Metabolism is the changing of the chemical energy of food into the electrical energy of brain and nerve activity, mechanical energy for muscle contraction, thermal energy of body temperature control and other forms of chemical energy in the body. There are two types of metabolic reactions, which constantly occur: anabolism (substances are synthesized and energy is stored) and catabolism (substances are broken down and energy is released).

When food is not available, the body draws on its own stores. Carbohydrate stores (glycogen) are most easily depleted, and therefore, the first to undergo catabolism. Fat stores (adipose tissue) are larger and catabolized once glycogen stores are depleted. Protein stores (body tissue) contain a fair amount of potential energy (stored or bound in various chemical compounds) and are catabolized also after carbohydrate is depleted, along with fat stores.

Total energy needs are based on basal and no basal requirements. The **basal metabolic rate (BMR)** contains all chemical activities that maintain the body at rest and is influenced by many factors. The best indicator of BMR is body composition especially lean body mass. Important is also growth (during growth periods BMR is increasing from 15 % to 20 %). Fever increases the BMR about 7 % for each 0.83 °C. Cold climate BMR rises in response to lower temperatures.

Non-basal requirement for energy includes food intake and physical exercise.

Food intake effects: The overall stimulating effect of food is called its specific action (SDA), or dietary thermogenesis. About 10 % of the body's total energy needs for metabolism is attributed to activities related to handling the food we eat.

Physical activity needs: Exercise involved in work and recreation accounts for wide individual variation in energy requirement. Heightened emotional states alone do not increase metabolic activity, but they may bring additional energy needs because they involve increased muscle tension, restlessness, and agitated movement.

Total energy requirements: The energy demands of basal metabolism and the effect of food and of physical activity make up a total energy requirement (Table 5.8 and 5.10).

Energy Balance is a state where energy intake is equivalent to energy expenditure, resulting in no net weight gain or weight loss. Imbalance in the energy equation, when daily intake of calories is greater than energy expended, leads to obesity.

Energy Density is the amount of energy stored in a given food per unit volume or mass. As is above fat stores 9 kcal (37 KJ)/ g, carbohydrate and protein each store 4 kcal (17 KJ)/g, fiber stores 1.5 to 2.5 kcal/g, and water has no energy.

5.1.2 Nutritional quality of food

Five categories of nutrients: proteins, carbohydrates, fats, vitamins and minerals satisfy the basic body needs:

- energy for muscle contraction – physical activities;
- conduction of nerve impulses;
- growth – formation of new body cells and tissues and their repair;
- chemical regulation of metabolic functions, and
- reproduction.

5.1.2.1 Protein

Protein has unique structural unit, the amino acid, which is made up of the three elements – carbon, hydrogen, oxygen – that make up also carbohydrates and fats. Nevertheless, amino acids and their proteins have an additional important element – nitrogen – as the base (alkaline) ($-NH_2$) portion of their structure. There are some 22 amino acids, which are important.

Essential amino acids: Nine of the amino acids are vital (Table 5.1). The remaining (non-essential) group can be synthesized in the human body.

The amino acids are used by the body to construct specific tissue proteins. This process is made possible by the nature of amino acids, which enables them to form peptide linkages and arrange themselves in to peptide chains.

Complete proteins are those that contain all the essential amino acids and are of animal origin: egg, milk, cheese and meat. Incomplete proteins (deficient of the essential amino acids) are mostly of plant origin: grains, legumes, nuts, and seeds.

Functions of protein:

- the primary function is the growth, development and maintenance of body cells, tissue and organs (basis of muscles, bones, skin, nails, mucosa, antibodies);
- in detoxication processes as a components of enzymes;
- in transportation of nutrients, because are water absorbing;
- keep nitrogen balance in organism
- specific function in nutrition of brain and nerve system
- Some amino acids perform important physiologic and metabolic roles (e.g. tryptophan is the precursor of the B vitamin niacin and of the neurotransmitter serotonin, prolin is an

essential component of collagen, glutamine is essential for maintenance of acid-base balance in the kidney).

− contributes to the body´ s overall energy metabolism; may be used for gluconeogenesis.

Factors influencing protein requirements are tissue growth (includes age, body size and general physical status); diet (includes nature of the protein in the diet and its ratio or pattern of amino acid structure). Presence of any disease will usually increase the requirement for protein.

Measure of protein requirements refers to **protein quantity** (recommended daily intake for adults is 0.8 – 1 g/kg body weight, which is about 60 – 76 g for a man and 48 – 67 g for a woman. Increased protein is indicated during pregnancy and lactation. There is tendency in adults to keep **nitrogen balance** which is balance between synthesis and catalysis of proteins in the body. Requirements for infants and children vary according to age and growth pattern and nitrogen balance should be positive. Dietary recommendations advice to maintain protein intake on the level 10 – 15 % of daily caloric intake. Over intake of proteins, using for energy, results in excessive production of toxic metabolic by-products. Deficiency in protein consumption, seen in the diets of people in developing countries, may result to such serious forms of protein malnutrition as marasmus and kwashiorkor.

Protein quality requires an analysis of the amino acid quality. Its nutritional quality depends upon amino acid composition, digestibility, and any unique unavailability of specific amino acids. Proportion of the proteins animal and plant origin are recommended: P (anim) : P (plant) = 1 : 1.

5.1.2.2 Fats

Fats are composed of glycerol and attached fatty acids are an essential nutrient, which supply the highest density of energy, protect against low temperatures and damages of the vital organs. It also aids in the transmission of nerve impulses, production of metabolic precursors, and formation of cell membrane structure and transport of other molecules such as protein.

The class name for fats and similar compounds is lipids. These compounds are defined by their common relationship to the fatty acids (the basic elements are carbon, hydrogen, and oxygen – also make up fatty acids and their related fats. Three terms for degrees of saturation of fatty acids are used:

− **Saturated fats** composed mainly of saturated fatty acids (SFA) are of animal origin;

− **Monounsaturated** food fats composed mainly of fatty acids (MUFA) with one less hydrogen atom;

− **Polyunsaturated** food fats composed mainly of fatty acids (PUFA) with one or more less hydrogen acids.

Essential fatty acids are long-chained unsaturated fatty acids that cannot be manufactured by the body. Linoleic, linolenic, arachidonic and eicosapentaenoic are the only fatty acids known to be essential and serve important functions of the body: they strengthen capillary and cell membrane structure, which helps prevent and increase skin and membrane permeability, they combine with cholesterol for its transport in the blood; they prolong blood clotting time and increase fibrinolytic activity and they help to form prostaglandins.

Prostaglandins is a group of naturally occurring long-chain fatty acids having many tissue activities including maintaining smooth muscle tone and platelet aggregation.

Chain length of fatty acids is important in their absorption because the medium and short chain fatty acids are more soluble in water.

Triglycerides When glycerol is combined with one fatty acid it is called a monoglyceride, with two fatty acids a diglyceride, and three fatty acids as a triglyceride. These fats (triglycerides) with the lipoprotein complexes serve multiple functions throughout the body.

Cholesterol belongs to a family of substances called steroids (sterols) and is a precursor to all steroid hormones. A derivative of cholesterol in the skin, 7-dehydrocholesterol, is irradiated by sunlight's ultraviolet rays to produce vitamin D. It is essential in the formation of bile acids and it is an essential component of cell membrane, too. The concern about cholesterol has resulted from studies indicating that high blood cholesterol levels-not necessarily high dietary cholesterol was one of the risk factors associated with atherosclerosis.

Lipoproteins are packages of fat wrapped in water-soluble proteins. These plasma lipoproteins contain triglycerides, cholesterol, fatty acids, phospholipids (any of a class of fat related substances that contain phosphorus, fatty acids and a nitrogenous base), and traces of fat-soluble vitamins and steroid hormones. The higher the protein ratio, the higher is the density:

- **Chylomicrons** have the lowest density and are mostly triglycerides (90 %) with a small amount of protein, delivering diet fat to liver cells;
- **Very low-density lipoproteins** (VLDL) deliver endogenous triglycerides to tissue cells;
- Intermediate low-density lipoproteins (ILDL) continue the delivery of endogenous triglycerides to tissue cells;
- **Low density lipoproteins** (LDL) deliver cholesterol to the peripheral tissue cells;
- **High-density lipoproteins** (HDL) transfer free cholesterol from tissues to the liver for catabolism and excretion. All the lipoproteins are closely associated with lipid disorders related to cardiovascular diseases.

Daily requirements of fat depend on age, gender, health status, energy expenditure and other factors. The recommendation is 60 – 105 g daily for a man and 55 – 85 g daily for a woman. Ratio of fatty acids SFA : MUFA : PUFA in food should be 1 : 1 : 1. Fats should provide 25 – 30 % of all energy (caloric) intakes.

5.1.2.3 Carbohydrates

Carbohydrates are necessary to meet energy needs. The name carbohydrate comes from its chemical nature. It is composed of carbon, hydrogen and oxygen, with a hydrogen/carbon ratio usually that of water – H_2O. There are two basic types of carbohydrates: simple and complex.

Single carbohydrates consist of single and double sugar units (mono- and disaccharides), that are easily digested and provide quick energy.

Complex carbohydrates or **polysaccharides** are less easily prepared for use. Generally, they provide energy more slowly and prevent large fluctuations in blood glucose levels.

Carbohydrates also maintain liver, heart, brain and nerve tissue function and present the breaking down of fats and proteins for energy, which results in excessive production of toxic metabolic by-products. **Fiber** is a complex carbohydrate that forms the indigestible part of plants, affects the digestion and absorption of foods in ways that are beneficial to good health. Fiber intake is associated with reduced colorectal cancer risk.

Monosaccharides In human metabolism, all types of sugar are converted into **glucose**. **Fructose** – it is converted to glucose for energy. **Galactose** – is produced in human digestion from lactose and is then changed to glucose for energy.

Disaccharides Sucrose is a common table sugar. **Lactose** is the sugar in milk and is formed in the body from glucose. **Maltose** plays a role as an intermediate product of starch digestion.

Polysaccharides Starch is the most important source of carbohydrate made up of many chains of single sugar units. **Glycogen** is stored in relatively small amounts in the liver and muscle tissues and helps sustain normal blood sugar levels during fasting periods. **Dextrins** are intermediate products in the break down of starch. **Dietary fiber** contains cellulose, noncelullose polysaccharides and lignin. Physiologic properties consist in water absorption, binding effect and colon bacteria relation, which provides fermentation substrates for bacterial action, producing volatile fatty acids and gas.

The primary function of carbohydrates is to provide fuel for energy; the human body **requires daily 50 % to 65 % of the total energy intake**, it is important to maintain energy reserves.

Carbohydrates serve several special functions: glycogen reserves (the liver and muscle glycogen reserves provide a constant interchange with the body's overall energy balance system). Carbohydrates help regulate protein metabolism so, that protein is used for its basic purpose of tissue building. The amount of carbohydrates also relates to fat metabolism and prevents the breaking down of fats and proteins for energy, which results in excessive production of toxic metabolic by-products. Regarding the heart activity, the glycogen in cardiac muscle is an important emergency source of contractile energy and a constant amount of carbohydrate is necessary for the proper functioning of the central nervous system.

Table 5.2 Glycemic Index (Reference value is glucose GI = 100)
(Source: http://www.diabetesnet.com/diabetes_food_diet/glycemic_index.php)

Cereals		Snacks		Pasta		Beans	
All bran	51	Chocolate bar	49	Cheese tortellini	50	Baked	44
Bran buds	45	Corn chips	72	Fettucini	32	Black beans, boiled	30
Bran flakes	74	Croissant	67	Linguini	50	Butter, boiled	33
Cheerios	74	Doughnut	76	Macaroni	46	Cannellini beans	31
Corn	83	Graham crackers	74	Spagh, 5 min boiled	33	Garbanzo, boiled	34
Cornflakes	83	Jelly beans	80	Spagh, 15 min boiled	44	Kidney, boiled	29
Cream of wheat	66	Life savers	70	Spagh, prot enrich	28	Kidney, canned	52
Frosted flakes	55	Oatmeal cookie	57	Vermicelli	35	Lentils, green, brown	30
Grapenuts	67	Pizza, cheese & tom	60	**Soups/vegetables**		Lima, boiled	32
Life	66	Pizza Hut, supreme	33	Beets, canned	64	Navy beans	38
Muesli, natural	54	Popcorn, light micro	55	Black bean soup	64	Pinto, boiled	39
Nutri-grain	66	Potato chips	56	Carrots, fresh, boil	49	Red lentils, boiled	27
Oatmeal, old fash	48	Pound cake	54	Corn, sweet	56	Soy, boiled	16
Puffed wheat	67	Power bars	58	French fries	75	**Breads**	
Raisin bran	73	Pretzels	83	Green pea, soup	66	Bagel, plain	72
Rice	89	Saltine crackers	74	Green pea, frozen	47	Baguette, French	95
Shredded wheat	67	Shortbread Cookies	64	Lima beans, frozen	32	Croissant	67
Special K	54	Snickers bar	41	Parsnips	97	Dark rye	76
Total	76	Strawberry jam	51	Peas, fresh, boil	48	Hamburger bun	61
Fruit		Vanilla wafers	77	Pot, new, boiled	59	Muffins	
Apple	38	Wheat thins	67	Pot, red, baked	93	Apple	44
Apricots	57	**Crackers**		Pot, sweet	52	Blueberry	59
Banana	56	Graham	74	Pot, white, boiled	63	Oat & raisin	54
Cantaloupe	65	Rice cakes	80	Pot, white, mashed	70	Pita	57
Cherries	22	Rye	68	Split pea soup w/ham	66	Pizza, cheese	60
Dates	103	Soda	72	Tomato soup	38	Pumpernickel	49
Grapefruit	25	Wheat thins	67	Yam	54	Sourdough	54
Grapes	46	**Cereal grains**		**Dairy products**		Rye	64
Kiwi	52	Barley	25	Chocolate milk	35	White	70
Mango	55	Basmati white rice	58	Custard	43	Wheat	68
Orange	43	Bulgur	48	Ice cream, van	60	**Drinks**	
Papaya	58	Couscous	65	Ice milk, van	50	Apple juice	40
Peach	42	Cornmeal	68	Skim milk	32	Colas	65
Pear	58	Millet	71	Soy milk	31	Gatorade	78
Pineapple	66	**Sugars**		Tofu frozen dessert	115	Grapefruit juice	48
Plums	39	Fructose	22	Whole milk	30	Orange juice	46
Prunes	15	Honey	62	Yogurt, fruit	36	Pineapple juice	46
Raisins	64	Maltose	105	Yogurt, plain	14		
Watermelon	72	Table Sugar	64				

Fruit, vegetables, brown rice, enriched whole-grain breads, whole grain cereals, rolled oats, beans, legumes, and sweet potatoes are good examples of healthy carbohydrate foods.

Some food carbohydrates increase the blood glucose level more than others do, which is expressed in Glycemic Index (Table 5.2).

Table 5.3 Minerals

Mineral	RDA (adult)	Physiological functions	Deficiency Diseases /Overload Disorders	Food Sources
Calcium (Ca)	800 – 1,500 mg	Bone mineralization, muscle contraction	Tetany /Calcium deposits in soft tissues	Dairy products, fortified soy and rice milk, fish bones
Phosphorus (P)	1,000-1,500 mg	Builds bones and teeth	Bone diseases /renal insufficiency	Meat, fish, eggs, legumes and dairy products; whole wheat, rice
Magnesium (Mg)	300 – 450 mg	Bone mineralization, active in more than 300 chemical reactions in the body (coenzyme)	Tremor, spasm, /Diarrhea, decreased calcium absorption	Whole grains, meat, milk, nuts, green vegetables, legumes
Sodium (Na)	1,100 – 3,000 mg	Maintains body's fluid balance; important for nerve function and muscle contraction; controls heart's rhythm	Fluid-electrolyte and acid-base balance disorders	Salt – naturally in many foods and is added to many prepared foods
Potassium (K)	1800 – 5,600 mg	Helps nerves and muscles function; regulates heart's rhythm; regulates bodily fluids	Fluid-electrolyte and acid-base balance disorders	Potatoes, dried fruits, bananas, legumes, raw vegetables, mushrooms; lean meat, milk and fish
Chlorine (Cl)	1,700 – 5,000 mg	Major anion in extracelular fluid	Hypochloremic alkalosis	Salt (NaCl)
Sulphur (S)	Diet with adequate proteins	Essential constituent of proteins, enzyme activity, energy metabolism	Malnutrition symptoms /Cystinuria	Meat, egg, diary products

5.1.2.4 Minerals

Minerals are inorganic elements widely distributed in nature. They have vital and varied roles in metabolism with many of metabolic functions, building, activating, regulating, transmitting and controlling.

Minerals are classified as **major minerals**, required in relatively large quantities, which make up 60 % to 80 % of all the inorganic material in the body and include: calcium, magnesium, sodium, potassium, phosphorus, sulphur and chlorine. Summary of major minerals (required intake over 100 mg/day) is presented in Table 5.3.

Trace elements are essential elements, which required intake is under 100 mg/day. Definitely essential trace elements include: iron, iodine, zinc, copper, manganese, chromium, cobalt, selenium, molybdenum and fluorine (Table 5.4) with required intake less than 100 mg/day. A remaining group of six and possibly eight trace elements are essential (Table 5.1).

Table 5.4 Trace elements

Element	RDA (adult)	Physiological functions	Deficiency Diseases /Overload Disorders	Food Sources
Iron (Fe)	10 – 28 mg	Hemoglobin synthesis, oxygen transport, cell oxidation, heme enzymes	Anemia hypochromic /hemosiderosis, heart disease, liver cirrhosis	Meat, egg, legumes, tofu, leafy greens, cereals
Iodine (I_2)	150 – 300 µg	Thyroid hormones; regulation of cell metabolism	Endemic goiter, cretinism, during pregnancy fetal development disorders, hypothyroidsm /hyperthyroidsm	Saltwater fish, shellfish, sea kelp and iodized salt
Zinc (Zn)	10 – 16 mg	Essential coenzyme, growth, immunity, wound healing, taste, sperm production, antioxidant, prostate health	Hypogonadism, test and smell impairment /Immune suppression, nausea, metallic taste, copper deficiency	Oysters, meat, milk, poultry, fish, grain
Copper (Cu)	1.5 – 2.5 mg	In enzyme systems with iron, maintains connective tissue and blood vessels; may play a role in cancer prevention	Hypocupremia – nephrosis /Wilsons disease (excess storage)	Meats, shellfish, whole-grain products, legumes and dried fruits
Manganese (Mn)	2.5 – 5 mg	Enzymes component, reproductive processes, sex hormone formation; essential for normal brain function and bone development	With protein-energy malnutrition /Inhalation toxicity	Tea, green vegetables, whole grain, legumes, oats, rice
Chromium (Cr)	60 – 180 µg	Glucose and fat metabolism; prevention high cholesterol and atherosclerosis		Whole grains and molasses, legumes
Cobalt (Co)		Constituent of Vitamin B_{12},	As deficiency B_{12}	Liver, meat, milk
Selenium (Se)	50 – 70 µg	Antioxidant, constituent of enzyme, immunity, possible cancer prevention, viral infections	Low content in soil, malnutrition /Brittle hair and nails, irritability, garlic breath, fatigue, nausea	Whole grains from selenium-rich soils, poultry, meat, dairy
Molybdenum (Mo)	150 – 500 µg	Constituent of oxidase emzymes		Whole grain, milk, legumes
Fluorine (F)	1.5 – 4 mg	Promotes bone and tooth formation; prevents tooth decay	Dental caries, osteoporosis /flourosis	Seafood, tea, coffee, soybeans, sodium fluoride is added to water supply to prevent tooth decay

Table 5.5 Fat-soluble vitamins

Vitamin	RDA (adult)	Physiological functions	Deficiency Diseases / overload disorders	Food Sources
A Beta-carotene (carotenoids) retinol	750 – 1200 µg 4 – 10 mg	Production of rhodopsin, healthy immune barriers and epithelial tissue, growth, reproduction, bone and red blood cell formation, vision antioxidant, possible cancer prevention,	night blindness, xerophtalmia, keratomalacia; /Hypervitaminosis liver toxicity, dry rough skin and cracked lips, irritability, headache, birth defects	milk, butter, cheese, egg, liver, fish, orange, yellow, red and green vegetables and fruits
D Ergocalciferol, cholecalciferol	5 – 10 µg	Calcium metabolism, bone mineralization, possible cancer prevention	Rickets and Osteomalacia /Hypervitaminosis: Heart, liver, kidney toxicity, hypercalcemia	Fortified milk, fatty fish, sunlight on skin
E Tocopherols, tocotrienols	12 – 18 mg	Antioxidant, hemopoesis, anticoagulant, protection from heart disease, possible cancer prevention	Deficiency is very rare; mild hemolytic anemia in newborn infants, impaired fat absorption /Possible increase in heart disease, excess bleeding	Wheat germ, vegetable oils, nuts
K Phylloquinone, menaquinones	12 – 20 µg	Bone mineralization, blood clotting	Bleeding diathesis /Interaction with blood thinners	Green leafy vegetables, synthesized by intestinal bacteria

RDA: recommended dietary allowance (from all sources)

5.1.2.5 Vitamins

Three key characteristics of these **organic non-calorigenic food substances** are evident: they are not "burned" to yield energy, they are vital to life, often not a single substance but a group of related substances turned out to have the particular metabolic activity.

Vitamins are grouped according to their solubility in either fat or water.

The fat-soluble vitamins – A, D, E, and K – are closely associated with lipids in their fate in the body. They can be stored, and their functions are more related to structural activities (Table 5.5).

The water-soluble vitamins – B complex and C (Table 5.6) **–** have fewer problems in absorption and transport, cannot be stored except in the "tissue saturation" sense, and function more as coenzyme factors in cell metabolism.

The content of vitamins in fresh dietary sources is during processing reduced, which should consider (Table 5.7).

Table 5.6 Water-soluble vitamins

Vitamin	RDA (adult)	Physiological functions	Deficiency Diseases/ Overload Disorders	Food Sources
C Ascorbic Acid	75 – 130 mg	Antioxidant, immunity, antiviral in test-tubes, cancer prevention, increases iron absorption	Scurvy /Pro-oxidant, excess iron absorption, diarrhea	Fruits and vegetables, especially peppers and citrus fruits
B_1 Thiamine	1 – 1.4 mg	Carbohydrate metabolism, Energy metabolism, mood, nervous system, muscles and heart	Beriberi, Wernicke-Korsakoff syndrome /Drowsiness or muscle relaxation with large doses	Whole grains, seed, brown rice, fortified foods, legumes, pork, oysters
B_2 Riboflavin	1.2 – 2.1 mg	Energy metabolism, antioxidant, hormones, promotes eye and skin health	Ariboflavinosis, cheilosis, glossitis, skin disorders	Dairy products, leafy greens, liver, oysters
Niacin Nicotinic acid PP, B_3	12 – 23 mg	Energy metabolism, lowers LDL cholesterol and triglycerides, raises HDL cholesterol	Pellagra, anorexia /Itching, skin flushing, liver toxicity, insulin resistance	Poultry, red meat, fish, legumes, peanut butter, nuts
B_5 Pantothenic acid	8 – 10 mg	Coenzym A, general metabolism	Paresthesia /Diarrhea; possibly nausea and heart burn	Liver, egg, milk
B_6 Pyridoxin	1.8 – 2. 5 mg	Protein metabolism, immunity, neurotransmitter synthesis (e.g. serotonin and dopamine), treats peripheral neuropathy	Anemia, peripheral neurological disorders /neuropathy	Meat, liver, fish, poultry, eggs, potatoes, fortified cereals, peanuts, soybeans, leafy veg
B_7 Biotin	25 – 200 µg	General metabolism	Dermatitis, enteritis	Liver, egg, yolk
Folic Acid Folate B_9	200 – 400 µg	General metabolism, prevents neural tube defects and other birth defects, lowers homocysteine, possible cancer prevention	Deficiency during pregnancy is associated with birth defects - neural tube defects /May mask symptoms of vitamin B12 deficiency; other effects, nerve damage	Leafy greens, legumes, oranges, broccoli, cauliflower, peanuts
B_{12} Cobalamin	2 – 2.6 µg	Cell division, amino acid metabolism, nervous system, mental function	Megaloblastic anemia Pernicious anaemia, neurological disturbance	Fish, shellfish, meat, liver, milk, fermented soy products

5.2 HEALTHY DIET

5.2.1 Guidelines for healthy diet

The ideal diet should provide energy and essential nutrients within optimal ranges from foods that are available, affordable and palatable. Recommendations are expressed in The Food Guide Pyramid (Figure 5.1), which emphasizes foods from the five food groups shown

in the sections of the pyramid. Each of these groups provides required nutrients for good health. For everyday living, the simplest and most practical plan is to follow those same guidelines, selecting from the various food groups the type and amount of food recommended.

Levels for nutrients are established according to: age, sex, developmental stage, body size, levels of physical activity, safe and adequate range.

Table 5.7 The losses of vitamins by food processing

Vitamin	Losses by processing [%]	Vitamins destruction by			
		Light	Temperature	Oxygen	Leach out
A	10 – 30	+	+	+	–
D	–	–	–	–	–
E	50	+	–	+	–
K	–	–	–	–	–
C	50 – 55	+	+	+	+
B_1	25 – 45	+	+	+	+
B_2	20 – 50	+	+	–	+
B_3	25 – 50	–	+	–	+
B_6	30 – 60	+	–	–	+
B_{12}	> 10	–	300 °C	–	+
Folic acid	50 – 90	–	250 °C	–	+
Niacin	10 – 20	–	–	–	+
Biotin	0 – 70	–	230 °C	–	+

Common recommendations are as follow:

Consummation a **nutritionally adequate diet** composed of a variety of foods and food sources of energy in moderation in order to maintain appropriate body weight.

Carbohydrates intake: consumption fiber-rich fruits, vegetables, and whole grains often, intake foods and beverages with little added sugars or caloric sweeteners.

Fat intake: consumption less than 10 percent of calories from saturated fatty acids and less than 300 mg/day of cholesterol, and keep trans-fatty acid consumption as low as possible, keep total fat intake between 20 to 35 percent of calories, with most fats coming from sources of polyunsaturated and monounsaturated fatty acids, such as fish, nuts, and vegetable oils, at selecting and preparing meat, poultry, dry beans, and milk or milk products, make choices that are lean, low-fat, or fat-free; limiting intake of fats and oils high in saturated and/or trans-fatty acids, and choose products low in such fats and oils.

Trans fatty acids found in animal and plant foods are originally unsaturated the “good ones” which are changed to “bad ones” through chemical changes including hydrogenation. Food sources of trans fat are meats and dairy products (from naturally occurring chemical changes in the animal’s body as it digests food) and plant

oils that have been hydrogenated – change cis form to trans. Recent research suggests that trans fatty acids may increase the risk for heart disease.

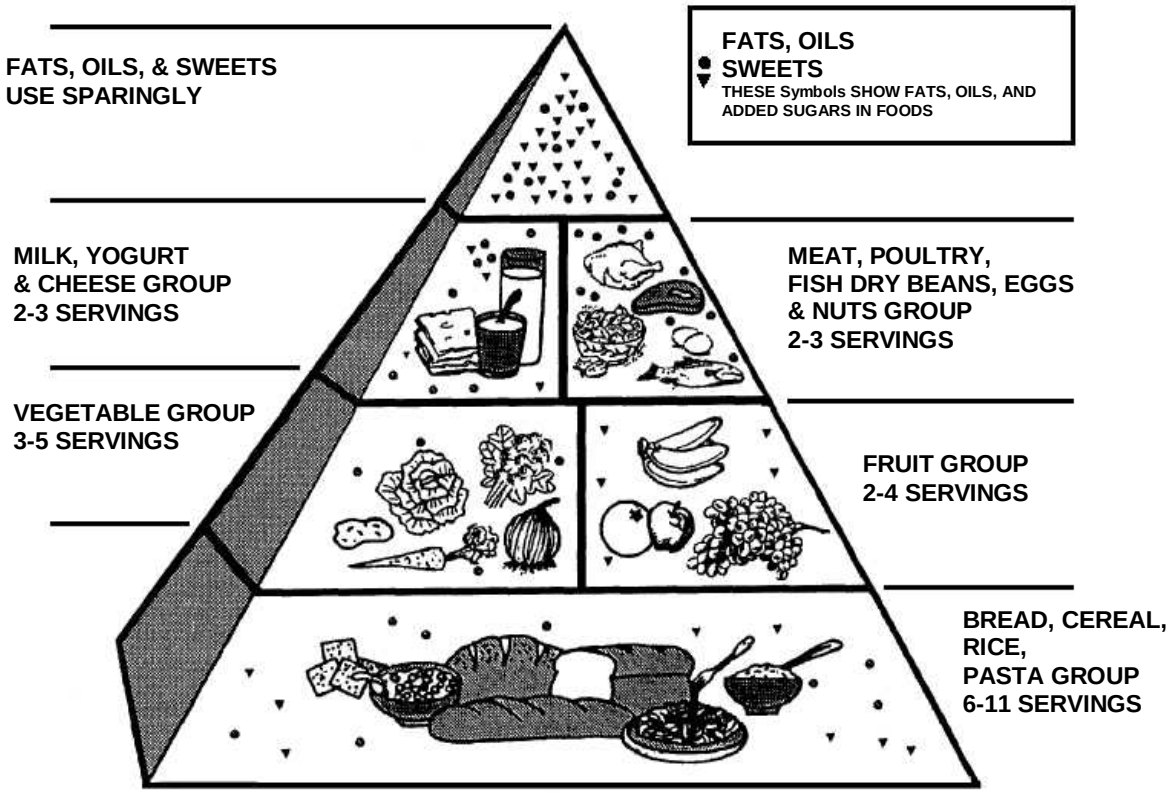

Figure 5.1 The Food Guide Pyramid (Source: USDA, 2000)

Recommended daily energy:

Carbohydrate : Fat : Protein = 50 – 65 % : 25 – 30 % : 10 – 15 %.

Sodium and potassium intake: less than 2.3 mg (approximately 1 tsp of salt) of sodium per day, choose and prepare foods with little salt. At the same time, consume potassium-rich foods, such as fruits and vegetables. Individuals with hypertension, and middle-aged and older adults are recommended to consume no more than 1.5 mg of sodium per day, and meet the potassium recommendation 4.7 mg/day with food.

Alcoholic beverages: should drink so sensibly and in moderation (defined as the consumption of up to one drink per day for women and up to two drinks per day for men).

Maintain body weight: in a healthy range, balance calories from foods and beverages with calories expended.

5.2.2 Recommended dietary allowances

On the basis of estimated nutritional average requirements (EAR – nutrient intake value estimated to meet the requirement of half the healthy individuals in a group) are calculating recommended dietary allowances (RDAs).

RDAs represent the mean requirement plus 2 SD (Standard Deviation), i.e. that intake which meets the needs of almost all (97 – 98 %) healthy people in a group.

The risk of inadequate intake increases as it approaches the EAR. RDA meets the requirements of most people in a population. At levels of intake above Tolerable Upper Intake Level (UL – highest level of daily nutrient intake likely to pose no risks of adverse health effects to almost all individuals in the general population) the risks of excess intake increase (Figure 5.2).

RDAs are published for professionals as well for public (Table 5.8. – 5.11). They are used for planning for national emergencies and for the needs of institutionalized or socially deprived persons. The RDAs are modified in light of expanding knowledge of nutrition and have become a guideline for proper nutrition for the health-conscious individual.

5.2.3 Special nutritional needs

RDAs accept also special nutritional needs in some population groups such as: pregnant and lactating women, children and adolescents, elderly people, physically active persons or sportsmen.

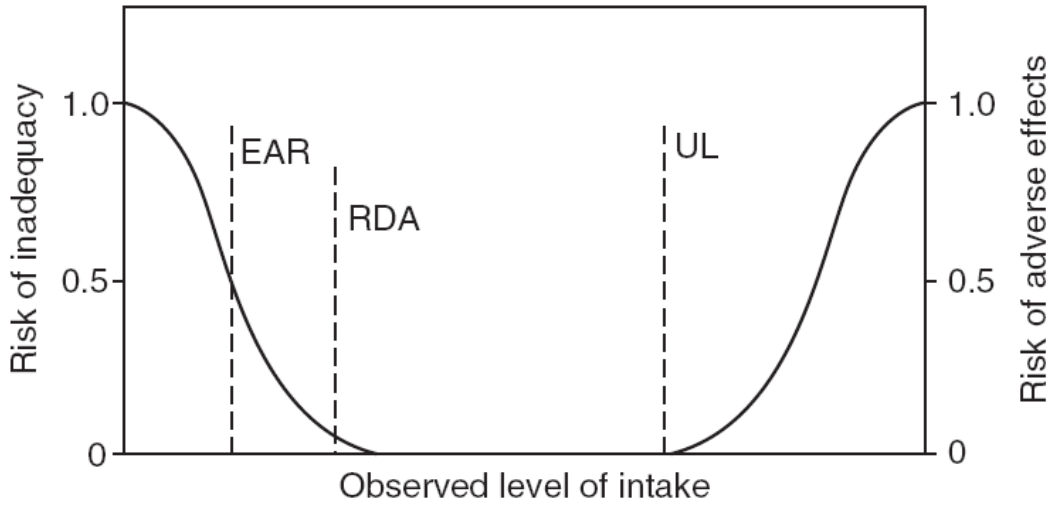

Figure 5.2 Dietary reference intakes (Source: Nestle, 2008)

5.2.3.1 Nutrition of pregnant and lactating women

Pregnant and lactating women have a higher need for energy and some vitamins and minerals. Fetal growth during pregnancy and milk secretion during lactation are nutrient-requiring processes. In well-nourished women, normal physiologic and metabolic adjustments in nutrient utilization probably provide the additional nutrient needed for fetal growth and milk secretion.

In poorly nourished women, the additional demand for nutrients during these processes may lead to maternal and or fetal nutrient deficiencies.

Recommended dietary allowances for pregnant and lactating women are presented in Table 5.8 and 5.9.

5.2.3.2 Children nutrition

Optimal nutrition is necessary for growth, development, metabolism, health, and well-being of children and adolescents.

Early nutrition has a powerful effect on cognitive development and growth, particularly in the first 2 – 3 years.

Breastfeeding for the first 6 months of age best supports healthy growth and development; breastfeeding is recommended for at least 12 months and thereafter at the discretion of the mother. Breast milk provides the correct balance of nutrients, enzymes, immunoglobulin, hormones, anti-infective and anti-inflammatory substances, and growth factors for the infant. Breast-feeding is especially effective in developing countries where access to sanitized water is limited.

Children above the age of two should follow a **balanced diet** as defined by the Dietetic Associations or individual countries' health ministries. Children who do not follow a balanced diet are at risk for lifetime healthcare problems such as an obesity, high blood pressure, cardiovascular diseases, and diabetes or from undernourishment deficiency diseases.

In developed countries children and adolescents are more likely to eat prepackaged foods, high in sugar and fat, rather than more nutritious alternatives, which lead to obesity.

In developing countries, malnutrition affects nearly 250 million children; effects of undernourishment can last a lifetime including blindness, stunted growth, disability, and death. Diarrheal diseases are consequences of sanitation deficiencies, and contaminated food.

It is important to develop healthy eating habits in childhood and adolescence, help healthy food choices, raise a healthy eater by setting a good example and practicing positive habits and follow food safety rules.

Recommended dietary allowances for children and adolescents are presented in Table 5.10 and 5.11.

5.2.3.3 Nutrition in elderly

Nutrition is very important means for healthy ageing. The many physical changes are occurred with aging and affect nutrition changes. Senses of **taste and smell** tend to decline in later years. These changes in taste and smell may decrease one's appetite for foods to such an extent that the diet becomes unbalanced.

Eyesight generally becomes poorer with age. As a result, shopping, cooking, and eating may become more difficult. These problems may result in decreased meal preparation.

Less saliva may be produced with aging and foods are more difficult to swallow.

The loss of teeth makes it difficult to eat and chew foods properly. This often leads to eating softer foods, which restricts food intake and can lead to an unbalanced diet.

Muscular tone and coordination often decreases with aging. This may make swallowing difficult and causes food to move slower through the intestine. Older adults are primary

targets for laxative advertisements. A well-balanced diet with a variety of foods, adequate fiber, liquids, and physical activity often help to combat constipation.

A decrease in the amount of **acid in the stomach gastric juice** may occur with aging. This causes decreased digestion and a feeling of indigestion. Older adults may be tempted to take baking soda, which can further decrease the stomach acid content. A decrease in the amount of digestive enzymes may decrease tolerance of milk or high fat foods.

A **decrease in strength and energy** may occur with increasing age. As a result, food purchasing, carrying heavy groceries, choosing from a wide variety of foods and preparing meals may become difficult.

This is a challenge facing developed and developing countries alike, for nutrition interventions in elderly population. Promoting healthy ageing must become a major policy initiative globally.

Body composition changes with age and the decline in lean body mass leads to decreased strength and mobility, poor balance and an increased frequency of falls. Conserving muscle mass in old age is therefore a strategy for preserving strength, and is of significance in maintaining physical activity, retarding insulin resistance and ensuring normal immune function, too. Preventing age-related decline in cognitive function and maintaining good eye health into older age are both major challenges.

The importance of good nutrition among older people for the maintenance of health has long been advocated, and evidence-based dietary recommendations for older people have recently been published by WHO. However, for a variety of functional, physiological, psychological and social reasons older people are nutritionally vulnerable and frequently consume diets that are poor in both quality and quantity. This vulnerability often results in macronutrient and micronutrient undernutrition. As populations age, the proportion and absolute number of individuals with age-related cognitive impairment rises. There has been particular interest in the hypothesis that improving the diet of older people may be able to delay the initiation, or slow the progression, of cognitive decline.

Recommended dietary allowances for older people are presented in Table 5.8 and 5.9.

5.3 ALTERNATIVE NUTRITION

5.3.1 Vegetarian diet

Many millions have become vegetarians, replacing meats as a main item of protein with legumes, grains and vegetables. It is therefore needed to achieve the necessary balance of essential amino acids.

The meals of vegetarians follow a variety of patterns. True vegetarians allow no animal products and their "dietary laws" have caused serious malnutrition. This concern:

- **Zen macrobiotics**, who eat only brown rice and herb tea to achieve a perfect balance of yin and yang in order to fend off disease;
- **Vegans**, they rely on fruits, vegetables, nuts and seeds, refusing any animal protein, fortified foods, or nutritional supplements;
- **Fruitarians**, who eat only fresh and dried fruits, nuts, honey and sometimes olive oil.

"Animal product" vegetarians include:

- **Lactovegetarians**, who rely on milk, cheese and other milk products as the only animal protein;
- **Ovovegetarians**, who use eggs as their only source of animal protein;
- **Lactoovovegetarians**, who consume milk and eggs, but no other animal products;
- **Pescovegetarians**, who eat fish as their only animal product;
- **Pollovegetarians**, who allow poultry;
- "**Red-meat abstainers**", who eat any animal product except red meat and consider themselves to be vegetarians, too.

Vegetarians can meet the recommended dietary allowances for major nutrients without taking supplements, but there are some problems:

Vitamin B_{12} is found only in animal products. A deficiency can be avoided by including fortified foods or taking a B_{12} supplement from complementary amino acids.

Vegetarians consume more provitamin A (carotene) than they need. The problem is that most of vegetarians take supplement, which might include as much as 10 times the recommended doses for vitamin A, which can build up in body tissues and reach toxic levels.

Iron in grains and legumes is poorly absorbed from the gut and therefore vitamin C should be used for better absorption.

Cadmium: environmental and food concerns associated with cadmium related to agricultural areas where large amounts of phosphate fertilizers containing cadmium have been applied to the soil.

Women get enough protein for a successful pregnancy, though including animal products, as in lacto-ovo-vegetarianism, may become essential to meet extra nutritional needs and supplements are recommended as iron.

Children manage to grow and develop fairly well on a vegetarian diet that includes the non-meat animal proteins milk, cheese, and eggs. The children tend to be a little shorter and mildly anemic (poor availability of iron, vitamin C may be helpful). Some vegetarians have to be careful to get enough kcal (especially pregnant women and children).

Thus, the well-planned vegetarian diet can be nutritious. If used wisely in its lacto-ovo forms it can offer advantages in terms of health, ecology and economy.

Table 5.8 Recommended dietary allowances for adults – Basic able

Age [years]	Energy [kJ]	Proteins [g]	Fats [g]	Carbohydrates [g]	Linoleic acid [g]	Linolenicacid [g]	Calcium [mg]	Iron [mg]	Vitamin A [mg]	Vitamin B_1 [mg]	Vitamin B_2 [mg]	Vitamin C [mg]	Vitamin E [mg]
Males 19 – 34													
Light work	11,500	66	80	442	8.0	2.0	1,000	12	950	1.1	1.6	80	12
Medium work	13,500	70	90	534	8.0	2.4	1,000	14	950	1.2	1.8	85	14
Hard work	15,500	76	105	614	10.0	2.8	1,100	16	950	1.4	2.1	90	16
Males 35 – 59													
Light work	11,000	64	75	424	8.0	2.0	900	12	950	1.0	1.5	80	12
Medium work	13,000	68	85	517	8.0	2.4	900	14	950	1.2	1.7	85	14
Hard work	14,500	72	95	581	10.0	2.8	1,000	14	950	1.4	2.0	90	16
Males 60 – 74	9,500	62	70	348	8.0	2.0	800	12	850	1.2	1.4	75	12
≥ 75	8,500	60	60	313	8.0	2.0	800	10	800	1.0	1.3	75	12
Females 19 – 34													
Light work	9,500	52	65	369	7.0	2.0	900	16	850	1.0	1.4	75	12
Medium work	10,500	57	75	402	8.0	2.4	900	16	850	1.1	1.6	80	14
Physical load	11,500	61	85	435	9.0	2.8	1,000	18	850	1.2	1.7	90	16
Pregnancy	11,000	63	75	426	9.0	2.4	1,300	28	1,100	1.2	1.6	120	14
Lactation	12,000	67	85	458	9.0	2.8	1,500	20	1,200	1.4	1.8	130	18
Females 35 – 54													
Light work	9,000	51	60	352	7.0	2.0	800	15	850	1.1	1.4	75	12
Medium work	10,000	55	70	385	8.0	2.4	800	15	850	1.2	1.5	80	14
Physical load	11,000	58	75	431	9.0	2.8	900	17	850	1.4	1.6	90	16
Female 55 – 74	8,500	50	60	323	7.0	2.0	800	12	800	1.1	1.4	75	12
[3] 75	7,600	48	55	282	7.0	2.0	850	10	750	1.0	1.2	75	12

Table 5.9 Recommended dietary allowances for adults – Additional Table

Age [years]	Fiber [g]	Magnesium [mg]	Phosphorus [mg]	Zinc [mg]	Med' [mg]	Chromium [mg]	Selenium [mg]	Iodine [mg]	Vitamin B_6 [mmg]	Niacin [mg]	Pantothenic Acid [mg]	Folacin [mg]	Vitamin B_{12} [mg]	Vitamin D [mg]	Carotenoids [mg]
Males 19 – 34															
Light work	26	400	1,200	12	2.0	100	60	150	1.9	18	8	200	2.0	7.5	6.0
Medium work	30	400	1,200	12	2.2	130	65	150	1.9	20	8	200	2.0	7.5	7.0
Hard work	32	400	1,200	12	2.5	150	70	150	2,1	23	8	200	2.0	7.5	8.0
Males 35 – 59															
Light work	24	350	1,200	11	1.8	80	55	150	1.9	16	8	200	2.0	5.0	5.0
Medium work	28	350	1,200	11	2.0	100	60	150	1.9	18	8	200	2.0	5.0	6.0
Hard work	30	350	1,200	11	2.5	130	65	150	2.1	22	8	200	2.0	7.5	7.0
Males 60 – 74	22	350	1,000	10	2.0	80	55	150	1.8	16	8	200	2.0	5.0	5.0
≥ 75	20	350	1,000	10	1.8	70	50	150	1.8	14	8	200	2.0	5.0	5.0
Females 19 – 34															
Light work	22	350	1,200	11	1.6	80	50	150	1.8	15	8	200	2.0	7.5	5.0
Medium work	24	350	1,200	11	2.0	100	50	150	1.8	17	8	200	2.0	7.5	5.5
Physical load	26	350	1,200	11	2.4	130	55	200	1.9	19	8	200	2.0	7.5	6.0
Pregnancy	26	450	1,300	16	2.3	150	65	250	2.5	18	10	400	2.2	10.0	8.0
Lactation	28	450	1,500	16	2.5	180	70	300	2.5	20	10	300	2.6	10.0	10.0
Females 35 – 54															
Light work	22	300	1,200	10	1.6	70	50	150	1.8	14	8	200	2.0	5.0	4.0
Medium work	24	300	1,200	10	1.8	80	50	150	1.8	16	8	200	2.0	5.0	4.5
Physical load	26	300	1,200	10	2.2	100	55	170	1.9	18	8	200	2.0	7.5	5.5
Female 55 – 74	20	300	1,000	10	1.6	70	50	150	1.8	14	8	200	2.0	5.0	5.0
≥ 75	18	300	1,000	10	1.5	60	50	150	1.8	12	8	200	2.0	5.0	5.0

Source: Kajaba et al, 2003

Table 5.10 Recommended dietary allowances for children and youth – Basic Table

Age [years]	Energy [kJ]	Proteins [g]	Fats [g]	Carbohydrates [g]	Linoleic acid [g]	Linolenic acid [g]	Calcium [mg]	Iron [mg]	Vitamin A [mg]	Vitamin B_1 [mg]	Vitamin B_2 [mg]	Vitamin C [mg]	Vitamin E [mg]
Infants													
0.0 – 0.5	2,635	14	33	70	3.0	0.5	500	8	400	0.2	0.4	50	5
0.5 – 1.0	3,640	16	38	116	3.5	0.7	700	10	400	0.5	0.7	50	6
Preschool Children													
1 – 3	5,500	20	45	208	4.5	0.9	800	10	400	0.5	0.8	55	6
4 – 6	7,530	26	60	289	5.5	1.1	900	10	500	0.7	1.0	60	8
School Children													
7 – 10	9,000	33	70	347	7.5	1.3	1,000	10	700	1.0	1.3	65	10
11 – 14 Males	10,500	50	80	397	9.0	2.0	1,200	12	900	1.2	1.7	80	12
Females	10,000	52	75	377	8.5	1.8	1,200	14	900	1.1	1.6	90	10
Adolescents Males													
15 – 18													
studying	12,500	60	85	496	10.0	2.4	1,200	12	1,000	1.3	2.0	100	14
working	15,000	69	100	602	11.0	2.6	1,200	15	1,000	1.5	2.2	110	15
Adolescents Females													
15 – 18													
studying	9,600	50	65	378	9.0	1.8	1,200	12	900	1.0	1.5	90	12
working	11,500	55	80	453	10.0	2.2	1,200	14	900	1.1	1.6	100	12

Table 5.11 Recommended dietary allowances for children and youth – Additional Table

Age [years]	Fiber [g]	Magnesium [mg]	Phosphorus [mg]	Zinc [mg]	Med' [mg]	Chromium [mg]	Selenium [mg]	Iodine [mg]	Vitamin B_6 [mmg]	Niacin [mg]	Pantothenic Acid [mg]	Folacin [mg]	Vitamin B_{12} [mg]	Vitamin D [mg]	Carotenoids [mg)
Infants															
0.0 – 0.5	1	50	300	5	0.5	15	10	40	0.3	4	2	60	0.3	7.5	0.4
0.5 – 1.0	3	100	500	5	0.7	30	15	50	0.6	6	3	60	0.5	10.0	0.7
Preschool Children															
1 – 3	10	100	700	8	0.8	40	20	70	0.6	9	3.5	100	0.7	10.0	1.0
4 – 6	14	200	900	10	1.2	60	20	100	0.8	11	4	100	1.0	7.5	1.5
School Children															
7 – 10	17	250	1,000	12	1.5	80	30	120	1.2	14	5	100	1.4	7.5	2.0
11– 14 Males	20	350	1,200	14	1.8	100	40	130	1.5	18	6	150	2.0	10.0	2.5
Females	18	300	1,200	15	2.0	130	45	170	1.5	17	6	150	2.2	10.0	3.0
Adolescents Males															
15 – 18															
studying	22	400	1,200	15	2.2	150	50	160	1.7	21	8	200	2.0	10.0	3.5
working	25	400	1,200	16	2.5	180	60	180	1.8	24	8	200	2.4	10.0	5.0
Adolescents Females															
15 – 18															
studying	18	350	1,200	12	2.0	120	50	160	1.5	16	8	200	2.0	10.0	3.0
working	22	350	1,200	12	2.2	150	55	170	1.5	18	8	200	2.2	10.0	4.0

Source: Kajaba et al, 2003

5.3.2 Conventionally and organically produced foodstuffs

Organic foodstuffs are those that are produced according to specified standards, which among other things, control the use of chemicals and medicines in crop and animal production, and emphasize protection of the environment. No explicit evidence of a difference in content of nutrients and other substances between organically and conventionally produced crops and livestock products was detected yet.

Comparison of composition (nutrients and other substances) of organically and conventionally produced foodstuffs needs a systematic review of the available knowledge.

5.4 BIOLOGICAL CONTAMINATION AND CHEMICALS IN FOOD

5.4.1 Microbiological hazards

Foodborne diseases caused by microorganisms present a major health issue.

With the improvement of standards of personal hygiene, basic sanitation, vaccination, food control and increasing application of technologies (e.g. pasteurization), many foodborne diseases have been either eliminated or considerably reduced (e.g. poliomyelitis, cholera, brucellosis, typhoid and paratyphoid fevers, bovine TB). Nevertheless, most countries are experiencing a great increase in several other foodborne diseases.

The most frequent infections are caused by *Escherichia coli, Salmonella, Campylobacter jejuni, Listeria monocytogenes*, parasites like cryptosporidium, cryptospora, trematodes, and viruses. According to WHO data almost 1.8 million children die each year in developing countries from diarrhoeal disease caused by microbes which are present in food and water. In the USA each year some 100 million cases are attributed to foodborne illnesses, resulting in 325,000 hospitalizations and about 5,000 deaths.

Five most frequent foodborne diseases are: **Botulism, Campylobacteriosis, E. coli infection, Salmonellosis** and **Shigellosis.**

Botulism is a disease caused by Bacillus botulinum, an agent emerging from soil. The most common sources are canned meat and vegetables and the production of toxin can be regulated by controlling the acid pH of food.

Campylobacteriosis is a bacterial gastrointestinal infectious disease caused by *Campylobacter jejuni, C. fetus,* and *C. coli*. The germs are found in the intestines of animals. Infection can be caused by handling raw poultry, eating undercooked poultry, drinking non-chlorinated water or raw milk, or handling infected animal or human feces. Most frequently, poultry and cattle waste are the sources of the bacteria, but feces from puppies, kittens, and birds may be contaminated, too.

***Escherichia coli* infection** is caused by different strains of *E. coli* bacteria. Harmless strains of *E. coli* can be found widely in nature, including the intestinal tracts of humans and warm-blooded animals. Disease-causing strains, however, are a frequent cause of both intestinal and urinary-genital tract infections. Several different strains of harmful *E. coli* can cause diarrheal disease. A particularly dangerous type is called *Enterohaemorrhagic E. coli*, or EHEC. EHEC often causes bloody diarrhea and can lead to kidney failure in children or people with weakened immune systems. In 1982, scientists identified the first dangerous strain in the United States. The type of harmful *E. coli* most commonly found in this country is named O157:H7, which refers to chemical compounds found on the bacterium's surface. This type produces one or more related, powerful toxins, which can severely damage the lining of the intestines. This strain is now found worldwide and present one of the most toxic bacterial sources to be found in food and water.

Salmonellosis is usually provoked by *Salmonella typhimurium* and ***S. enteritidis***. Salmonella bacteria can be found in food products such as raw poultry, eggs, and beef, and sometimes on unwashed fruit. Food prepared on surfaces that previously were in contact with raw meat or meat products can, in turn, become contaminated with the bacteria. This is called cross-contamination. With the spread of organic farming, new cases are recorded from eating raw alfalfa sprouts grown in contaminated soil. Salmonella infection frequently occurs after handling pets.

Shigellosis, also called bacillary dysentery, is an infectious disease caused by Shigella (*Shigella dysenteriae, S. flexneri, S. boydii,* and *S. sonnei*). It is commonly transmitted by food service workers who are sick or infected, but have no symptoms, and adequate personal hygiene.

Listeriosis is caused by *Listeria monocyotogenes.* This foodborne illness in pregnant women can result in miscarriage, fetal death, and severe illness or death of a newborn infant. Others at risk for severe illness or death are older adults and those with weakened immune systems. Listeriosis is now attributed to ready-to-eat foods and deli products.

Foodborne viruses (caliciviruses, rotavirus, astrovirus, and hepatitis A virus) present in food and water are frequent cause of diarrhea. **Hepatitis A** is also common throughout the world (e.g. shellfish borne hepatitis A, food infected by food handlers, and not subsequently sufficiently heated may also transmit the disease and many cases of hepatitis A are known to be restaurant associated).

Norwalk virus (a particular calicivirus) caused a number of outbreaks of food poisoning at buffets and caterings.

Prions Mad Cow Disease is the commonly used name for Bovine Spongiform Encephalopathy (BSE), a slowly progressive, degenerative, fatal disease affecting the central nervous system of adult cattle. In cattle with BSE, these abnormal types of protein, prions, initially occur in the small intestines and tonsils, and are found in central nervous tissues, such as the brain and spinal cord, and other tissues of infected animals experiencing later stages of the disease. There is a disease similar to BSE called Creutzfeldt-Jakob Disease (CJD) that is found in

people. A variant form of CJD is believed to be caused by eating contaminated beef products from BSE-affected cattle.

Despite progress in science and technology, contaminated food and water remain in this day a major public health problem. However, only a small portion of cases comes to the notice of the health services (in developed countries only about 10 % are reported while in developing countries about 1 % of the total).

Parasitic infections (e.g. Cryptosporidium infection) – infection is believed to be more common than Salmonella infection in young children. **Helmints** (e.g. *Trichinella spiralis, Taenia saginata* and *Taenia solium*), which are acquired through consumption of undercooked or uncooked meat Ascaris is estimated to affect some of 1,000 million people.

Biological contaminants are responsible for a wide range of foodborne diseases and infant diarrhoea is the dominant problem. According to WHO data almost 1.8 million children die each year in **developing countries** from diarrhoeal disease caused by microbes, which are present in food and water.

Foodborne diseases may also cause other serious health problems (e.g. chronic diarrhoea can lead to undernutrition, some diseases – listeriosis and toxoplasmosis are dangerous during pregnancy and some foodborne infections may lead to chronic diseases (e.g. joint disease, immune system disorders, heart and vascular diseases, diseases of the renal system).

Factors responsible for the prevalence of foodborne diseases are as follows:

- improved standards of living have led to an increase in consumption of food of animal origin;
- mass production of animals with the risk that many of these animals are subclinically infected by various pathogens (e.g. Salmonella and Campylobacter);
- many of the foodborne diseases are to errors in food preparation or lack of personal hygiene on the part of the foodhandlers;
- traditions and beliefs contribute to the occurrence of foodborne diseases (e.g. consumption of raw meat products, raw fish or raw milk);
- with increasing number of international travelers, some of the diseases are imported from endemic areas;
- many outbreaks occur as a result of failures during the food processing (e.g. insufficient cooking or reheating the food);
- international trade in food and animal food plays an important role in the spread of pathogens (e.g. animals given the contaminated feeds contaminated the environment);

– soil, rivers, surface water and, in turn, insects, rodents and birds with their faeces. In such a manner, the microorganisms have established themselves widely in the environment, including animals.

5.4.2 Chemicals in food

Thousands of chemical compounds have already been identified. Many of the substances are introduced by manufacturers influenced by such factors as technology, leisure and convenience, profit motive, the pressure of overpopulation and the human desire to improve on nature. Many are in food as contaminants because of ignorance, apathy, carelessness and neglect. Most of these substances have no known nutritional value, and because they are reactive compounds they can be expected to have some effects. The questions to be asked are: What are these substances and what are their effects? What conditions or factors influence these effects?

A growing number of consumers in industrialized countries are very concerned about the health effects of food chemicals. In the developing countries, consumers are more worried that products banned in developed countries are being exported to them. As a consequence, many consumers are turning toward the so-called "healthy foods" hoping in this way to avoid chemicals, but ignoring the fact that food itself is a mixture of chemicals and that many of the substances they fear may occur naturally in food (e.g. a normal diet contains at least 10,000 times more "natural" pesticides than man-made pesticide residues).

In the developed countries, the food supply is mostly safe from chemical viewpoint because of the complex food safety structure (e.g. legislation and its enforcement, monitoring and surveillance system). However, accidental contamination, or adulteration does occur, sometimes with serious consequences (e.g. in Spain 1981 – 82 adulterated cooking oil killed some 600 people and disabled – another 20,000, but the agent responsible for this mass poisoning has not yet been identified).

Veterinary drugs are given to animals as preventive measures (e.g. vaccines and feed additives) and as therapy. Use is made also of growth promotors (hormonal anabolic agents can yield a net increase of muscle meat of 5 – 10 % or more). Continued monitoring of possible residues is needed that permitted limits are not exceeded. Thyreostatics are still in use and primarily cause an increase of water content of intestines and the muscle meat, which results in fraud with low quality animals. Risk from residues is expected to be low. In the past years, new hormones (e.g. bovine somatotropin – (BST) and porcine somatotropin – (PST)) have been developed and the residues apparently carry no risk for the consumers. The phenylethanolamines include drugs, which have been found to be very effective growth promotors when used as food additives. The illegal use of such substances has been widespread in the past few years in Western Europe, especially in real production. In general, when all these drugs are used under

condition of good agricultural and veterinary practice, residue levels will be all below the appropriate maximum residue limits.

Agricultural chemicals The most common response to the growing problem of pests is the use of pesticides (mostly insecticides, fungicides and herbicides). The result has been disruption of ecosystems because of the death of the non-target species, accumulation of pesticide residues in the environment and in food, and a build-up of pesticide resistance in the target species. As a major consequence of widespread contamination of aquatic resources, several pesticides – particularly herbicides have been detected in drinking-water, which concerns especially developed countries. High levels of chlorinated pesticides have been reported from many developing countries.

There is no indication to date of any harm to human health arising from residues of agricultural chemicals, when the limits established by Codex Alimentarius Commission have been complied with. In most recorded cases where have been implicated in pesticide poisoning, the chemical was found in the food following accidental contamination, through either negligence or ignorance. For example, in a number of cases food has been contaminated because of unsafe packing and leakage of pesticides during storage and transport.

Other example is from Iraq (1971 – 2), where imported wheat and barley seed intended for sowing had been treated with methylmercury fungicide but much of the seed arrived too late for sowing, the warning labels on sacks where in English or Spanish and rural families ate the seed and fed it to their livestock. Officially, over 6,000 people were poisoned and nearly 500 killed, but an unofficial estimate put the figures at over ten times these levels.

The use of the good laboratory practices is extremely important when these substances are employed. Sometimes, foods have been found to contain high levels of pesticide residues, for example when the crops are harvested to soon after applications of pesticides.

Food additives are any substances not normally consumed as food by itself and not normally used as a typical ingredient of the food whether or not it has nutritive value. Food additives comprise a large and varied group of chemicals that are added to food and have several primary functions, which are:

- to make foods more attractive in color and improve the taste in other words increase their "food appeal";
- to extend the shelf life of foods (food preservation) and thus make possible, among other things, mass production;
- to facilitate processing (e.g. improving flavor and texture);
- to improve nutritional quality (nutritional additives); and
- to provide for the specific requirements of consumer groups with special dietary needs (e.g. non-nutritive sweeteners).

In recent years, there has been no evidence that any of the food additives evaluated and used in accordance with the Codex Alimentarius recommendations have led to ill health. The public often forgets that traditional food preservation usually involves the use of chemicals. Many colors and flavors as antioxidants and antimicrobials are synthetic duplicates of natural substances. There is, however, the risk that illegal use of chemicals in food can mask good quality, disguise food deterioration, or constitute a deliberate adulteration of the product. The adulteration of food can, in certain circumstances be very harmful to health besides damaging the consumer's perception of the identity and value of food.

Environmental chemicals A number of environmental chemicals may occur in food as a result of environmental contamination. Their effects on health may be serious and may caused great concern in recent years.

For instance, **lead** – soldered food cans can contain food with higher amounts of lead than in raw commodities and unsoldered cans. Humans are also exposed to traces of toxic metals, lead, cadmium, mercury and of metalloid arsenic in a variety of foods.

Lead in blood is biologically active and is used as an indicator of recent exposure and to evaluate the likelihood of health effects. As a result of atmospheric deposition cadmium is being constantly accumulated in arable soil and taken up by food crops. Recent studies indicate that cadmium may induce functional impairment of the kidney at levels to which certain segments of the urban populations in some industrial countries were exposed.

Methylmercury the more toxic form of mercury – has been shown to have serious effects on the nervous system and the fetal brain.

DDT was widely used between 1940s and 1960s as an insecticide, but because of its potential risk to the environment the use of it was banned or restricted.

Exposure to **polychlorinated biphenyls (PCBs**), mainly through dairy products, meat and fish causes cumulation in the mother milk and fat.

Radioactive contaminants in food Naturally occurring so-called internal emitters that contribute to the radioactive dose in the diet are ^{40}K, ^{226}RA, ^{228}U, ^{14}C, T, ^{87}Rb, ^{210}Pb and ^{210}Po. The environment and therefore food can be contaminated with manmade radioactive elements (effluents from nuclear reactors, spills from reactor accidents and nuclear warfare), too. What concerns a nuclear accident of the magnitude of the one in Chernobyl. Contamination can be widespread over many countries "far field". Food control of crops and animal products may have to be exercised for a long period since radionuclides deposited on the ground only very slowly enter the food chain.

Mycotoxins, the toxic products of microscopic fungi (molds) may also cause serious adverse health effects in humans and animals. Animal studies show that, besides of acute intoxication, mycotoxins may have carcinogenic, mutagenic and teratogenic effects. Among the several

hundreds of mycotoxins, aflatoxin is the most important from the point of view of public health. Aflatoxins are found mostly in groundnuts, oil seeds, cereals, tree nuts, and some fruits. As fungi producing aflatoxin are prevalent in areas with humidity and temperatures, crops in tropical and subtropical regions are more subject to contamination. Epidemiological studies show a strong correlation between the high incidence in liver cancer in some African and South-East Asian countries (12 – 13 per 100,000 annually) and the exposure of the population to aflatoxin. It is suggested that aflatoxins and hepatitis B are co-carcinogens.

Biotoxins and plant toxins Intoxication by marine biotoxin ("fish poisoning") is another problem of concern and in many areas of the world, this type of poisoning is on the increase. Toxicants in edible plants and poisonous plants, which resemble them, are important causes of ill health in many areas of the world.

5.5 DISEASES RELATED TO DIETARY AND BEHAVIORAL PATTERNS

The type of diet prevailing in the developed countries is characterized by an excess of energy-dense foods, rich in fat and free sugars, but a deficiency of complex carbohydrate foods (the main source of dietary fiber). Research and practice have demonstrated close and consistent relationships between the establishment of this type of diet and the emergence of a range of chronic non-communicable diseases. (A comprehensive review of current knowledge on diet, nutrition, and the prevention of chronic diseases is to be found in the reports of a WHO study group.)

The immune system provides the body with a major defense against environmental assaults, particularly invasion by microorganisms and spontaneously arising neoplasms. A variety of chemicals commonly found in the work place and widely distributed in the environment has induced changes in immune system. Immunosuppression may be associated with severe infection and cancer whereas immunopotentiation may be associated with allergic or autoimmune diseases.

Nutrition, through its modulation of specific and nonspecific immune responses, is a critical determinant of optimum immune function. Both severe and moderate nutritional deprivations are associated with impaired immune responses and malnutrition is the most frequent cause of immunodeficiency throughout the world. It is very important that correction of nutritional deficiencies improves immune function and so enhance the body's defense against environmental loads.

A food allergy is an allergic reaction to a particular food. Many different foods can cause allergic reactions. Most commonly they are triggered by certain nuts, peanuts, shellfish, fish, milk, eggs, wheat, and soybeans. Additives such as, monosodium glutamate, metabisulfite, tartrazine can cause allergy. Allergic reactions to foods may be severe and sometimes include an anaphylactic reaction. Allergies may start during infancy. They are most common among

children whose parents have food allergies, allergic rhinitis, or allergic asthma. Food allergies are sometimes blamed for such disorders as hyperactivity in children, chronic fatigue, arthritis, poor athletic performance, and depression.

Food intolerance differs from a food allergy in that it does not involve the immune system. Instead, it involves a reaction in the digestive tract that results in digestive upset.

Coronary heart disease (CHD) Epidemiological studies carried out on middle-aged men provide clear evidence that the risk of coronary heart disease is increased by major factors: high serum total cholesterol, CHD rises progressively with increases in total cholesterol levels from 3.84 mmol/l (150 mg/dl), high blood pressure, obesity and cigarette smoking. The presence of several risk factors, simultaneously, increases the risk of the disease. A low intake of saturated fatty acids is important for preventing the disease (high total fat intake coincides with a high saturated fat intake – diets with 40 % of energy from total fat often provide 15 – 20 % of the energy from saturated fat). It is therefore important to reduce total fat intake to 30 % of energy, but should still allow the unsaturated fatty acids to contribute up to 20 % of energy.

High blood pressure and cerebrovascular diseases The risk of both coronary heart disease and stroke increases as blood pressure rises. There is a fivefold difference in CHD and a tenfold difference in risk of stroke over a range of diastolic blood pressure of 40 mmHg (5.33 kPa). A high body-mass index (Body mass index = weight in kg /height in m^2) and high alcohol intake had strong, independent effects on blood pressure. Salt intake has significant effect on the rise of blood pressure (safe upper limit is 6 g/day). Several studies suggest lower blood pressures among vegetarians than non-vegetarians. A recommendation to maintain normal weight with increased physical activity, a diet low in fat and high in complex carbohydrates, low salt intake and minimizing of the intake of alcohol, is relevant to the avoidance of both obesity and hypertension.

Cancer Some epidemiologists estimate that 30 – 40 % of cancers in men and up to 60 % of cancers in women is attributable to diet.

Cancers of the oral cavity, pharynx, larynx, and esophagus In developed countries, the results of studies indicate that drinking alcoholic beverages is causally related to cancers of mouth, pharynx, esophagus, and upper part of the larynx. There are also positive associations between esophageal cancer and several dietary factors, including: low intakes of green vegetables, fresh fruits, animal proteins, vitamins A and C, riboflavin, nicotinic acid, magnesium, calcium, zinc and molybdenum, high intakes of pickles, and moldy foods containing N-nitroso compounds.

Stomach cancer A high incidence of stomach cancer is found in Japan and other parts of Asia and in South America, but not in North America and Western Europe where the rates are low and still decreasing. This diseases are associated also with diets comprising large amounts of

smoked and salt-preserved foods (which may contain precursors of nitrosamines) and low levels of fresh food and vegetables.

Colorectal cancer Diets low in fiber-containing foods and high in fat increase the risk of colon cancer. Several studies also demonstrate positive associations between the risk for colorectal (primarily colon) cancer and dietary fat (saturated rather than unsaturated fatty acids).

Female breast cancer Correlation studies provide evidence of a direct association between breast cancer mortality and the intake of high kJ diet, fats and specific sources of dietary fats (e.g. milk and beef).

Endometrial cancer Specific dietary factors, other than obesity, have not been identified for this disease.

Prostate cancer International data show a positive correlation of prostate cancer with the incidence of other diet-related cancers (cancers of the breast, corpus uteri, and colon). Analyses also show positive correlations between mortality from prostate cancer and intake of total food.

In conclusion, evidence indicates, that a diet, low in total and saturated fats, high in plant foods, (especially green and yellow vegetables and citrus fruits), and low in alcohol, salt-pickled, smoked, and salt-preserved foods is consistent with a low risk of many of the current major cancers (cancer of the colon, prostate, breast, stomach, and esophagus).

Obesity From a public health point of view, the challenge is to modify, first of all, the populations environment with increasing of the physical activity and providing a diet with modest amounts of fat, e.g. 15 – 20 % of energy. This may avoid problems of energy deficiency without unduly enhancing the hazards of obesity and other chronic diseases.

Non-insulin-dependent diabetes mellitus Approximately 80 % of patients are obese and therefore the most rational approach to preventing this disease is to prevent obesity. Physical activity not only improves glucose tolerance by reducing overweight, but also acts independently, by having a beneficial effect on insulin metabolism.

Osteoporosis is related to the determinants of bone density: lack of estrogen (postmenopausal women), physically inactivity, immobility, smoking, alcohol, drug therapy, and low calcium intake, low level of vitamin D. The other risk factors for osteoporosis include: female, white, older adults, small in body size. Fragility of bone is a major reason for hip fractures, instability of gait, etc. By 2020, one in two Americans aged 50 years or older will be at risk for fractures from osteoporosis or low bone mass.

Dental caries, sugars and fluoride Dental caries is a very common health problem affecting a large proportion of people. There is a direct relationship between the quantity and a sucrose consumption and development of caries (very little incidence of caries, when the sugar consumption is below 10 kg/person yearly and steep increase may occur from 15 kg upwards).

A sufficient daily ingestion of fluoride is needed to prevent dental caries (figures of 0.7 – 1.5 mg fluoride per day from all sources have been discussed – drinking water supplies about 75 % of daily fluoride intake "maintaining" a constant low level of fluoride in "as many mouth as possible". When it is attained by adding fluoride to water (around l mg/liter in temperate climate and 0.6 mg/liter for tropical countries, salt or toothpaste the chance of incidence of dental caries soon becomes evident. The other side of the story is that high concentrations of fluoride may give rise to fluorosis, with the appearance of white patches and lines on the teeth.

Non-cancer conditions of the large bowel and gallstones These certain chronic disorders (frequently in association with the "affluent diet" and low intake of dietary fibers include diverticular disease of the colon, hemorrhoids, and constipation). A starchy diet, rich in fiber, may therefore be protective, particularly if it helps to limit the problem of overweight.

See more on noncommunicable diseases related to nutrition in Chapter 9.

5.6 DIETARY RECOMMENDATIONS FOR THE DEVELOPED COUNTRIES

The quantities proposed in these recommendations are goals for intake by individuals. To achieve these goals, the mean intake by the population would have to be higher or lower than the recommended intake for individuals, depending on the direction of the proposed dietary modification. For example, a recommendation that all individuals should reduce their fat intake of 30 % or less of calories can be expected to lead to a population mean intake substantially below 30 % of calories from fat. Thus, the guidelines for individuals differ somewhat from the population goals, which need to be more stringent in order to achieve the goals for the individuals.

The recommendations derive from an assessment of the evidence on chronic diseases, but should be used in combination with the recommended dietary allowances of the country to achieve an optimal and highly desirable pattern for the maintenance of good health.

Basic recommendations:

- Reduce total fat intake to 30 % or less of calories. Reduce saturated fatty acid intake to less than 10 % of calories, and the intake of cholesterol to less than 300 mg daily. The intake of fat and cholesterol can be reduced by substituting fish, poultry, lean meats, and low-fat dairy products for fatty meats and whole-milk dairy products; by choosing more vegetables, fruits, cereals and legumes; and by limiting oils, fats, egg yolks, and fried and other fatty foods.
- Every day eat five or more servings (a serving is equal to a half cup for most fresh or cooked vegetables, fruits, dry or cooked cereals and legumes, one medium piece of fresh fruit, one slice of bread, or one roll) of a combination of vegetables and fruits, especially green and yellow vegetables and citrus fruits. Also increase intake of starches and other complex carbohydrates by eating more daily servings of a combination of bread, cereals and legumes.

- Maintain protein intake at moderate level (e.g. less than 1 g/kg body weight for adults).
- Balance food intake and physical activity. Children and adolescents should be provided with facilities and opportunities to take part in daily programs of enjoyable exercise so that physical activity may develop into a lifetime habit. Adults should be encouraged to increase habitual activity gradually, aiming to carry out every day at work and during recreational time, at least 30 minutes of physical activity of moderate intensity, e.g. brisk walking and stair climbing. More strenuous activities (e.g., slow jogging, cycling, field and court games and swimming could provide additional benefits.
- For those who drink alcoholic beverages it is recommended a limiting consumption to the equivalent of less than 30 g of pure alcohol daily. This is the equivalent of two cans of beer, two small glasses of wine, or two average cocktails. Pregnant women should avoid alcoholic beverages.
- Limit total daily intake of salt (sodium chloride) to 6 g or less. Limit the use of salt in cooking and avoid adding it to food at the table. Salty, highly processed salty, salt-preserved, and salt-pickled foods should be consumed sparingly.
- Maintain adequate calcium intake.
- Avoid taking dietary supplements in excess of the recommended dietary allowance. A single daily dose of multiple vitamin-mineral containing 100 % of the recommended dietary allowance is not known to be harmful or beneficial. However, vitamin-mineral supplements that exceed the recommended dietary allowance and other supplement (such as protein powders, single amino acids, fiber and lecithin) not only have no known health benefits for the population, but their use may be detrimental to health. The desirable way for the general public to obtain recommended levels of nutrients is by eating a variety of foods.
- Maintain an optimal intake of fluoride, particularly during the years of primary and secondary tooth formation and growth.

National nutrient goals (concerns all part of world)

The most immediate goal is an assurance that energy intakes are adequate for the needs of adults and for the growth and activity of children (per capita energy needs). The first priority is the adequacy of the total food supply (measured as energy) and equality of distribution of that supply in accordance with individual needs. The goals address the situation in which total intake of energy is reasonably appropriate, but where the balance of macronutrients (protein, fat, carbohydrate) is inappropriate and is a major contributing cause of chronic disease. The concept used is one of a safe range of intakes sufficiently high to avoid dietary inadequacies and sufficiently low to avoid the detrimental effects of excess.

The approach is to identify the level of population intakes that, for the population as a whole, will lead to a low risk inadequacy and a low risk of excess.

The concept of population nutrient goals represents the population average intake that is judged to be consistent with maintenance of health in a population. Health in the population is, in this context, marked by a low prevalence of diet-related disease in the population.

The desirable changes will depend upon existing intakes in the particular population, and could be in either direction. For example in some developing countries, the goal for fat intake (lower limit) might suggest that it would be desirable to increase the average intakes slightly. On the contrary, for developed countries, a reduction in fat intake is seen as desirable.

There is a clear need for a new approach to health and food policies in most parts of the world. Strategies for improving access and availability of healthy diets at affordable prices for all communities should be a key part of these policies.

5.7 FOOD SAFETY (FOOD HYGIENE)

Food safety presents a major health problem in the world. There are more than 250 food-borne diseases registered. Serious outbreaks of food-borne disease have been documented on every continent every year. Food-borne diseases may affect all levels of the population, but the most susceptible are children, pregnant women, the elderly, and those with chronic diseases.

Modern farming methods, globalization of the food trade and the higher accessibility of food produce a challenge for food safety and the prevention of the spread of food contaminants worldwide. Food safety programs are focusing on the farm-to-table approach as an effective means of reducing food-borne hazards. Hazards may emerge from microbiological, chemical or physical contamination of food. Health significance of these hazards is estimated through risk assessment method, and thus hazards are regulated, controlled and kept under surveillance.

Food safety can be defined as the absence of adverse health effects following food consumption. Absolute safety is an unattainable goal and must therefore be defined in relative terms such that any health risks associated with food consumption is limited to an acceptable level.

In order to achieve harmonization in food standards many countries adopt values recommended by WHO.

The health problems related to food contamination contain biological and chemical agents. What **concerns the biological contamination**, for the prevention and control measures, three lines of defense are available:

- **The first line of defense** is to improve the **hygienic quality of raw foodstuffs** at the agricultural level, by applying the principles of good agricultural practice and animal husbandry.
- **The second line of defense** is the application of **food processing** technologies (e.g. pasteurization, sterilization, fermentation or irradiation).
- **The third line of defense** is the most critical and will protect the health of consumers when the other two fail. This concerns **education of food handlers** (professional cooks, persons handling with food in food service establishment, as well as those of charge of the preparation of food at home). The education of food handlers is of almost importance, because the cases of foodborne diseases are frequently due to mishandling of food in homes, as a result of negligence, ignorance and ingrained traditions and habits.

What concerns **chemicals**:

- **The first line of defense** is the production of food in which the quantities of added chemicals and their quality lie within the limits permitted by legislation. For this purpose the primary industry as agriculture and processing industries have to comply with laws and observe the **principles of good agricultural and manufacturing practices**.
- **The second line of defense** is the application of **technologies, which can prevent or reduce** the use of chemicals in food (e.g. pesticides).
- **The third line of defense** is the strict **control and monitoring** of levels of chemicals in food, the responsibility for which is laid on governments' food control agencies.

For additives, pesticides and veterinary drugs the levels of acceptable daily intake (ADI) are established, for such persistent chemical compounds as lead, cadmium and mercury the levels of provisional tolerable weekly intake (PTWI) are established.

Consumers have an important role in the prevention of foodborne diseases due to biological contamination. In the prevention of intoxication due to food additives, veterinary drugs, pesticide residues and environmental chemicals, this role is more limited.

Food quality assurance

The main actors in the food quality assurance include the government, consumers and the food industry.

Food quality is determined by organoleptic (sensoric), nutritional, functional and hygienic properties.

In order to ensure or stimulate food preparation at home, it is important to realize that the general public, especially in the industrialized world, has a different perception on food related health risks as compared to the ranking order of food hazards based on objective scientific

criteria. The difference in ranking order between consumers and scientists is a cause of concern, especially as risk prevention is also partly the responsibility of the consumer. The observed difference is partially attributable to information in the media as well as to psychological factors.

The household is perhaps the most relevant place for development measures to combat foodborne illnesses, as it is the location where the consumer can exert the mostly control over what he or she eats.

Illness due to contaminated food is a widespread health problem; in infants and the elderly, its consequences can be fatal. WHO data indicate that only a small number of factors are responsible for a large proportion of foodborne disease episodes.

Common errors include:

- preparation of food too far ahead of consumption;
- prepared food being left too long at a temperature that permits bacterial proliferation;
- inadequate heating;
- cross-contamination;
- an infected or "colonized" person handling with the food.

The **Ten Golden Rules** presented below respond to these errors, offering advice that can reduce the risk that foodborne pathogens will be able to contaminate, to survive, or to multiply. The rules have been drawn up by the World Health Organization to provide guidance to members of the community on safe food preparation in the home. They should be adapted, as appropriate, to local conditions.

1. Choose foods processed for safety

While many foods, such as fruits and vegetables, are best in their natural state, others simply are not safe unless they have been processed. For example, always buy pasteurized as opposed to raw milk and, if you have the choice, select fresh or frozen poultry treated with ionizing radiation. When shopping, keep in mind that food processing was invented to improve safety as well as to prolong shelf-life. Certain foods eaten raw, such as lettuce, need thorough washing.

2. Cook food thoroughly

Many raw foods, most notably poultry, meats, and unpasteurized milk, are very often contaminated with disease-causing pathogens.

Thorough cooking will kill the pathogens, but remember that the temperature of **all parts of the food must reach at least 70 °C**. If cooked chicken is still raw near the bone, put it back in the oven until it is done-all the way through. Frozen meat, fish, and poultry must be thoroughly thawed before cooking.

3. Eat cooked foods immediately

When cooked foods cool to room temperature, microbes begin to proliferate. The longer they wait, the greater is the risk. To be on the safe side, eat cooked foods as soon as they come off the heat.

4. Store cooked foods carefully

If you must prepare foods in advance or want to keep leftovers, be sure to store them under either hot (near or above 60 °C) or cool (near or below 10 °C) conditions. This rule is of vital importance if you plan to store foods for more than four or five hours. **Foods for infants should preferably not be stored at all**. A common error, responsible for countless of foodborne disease, is to put too large a quantity of warm food in the refrigerator. In an overburdened refrigerator, cooked foods cannot cool to the core as quickly as they must. When the center of food remains warm (above 10 °C) too long, microbes thrive, quickly proliferating to disease-producing levels.

5. Reheat cooked foods thoroughly

This is your best protection against microbes that may have developed during storage (proper storage slows down microbial growth but does not kill the organisms). Once again, thorough reheating means that **all parts of the food must reach at least 70 °C**.

6. Avoid contact between raw foods and cooked foods

Safely cooked food can become contaminated through even the slightest contact with raw food. This cross-contamination can be direct, as when raw poultry meat comes into contact with cooked foods. It can also be more subtle. For example, do not prepare a raw chicken and then use the same unwashed cutting board and knife to carve the cooked bird. Doing so can reintroduce all the potential risks for microbial growth and subsequent illness present prior to cooking.

7. Wash hands repeatedly

Wash hands thoroughly before you start preparing food and after every interruption-especially if you have to change the baby or have been to the toilet. After preparing raw foods such as fish, meat, or poultry, wash again before you start handling with other foods. Moreover, if you have an infection on your hand, be sure to bandage or cover it before preparing food. Remember too, that household pets – dogs, birds, and especially turtles-often harbor dangerous pathogens that can pass from your hands into food.

8. Keep all kitchen surfaces meticulously clean

Since foods are easily contaminated, any surface used for food preparation must be kept absolutely clean. Think of every food scrap, crumb or spot as a potential reservoir of germs. Cloths that come into contact with dishes and utensils should be changed every day and boiled before reuse. Separate cloths for cleaning the floors also require frequent washing.

9. Protect foods from insects, rodents, and other animals

Animals frequently carry pathogenic microorganisms which cause foodborne disease. Storing foods in tightly sealed containers is your best protection.

10. Use pure water

Pure water is just as important for food preparation as for drinking. If you have any doubts about the water supply, boil water before adding it to food or making ice for drinks. Be especially careful with any water used to prepare an infant s meal.

HACCP

Food inspections follow a method known as Hazard Analysis Critical Control Points (HACCP), which involves analysis of the steps of food processing to determine which steps involve the greatest risk of contamination. Monitoring and inspection then focus on those critical points.

Inspectors visit food processing plants and warehouses to monitor all phases of processing, packaging, and distribution. Samples of food products are analyzed by chemists to ensure the foods are wholesome and do not contain harmful substances, such as levels of pesticides above the limits set by the EU agencies and Codex Alimentarius.

Labeling

In response to the prevalence of diet-related diseases, governments and food companies increasingly promote nutrition information on food labels to help the consumer make healthy, informed food choices.

What began as an effort to make sure that labels were accurate has now expanded to require labels that provide more information to increasingly health-conscious consumers. Truth in labeling act required the package label to provide an accurate description of the expiration time, products weight, volume, or count of the package contents, a description of the contents, and the name and address of the manufacturer. Labels must list the serving size and number of servings per package, and detail the foods content of various nutrients even present in very small amounts. Today legislation will require labeling also additives in food, which might have side effect, might be allergic or some people have to avoid them due to health status.

6. HYGIENE OF CHILDREN AND YOUTH

Hygiene of children and youth is a branch oriented to health promotion and protection of children and adolescents. It is a medical scientific discipline of preventive character, which investigates influences of living and working conditions on developing organism. It is aimed at creating of suitable conditions for optimal physical and psychical development in all periods of a child’s and adolescent's life. On the basis of anatomical, physiological and psychological peculiarities of the single evolutionary phases hygiene of children and youth states:

- Principles of planning, construction, reconstruction and service in preschool institutions, schools and in centers for studying and working adolescents;
- Principles of lifestyle, educational process, work, nutrition, physical training, recreation rest, principles of production of the daily used objects for children and adolescents;
- Principles of diseases and health disorders prevention in children and adolescents.

The aim of hygiene of children and youth is not only protection of developing organism against adverse environmental influences, but also **health promotion** by setting the principles of lifestyle supporting health, increasing resistance, improving efficiency, i.e. creating conditions for realization of a harmonic development. There are Public Health Institutes participating in fulfilling the tasks in hygiene of children and youth in practice. They:

- perform preventive and current health control and supervision;
- professionally direct creation and protection of healthy living conditions;
- use team's cooperation with public health professionals, physicians and specialists from the curative and preventive sector and other different technologists, environmentalists, psychologists, pedagogues, etc. for develop and applying intervention and prevention measures.

Social relevance and specification of health protection and promotion of young population have caused to single out this branch of hygiene in theory and in practice.

6.1 PHYSICAL AND PSYCHICAL DEVELOPMENT OF CHILDREN AND YOUTH AND PRIMARY PREVENTION

Timely and periodic assessment of young children’s development makes it possible to identify and treat developmental disabilities at the earliest possible point of manifestation, to prevent developmental disorders, and to identify developmental risk factors.

Every living organism has certain growth potency. Conception of **growth** represents increasing of the amount and magnitude of cells – quantitative changes in the organism. The **development** is not only growth, but also differentiation, forming, functional improving, i.e. gradual qualitative changes of individual cells, tissues, organs and systems. This occurs in intervals of slower growth. Growth and development are the results of **endogenic factors** (genetic or hereditary – 50 – 60 %), and of exogenic factors (40 – 50 %). The most important **external factors**, which have an impact on development, are **natural environmental factors, socio-economical conditions, mainly nutrition, housing, family income, level of education, work load, health care, health status, physical activity, sleep, family, education and school environment, consequences of urbanization, industrial progress,** etc. Environmental factors have the power in a sense to help or to brake the realization of genetic developmental assumptions of the individual.

Growth and development don't run equably. The most intensive growth is during the intrauterine period of life. The newborn child reaches on the average the length of 50 cm and weight 3,2 kg. In the first year of age the length increases about 25 cm, weight multiplies three times. In the preschool age according to body changes, between 1st and 4th year we talk about the first period of fullness, which is followed by period of the first slimness between 5th – 7th year. The second period of fullness lasts between the ages of 8 to 10. The growth intensity, except for the pubertal intense period of growth when the figure becomes slim expressively, has decreasing character. The growth and development stops in girls at the age of 18 and in boys at the age of 20 in the area of the Central Europe.

These following developmental periods according to typical growth phases are used:

- **Neonatal period** (newborn) – from the birth to 28 days of life;
- **Suckling period** (infant) – from the 1st month to the 1st year;
- **Toddler period** – to the end of the 3rd year;
- **Preschool age** – to the end of 5th year;
- **School age - younger** – to the end of 10th year;

  - older – to the end of 15th year;
- **Adolescent period** – to the age of 19.

These are specific periods, which differ in quantitative and qualitative level of functional relationships. This level depends on the rate of maturity, on differentiating of morphological processes and on functional improvement.

Sexual dimorphism as a growth parameter is manifested from the earliest age. This is most expressive during adolescence and in adulthood. Excepting pubertal period girls reach lower level of somatic parameters. In Central Europe puberty starts on the average in girls between 11 – 13 years of age, in boys 13 – 15 years of age and all parameters of functional development are higher – **pubertal acceleration**.

Typical unequability of anatomic development can be seen in a different growth trend of single organs and tissues. This is reflected in a different level of the functional relationships in each developmental phase.

For example:

- development of the genital organs is delayed up to puberty, and their intensive development runs during puberty;
- fast development of lymphatic tissue is in preschool and younger school age and its involution in
- pubertal period;
- the head of a newborn is 25 % of the body height, in adult it is only 12 %, but the lower extremities are in the newborn relatively short (33 %), in adulthood they represent even 50 % of the height.

There has been found **growth acceleration** in development and growth of the young population. The growth characteristics of the contemporary children, in comparison with previous generations, have reached higher growth value in younger age. The functional, psychical and sexual maturities are reached earlier. This long-term trend of the changes, which have most markedly manifested at the turn of the 20th century, has been called a **secular trend**. It has been identified in all developed countries **as a consequence of the changes of the socio-economic conditions of life, particularly of nutritional improvement**.

The growth changes in Czech and Slovak population of children have been presented simultaneously in results of nation-wide representative anthropological surveys of children and adolescents from 0 to 18 years of age in 10-year intervals. The first measurement in 1951 has already shown marked differences in height and weight in all age groups in comparison with the results of Matiegka's research in 1895.

For example, the difference in height in Czech school boys was 7-11 cm and in weight 4-8 kg, which is equal to age difference of 15-24 months. This is the time in which boys in 1951 reached earlier the same values than in 1895. Similar differences were found in girls.

The research has confirmed lagging of Slovak children in height and weight behind Czech children. During last 40 years, these differences have decreased. Growth acceleration in Slovak children is higher and has been caused by improvement of the living conditions. **Urban children** reached higher growth values than rural children. It can be explained by different living conditions, by more intensive irritation of the nervous system and stress situations higher production of the growth hormone and mineralocorticoides, dominating anabolic processes. **Regional differences** were found out caused by already noticed factors.

The increase of the body-height on the average about **1 cm each 10 years** is known in adult population. The menarche appears in younger age and the beginning of menopause is shifted to the older age.

For **evaluation the growth and development** some selected biological parameters are used: the measurement of the body-height, body-weight and various body circumferences (of the head, the trunk etc.). Anthropometric signs are evaluated according to the sex and age. The growth of an individual (e.g. at evaluating his nutritional status), or growth of groups are assessed. Group diagnostic is used when the influences of the living conditions on children's growth and development are estimated. These methods are used:

- **Cross-sectional (transversal) method**: large number of children of all ages is measured once in a short time. The group's characteristics of the measured anthropometric signs are calculated and they are compared with growth standards in the tables and graphs.
- **Longitudinal (prospective) method**: smaller number of children is measured repeatedly in definite intervals. This is more exacting and valuable way.
- **Semilongitudinal method (combined)**: groups of different ages are selected and after repeated measurement connected data are obtained.

The growth tables contain the average values and standard deviations, which are obtained by the transversal measurement of the large groups of children and adolescents. They are used for an orientational evaluation. They don't take inter-individual variability into consideration. The data are calculated for the average age. The table values are then interpolated to the real age of the child.

The **percentile distribution** system enables more precise evaluation (Figure 6.1). The growth graphs are an aid to enable to estimate the dynamics of the child's development. A regular growth is, when child persists at repeated measurements in his zone. Marked deviations, except puberty period, don't occur. The lack of nutrition or disease can early manifest intense decrease of the body weight and after longer time (0.5 – 1 year) also of height. The positive or negative influences of living conditions are judged from different percentages of children in zones.

Proportionality and somatotype are expressed by growth indexes, which are relations of body height to other anthropometric signs. The most used of them are:

$$\text{Body mass index} = \frac{\text{weight } [\text{kg}]}{\text{height}^2\ [\text{m}]}$$

$$\text{Rohrer's index} = \frac{\text{body weight } [\text{kg}] \text{ x } 10^5}{\text{body height}^3\ [\text{cm}]}$$

$$\text{Brugsh's index} = \frac{\text{chest circumference } [\text{cm}] \text{ x } 100}{\text{body height } [\text{cm}]}$$

$$\text{Pignet's index} = \text{body height } [\text{cm}] - (\text{chest circumference } [\text{cm}] + \text{body weight } [\text{kg}])$$

The persons with certain somatotype have similar signs of the body composition, similar levels of adaptations, copying with stress and diseases, the start of puberty etc. The important parameter of the development is the determination of the active body mass, which has close relation to the functional efficiency of the organism. It is important to follow cardiovascular, respiratory, immune system and to evaluate physical efficiency.

The children of the same **calendar (chronological) age** can be different in the level of maturity. This difference is most remarkable during puberty. The calendar age is not sufficiently reliable characteristic.

Biological age is a more precise measure of the child's maturity. It is determined according to:

- **Bone age** – by evaluation of the ossification procedure, usually on the bones of the hand. This is the most precise method (determined only in indicated cases).
- **Tooth age** – by the number of the cut permanent teeth at the age of 6 – 11. This is less precise information.
- **Development of the primary and secondary sexual signs during puberty**. There is estimated also the
- **Age of menarche and pollution**.

The differences in children the same sex and age can be 2 years in the younger school age, in the older school age up to 5 years. **Unfavorable environmental conditions cause that the biological age has fallen behind the real (calendar) age**.

The level of the somatic development is used also at determining of the child's capability for school-attendance, at choice of a profession, etc. The morphological and functional development is running parallel with neuropsychic, psychomotorical and social development of a child. That depends first of all on living conditions as well as on a level of differentiation and maturity of relevant biological structures – CNS, organs of senses.

Evaluation of the growth rate of an individual child is the basic part of medical examination. It has been shown at the repeated measure that the **deviation from the normal growth rate is associated with nutritional, health, social, intellectual or psychological problems.** The somatometric parameters are important **indicators of of good health and nutrition** in children.

Pediatrician monitors the individual growth chart to be sure a child continues to follow the same "curve" over time and the growth pattern does not unexpectedly change.

Newborn and suckling period

In the first weeks of life only the subcortical parts of the CNS work; only **inborn unconditional reflexes** are disposable – feeding reflexes (searching, sucking, swallowing, gripping), emptying, defensive reflex, orienting (at the touch, taste stimuli). The complicated chain of unconditional reactions is also of use in later age (e.g. food instinct, sexual instinct) and influences the activity of an individual. They are regulated by the higher nervous activity, which is gradually developed.

Newborn sleeps daily more than 20 hours. His other activity consists in food intake, in being wakeful and in undifferentiated reactions to strong stimulus from surroundings. From the close biological relationship between mother and child, the basis of the emotional and social component of adaptation is created. The cortex is gradually maturing, its cells are differentiating, nervous ways are myelinizating and in the second half of the first month the conditional reflexes have appeared first from vestibular and auditory analyzer, later from analyzer of sight, smell, taste, tactile and proprioceptive analyzers. The motor analyzer starts its function as one of the first and is the last to end its development in a consequence inequable maturity of neuromuscular apparatus in peripheral and central areas. The beginning of impulsive uncoordinated movement is gradually changing to systematic movements. Their development have cephalocaudal procedure – the infant begins actively command the head, then the movements of hands, trunk and at the end legs.

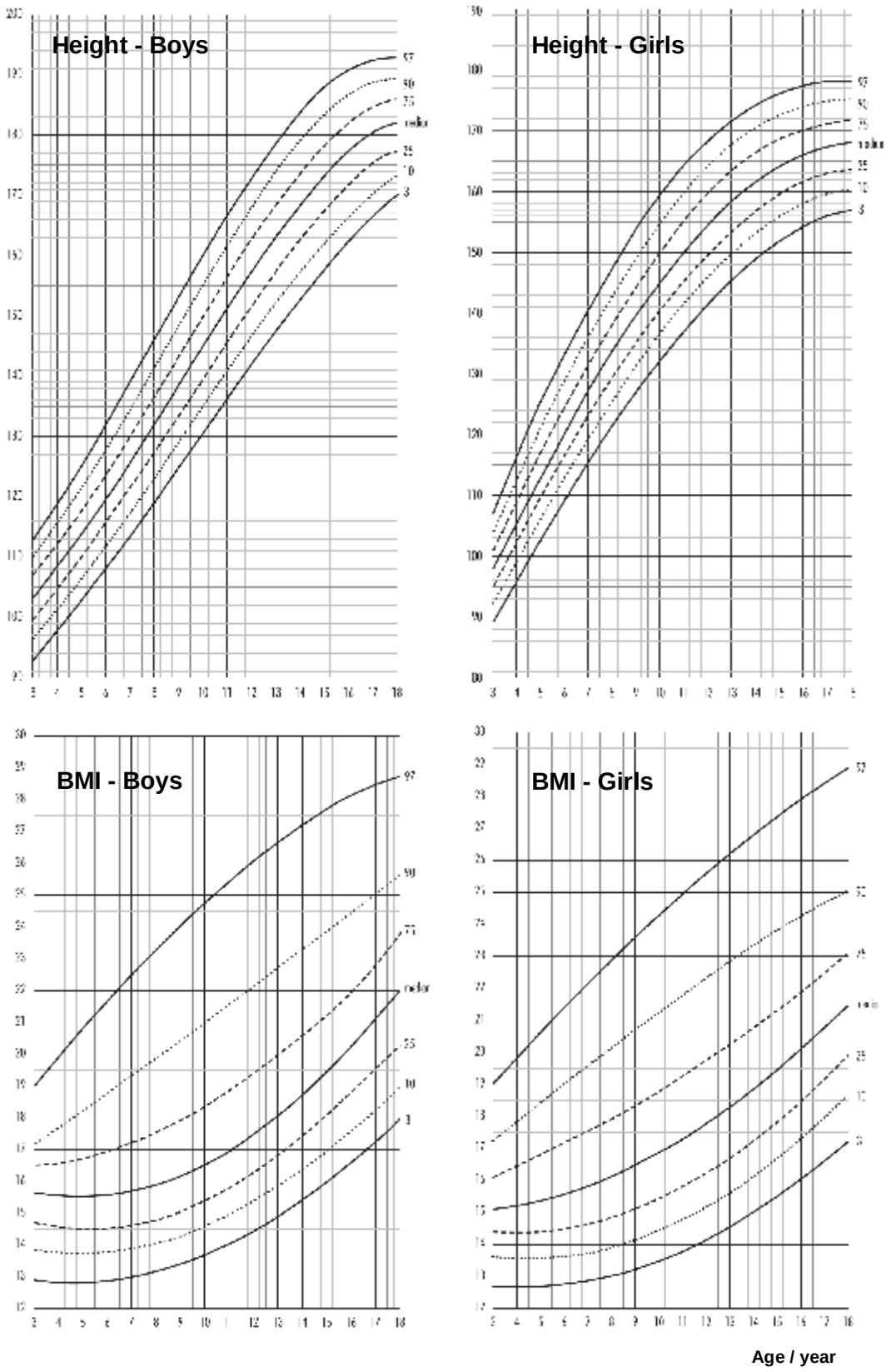

Figure 6.1 Growth charts of boys and girls 3 – 18 years – Body height, Body mass index (Source: Sevcikova L, Novakova J, Hamade J et al, 2004)

At 3 months of life, the infant distinguishes the color stimuli. The attention paid to acoustic stimulus is more expressive - the child restricts spontaneous activity at moderate sound. The infant begins to give up the first speech-sound, which are part of speaking later. At 4th month, the child responds to persons, who he/she is in contact with. Between 6 – 8 month he distinguishes between known and unknown person, creates **specific relation to one person** (mother), who is the basis of the later social contacts. This is an unavoidable condition of the psychic balance and harmonic development of personality.

In the course of development, the conditional reflexes are more and more gentle, complicated and constant. The speed of their creation is graduated. In the second half of the 1st year the processes of internal inhibition are developed, which gives the possibility of more perfect behavioral forms. The concentration of the perceptions to the smaller cortical areas delays the beginning of fatigue. The intervals of the vigilance are prolonged.

In the **6th month, the child begins to sit** and has much more possibilities for manipulations with objects and for observation.

The gentle movements are more expressively developed from the 7th month of age (grasping with thumb in opposition to the other fingers).

In the 6th – 9th month the child reaches the position on the palms and knees, he starts to crawl and tries to stand up. There are the first **attempts to walk from the 9th to 10 months** of age. In the turn of the 1st to 2nd year of age, the independent walk is the great locomotor and psychic developmental point.

Toddler period

After the 1st year there are prevailing word's impulses in conditional reflexes. The second signal system, speech, language, thoughts, memory and imagination are developed.

The extent of the known words is influenced by one person – mother, who directs and stimulates the child's speech. A feedback between speech and thought is created. The thought is concrete and illustrative; the language is a reflection of external and internal environment.

At the end of toddler's age, the speech is the main means of learning and expressively influences behavior of the child. Word's supply is created by more than 1,000 words.

The level of speech development is the most sensitive indicator of the quality of social environment.

The total independence in movements is very important moment. Rough and gentle movements are developing. The walk is not perfect, yet. This level of physical and mental development gives possibility for advance in social area.

The relation of the child to the surroundings is formed on the basis of experiences. During the 2nd year, he is learning to keep the body clean.

For this age the **emotional instability** is typical – changing of mood, weeping and laughing. The child is copying activity of adults, practices movement games, in the age of three also the task games (shop-assistant, family members). At the end of the 2nd year, the interest of other children's activities is increased. The parallel game appears to have character of cooperation at the age of three.

The developmental disabilities and risks are often not identified in many children until they enter kindergarten, although nearly all young children have regular pediatric visits during which problems could have been identified. It is important also to inform and teach parents about child development, to highlight typical development in their children, and to reframe maladaptive perceptions and inappropriate attributions regarding their child’s behavior.

Preschool age

This period is characterized by intensive development of speech, thinking in abstracts, by improving the second signal system. There is increased ability of the active inhibition, creation of ability to delay the final reactions (waiting in the line). **The impulsive activity is continually substituted by the intellectual activity.**

At this age imagination, fantasy and imaginative remembering is reached. The coordination of movements and gentle movements of the hands are improved. An assumption to draw his imagination is created. The expressive emotional instability and feature of negativism – **the period of the first defiance** – are typical.

A preschool child is passive in social contacts with other children and adults and so he needs direction and help. The child of this age takes dominant male or female behavior. The base form of his activity is game. The interest in society of peers is increasing and so the first socialization begins. The play together with peers is preeliminated. The features of planning and aiming are apparent there. This is important in relation to school adjustment.

School age

In this period are distinguished **younger school age** (to the end of 10th year of the age) and **older school age** (to the age of 15). It is characterized by further improvement of the rough and gentle movements, sensoric perception. Moves of the hands are speeded up (at the age of 8 – 10). Each child creates its own characteristic mimic and gesticulation. The movements are systematic on the basis of balance between automatic and volitional mechanism.

Among children there have been found **differences in biological maturity** mainly not in favor of the boys. In older school age during puberty the inequable skeletal and muscular development has impact in rough locomotor activity in its coordination (clumsiness, inaccuracy); by improvement of the oculomotor coordination a skill in precise and fast work is found. Motor efficiency depends on stimuli from surroundings.

Language is developing and improving markedly in school age (its composition, articulation and spread of the vocabulary). This supports development of the memory. The child accepts the difference between play and reality. Perception, memory, ability to distinguish colors and tones and concentration of attention are developed. **Analytical thinking** and a new abstract way of thinking is an important advance in cognitive activity of a schoolchild. There are great interindividual differences caused by hereditary disposition as well as creating of occasions for solving problems.

The emotional development in younger school age can be characterized as relationship to friends and to work. These children have lower dependence on the family, create **of society of peers**, and play collective games. Leaders of them do well.

In older school age**, period of maturation,** the social adaptation is worsened, relationship to other sex is changed, and sexuality wakes up. In the emotional area this is period of instability, conflicts and general criticism. The child needs tactful direction and help of the parents as well as society of peers. The different level of maturity and different interests in the class collective are very pretentious in teaching process.

Adolescence

Adolescence is the period of life between puberty and maturity. Early, middle, and late adolescence are defined in pediatrics by sub-categories of chronological age: early adolescence is characterized as ages 11 – 14; middle adolescence, ages 15 – 17; and late adolescence as 18 – 21 years of age.

Adolescence is a transitional stage of development involving intense biological, social and psychological changes. Improvements are in coordination of all movements. Speed, precision, power and skills are developing. Thinking has all the qualities of intellectual operations. This is a period of the proper value order, emotional balance, making independence, sexual maturity, stabilizing of personality.

Objective information on the course of psychosomatic and functional development in children and adolescents are the basic assumption to create optimal conditions of living, educational, working and curative environment, and all children's activities. The normative items in the hygiene of children and youth are based on estimating of the developmental peculiarities of young generation.

6.2 CHILDREN'S AND YOUTH HEALTH AND ENVIRONMENT

6.2.1 Risk factors in the child's environment and intervention measures

The children are the most **vulnerable part of population**.

In developed countries, child mortality and morbidity have fallen to the lowest levels in recorded history. In the past, infectious diseases were the top cause of death in children. Improvements are attributable to vaccinations, better nutrition, water and sewage management, lowered fertility rate, and housing. Despite these advances, children are developing signs of chronic diseases typically not seen until adulthood. Diseases such as Type II diabetes, obesity, asthma, and cancer are on the rise. These diseases often disrupt daily life physically, emotionally, and socially. Lifestyle change has played a large role in the rise and earlier onset of childhood diseases. Social and physical factors are equally responsible. Children in these countries are more likely to eat prepackaged foods, high in sugar and fat, rather than more nutritious alternatives. Community layout, such as residential distance from schools and availability of parks, and increased television and video game use has lead to decreased walking and outdoor activity. The consequences of these diseases play out over the lifespan, as unhealthy children typically grow up to be unhealthy adults.

In developing countries live approximately 85 percent of the world's children. Malnutrition affects nearly 250 million children worldwide; effects of undernourishment can last a lifetime including blindness, stunted growth, disability, and death. Infectious diseases remain the primary cause of childhood death. Diarrheal diseases and respiratory infections, from sanitation deficiencies, pollution, and lack of access to healthcare, remain the top infectious burdens in developing countries. While vaccines have made progress in reducing acute illnesses, supply and access are typically limited in communities that are more rural. As a result, nearly 15 percent of deaths in developing countries are attributable to vaccine-preventable infectious diseases.

According the World Health Report (2005) almost 11 million children under five years of age die from causes that are largely preventable. Among them are 4 million babies who will not survive the first month of life. At the same time, more than half a million women will die in pregnancy, childbirth or soon after. Reducing this toll depends largely on every mother and every child having the right to access to health care from pregnancy through childbirth, the neonatal period and childhood.

From the eight "Millennium Development Goals" (MDGs) of United Nations Millennium Declaration, adopted in 2000, the MDG 4 is related to child mortality (Reduce by two thirds, between 1990 and 2015, the under-five mortality rate) and MDG 5 – initiative to monitor progress in maternal health (Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio).

The physical environment exposes children to external conditions, usually preventable, that affect their health. While advancements have been made in the **reduction of infectious diseases** worldwide, relatively little has been done to **reduce injuries**. Injuries represent a growing proportion of childhood deaths and the most common cause of physical disability. In addition to causing accidents, cars and trucks emit carbon monoxide, carbon dioxide, and hydrocarbons, among other hazardous chemicals.

Children are also affected by other common **air pollutants** such as smoking, extermination agents, toxic paint, fumes from cleaning supplies, molds, and asbestos in old school buildings. Children who live in high traffic areas, near industrial parks, and/or are in contact with indoor pollutants, such as cigarette smoke, are particularly at risk for respiratory infections, allergies, and asthma. Lead poisoning from lead pipes and paint cause neurological damage.

Contaminants in food, water, and immediate environment are particularly harmful to children. Children eat less diverse diets and consume more calories and water for their weight than adults, potentially exposing them to greater levels of pesticides, parasites, and pollutants in the water. Natural disasters, such as hurricanes, tsunamis, mudslides and earthquakes, ruin crops, homes, and stability in their wake. Children are particularly at risk from malnutrition and infectious diseases that often follow environmental events.

Children of **low socioeconomic status** (SES), immigrants, and those in war torn countries are more likely to have poor health outcomes. Families with low SES are less likely to have available resources to purchase nutritional food, heating, adequate shelter, and healthcare for themselves and their families. Parents living in poverty are more likely to exhibit feelings of depression, anxiety, and low self-esteem, possibly leading to an unstable home. The children of refugees and undocumented immigrants face similar issues. Access to care in war torn countries is limited due to blocked road access, limited supplies, and unsafe conditions. The prevalence of depression and posttraumatic stress syndrome is especially high among child refugees fleeing from war-torn countries. The children of undocumented immigrants tend to have poor health outcomes due to lack of social capital, community networks, and access to affordable healthcare. Currently there is no comprehensive analysis regarding racial disparities and children's health. The majority of the research has focused on adult health outcomes that are not applicable to youth. More studies must be done to confirm minority-status' effect on child health outcomes.

A working group coordinated by the World Health Organization developed a set of indicators (CEHI – Children's Environmental Health Indicators) to protect children's health from environmental risks and to support current and future policy needs.

In European region on the basis of identified policy needs, the WHO group developed a core set of 29 indicators for implementation plus an extended set of eight additional indicators for future development, focusing on exposure, health effects, and action.

The Children's Environment and Health Action Plan for Europe (CEHAPE) is an international instrument negotiated with member states to develop and manage environmental health indicators. CEHAPE sets **four regional priority goals (RPGs)** that encapsulate key themes for action on children's health in relation to environmental factors:

I. Gastrointestinal health related to safe water and adequate sanitation (see table 6.1)**;**

II. Healthy and safe transport, mobility, and home environment to reduce injuries and enhance physical activity (see table 6.2)**;**

III. Respiratory health and clean air (see table 6.3)**;**

IV. Health through environment free of hazardous chemicals, physical, and biological factors (see table 6.4)**.**

Table 6.1 Core and extended indicators related to CEHAPE regional priority goal I (Water safety) (Source: Pond K et al. WHO Working Group, 2007)

Indicator title (and type)	Definition of the indicator
Core indicators	
Wastewater treatment (exposure)	Percentage of the child population served by sewage connected to a wastewater treatment facility that produces a regulated effluent discharge monitored by the competent authorities, or to an alternative safe local wastewater disposal system, e.g., septic tank
Recreational water quality (exposure)	Proportion of identified bathing waters, falling under the EU bathing water directive definition (CEC 1976)
Drinking-water compliance (exposure)	Proportion of the drinking-water samples analyzed from regulated public supplies that fail to comply with the Escherichia coli parameter of the EU drinking-water directive (CEC 1998)
Safe drinking water (exposure/policy)	Proportion of the child population with continuous access to an adequate amount of safe drinking water in the home
Management of bathing waters	Percentage of identified bathing waters which are covered by management systems as described by (policy) WHO (2003)
Water safety plans (policy)	Proportion of the child population served by a potable water supply covered by a 'water safety plan' as described by WHO (2006)
Extended set of indicators	
Reliability of the water supply (exposure)	Percentage of the child population who have access to a reliable water supply
Outbreaks of waterborne diseases in children (health)	Number of outbreaks of fecal–oral water-related illness in the child population reported separately for drinking-water and recreational waters
Incidence of priority diseases in children (health)	The incidence of key water-related infections in the child population

CEHAPE recognizes that also social factors are critical in determining a child's possible increased exposure or vulnerability to a number of environmental factors.

Environmental factors affecting children in developing countries are contaminated air, food, and drinking water. Traditional infectious disease threats to children's health have largely been controlled in most industrialized countries by advances in water treatment, immunizations, waste disposal, and the provision of adequate food, but diseases such as asthma and other respiratory diseases and cancers including leukemia, learning disabilities, and congenital malformations are increasing in children in western Europe. Exposure to air pollution, lead, chemicals, and noise has been shown to impair children's health and their cognitive development.

Physical injuries also rank at the top of environmentally related threats to children's health in developed countries. Major contributing factors are smoking and obesity. Radiation and exposure to hazardous chemicals represent emerging environmental health risks.

Table 6.2 Core and extended indicators related to CEHAPE regional priority goal II. (Source: Pond K et al. WHO Working Group, 2007)

Indicator title (and type)	Definition of the indicator
Core indicators	
Child mortality from traffic accidents (health) **Policies for safe transportation for children (policy)**	Child mortality from traffic accidents by age group and by mode of accident Existence and actual enforcement of legislation and regulations establishing mandatory requirements for safe mobility and transport for children
Children's mortality due to unintentional injuries not related to traffic accidents (health)	Data available from the WHO Mortality Database. Cause-specific child mortality rates per 100,000 population for unintentional injuries not related to traffic accidents
Policies to reduce children's mortality due to unintentional injuries not related to traffic accidents (policy)	Existence and enforcement of legislation and regulations aimed at reducing child injury
Prevalence of overweight and obesity in adolescents (health)	Percentage of adolescents 15 – 19 years of age who are adequate weight, overweight, or obese, where adequate weight is defined as a BMI < 25 kg/m^2, overweight is defined as a BMI 25 – 30 kg/m^2, obesity is defined as a BMI of ≥ 30 kg/m^2
Percentage of physically active children (exposure)	The percentage of children reporting to be physically active for 1 hr/day at least 3 times per week
Policies to reduce childhood obesity (policy)	Composite index of the willingness and commitment to implement a national strategy to prevent obesity in accordance with the WHO Global Strategy on Diet, Physical Activity and Health (WHO 2004) and the WHO Food and Nutrition Action Plan for the WHO European Region, 2000 – 2005
Extended set of indicators	
Mode of child transportation to school (exposure)	Percentage of children going to school by different modes

An estimated 1.7 million deaths per year globally are attributed to unsafe water, sanitation, and hygiene; nine of 10 of these deaths occur in children.

Children spend almost 90 % of their time inside, therefore making the air they breathe a significant source of potential and actual exposure to pollutants. Children are more vulnerable because of the uniqueness of growth and development from infancy through adolescence. Young children spend much of their time close to the floor gaining exposure to pollutants such as heavy metals, pesticides, dander, or dust. They have increased respiratory rates, thereby inhaling more toxicants. The EPA and its Science Advisory Board have ranked indoor air pollution as one of the top five risks to public health.

Indoor air contaminants and symptoms occurring after short and long-term exposure:

− Environmental Tobacco Smoke (ETS): prenatal exposure may cause low birth weight, or pre-term birth, and new onset of asthma in pre-scholars; postnatal exposure may cause sudden infant death syndrome SIDS, a range of respiratory illnesses, inner ear infections,

lung function deficits, and severe asthma episodes, and may be associated with childhood brain tumors, lymphoblastic leukemia, and non-Hodgkin's lymphoma.

Table 6.3 Core and extended indicators related to CEHAPE regional priority goal III. (Source: Pond K et al. WHO Working Group, 2007

Indicator title (and type)	Definition of the indicator
Core indicators	
Policies to reduce tobacco smoke exposure in children (policy)	This indicator is aimed at constructing a composite index of capability for implementing policies to reduce smoking and exposure to ETS in children and adolescents
Prevalence of allergies and asthma in children (health)	Prevalence (%) of children with asthma in age groups (years) 0 – 4, 5 – 9, 10 – 14, 15 – 19 of total population of children in the respective age group Prevalence (%) of allergy toward house dust mites, pollens, furry animals, and molds
Infant mortality due to respiratory diseases (health)	Annual mortality rate due to respiratory diseases in children > 1 month and < 1 year of age
Children's exposure to air pollutants (exposure)	PM10: Child population-weighted annual mean PM10 concentration PM2.5: Child population-weighted annual mean PM2.5 concentration O3: Child population-weighted annual mean (of maximum daily 8 hr means) O_3 concentration NO_2: Child population distribution of exceedance hours of air quality limit values SO_2: Child population distribution of exceedance days of air quality values
Children living in homes with dampness problems (exposure)	Percentage of children 0 – 4, 5 – 9, 10 – 14, 15 – 19 years old living in damp housing This indicator uses the Eurostat SILC (variable HH040) on dampness-related problems such as a) leaking roof, b) damp walls/floors/foundations, and c) rot in window frames or floor; all of which could lead to or represent mold growth
Children exposed to tobacco smoke (exposure)	Percentage of children 0 – 4, 5 – 9, 10 – 14 years old daily exposed to ETS. Percentage of smokers among children 10 – 14, 15 – 19 years old.
Children living in homes using solid fuels (exposure)	Percentage of children 0 – 4, 5 – 9, 10 – 14 years old living in households using: coal, wood, dung, gas, or kerosene as the main source of heating and cooking fuel
Children living in proximity to heavily trafficked roads (exposure)	Percentage of children 0 – 4, 5 – 9, or 10 – 14 years old living in proximity to heavily trafficked roads
Extended set of indicators	
Hospital admissions and emergency room visits due to asthma in children (health)	No. of hospital admissions or emergency room visits for asthma per 1,000 children by age group
Children going to schools with indoor air problems (exposure)	Percentage of children going to schools or day care centers with moisture damage or mold growth during the year Percentage of children going to schools and day care centres with a ventilation < 7 L/sec per person

Table 6.4 Core and extended indicators related to CEHAPE regional priority goal IV. (Source: Pond K et al. WHO Working Group, 2007)

Indicator title (and type)	Definition of the indicator
Core indicators	
Children exposed to harmful noise at school (exposure)	Percentage of children going to primary or secondary schools located in places that are considered to be exposed to transport (road, rail, and aircraft) noises > 55 dB (A) average during school hours
Actions to reduce children's exposure to UV (policy)	This is a composite index of national efforts to improve protection of children against UV exposure
Incidence of melanoma (health)	Incidence of melanoma by age periods of 5 years, among children and adults up to 45 – 50 years of age
Incidence of childhood leukemia (health)	Annual incidence rate of leukemia
Work injuries among employees < 18 years of age (health)	Incidence rate of work accidents with victims < 18 years of age per 100,000 workers According to the severity, there are two subindicators: Nonfatal work injuries with > 3 days' absence from work Fatal work injuries
Children's exposure to chemical hazards in food (exposure/policy)	Dietary exposure assessment to potentially hazardous chemicals monitored in children's food Global Environmental Monitoring System/Food Contamination Monitoring and Assessment Programme (GEMS/Food)
Persistent organic pollutants in human milk (exposure)	Concentrations of dioxins and polychlorinated biphenyls in human milk fat (expressed as WHO toxicity equivalents in pg/g) in pooled samples using standardized collection and analytical protocols established by WHO
Blood lead levels in children (exposure)	Average of blood lead levels (μg/dL) in children < 6 years of age Percentage of children < 6 years of age with elevated blood lead levels (> 10 μg/dL)
Extended set of indicators	
Radon levels in schools (exposure)	Distribution of annual radon levels in classrooms and inhabited rooms of kindergarten, schools, and colleges Estimated arithmetic mean, median of radon concentration Estimated percentage (and number) of classrooms and other rooms with annual mean levels of radon > 200, 400 Bq/m3 Specified at the national or regional level
Children with hearing loss and reporting tinnitus (health)	Proportion of children with hearing loss due to noise

- Volatile Organic Compounds (VOCs; in personnel care and cleaning products, paints, chemical solvents, formaldehyde, adhesives, furnishings, pesticides, building materials) and gases – combustion pollutants (carbon monoxide [CO], and nitrogen dioxide [NO_2]): acute toxicity and death (CO), acute eye irritation, or respiratory symptoms, memory impairment, narcotic effects and depression of central nervous system, increased risk of leukemia.
- Biologic agents (bioaerosols: bacteria, viruses, molds; house dust mites, cat, cockroach antigens): onset of asthma, precipitation of asthma attacks; dog, rodent and fungal antigens worsen asthma in pre-scholars.
- Asbestos, radon: after long-term exposure increasing risk of lung cancer in adults.

Symptoms will vary and range in severity depending upon the pollutant to which the child is exposed and the duration of exposure. Short-term exposures are more common, generally acute, and short-lived, include headaches, allergic conditions, dizziness, fatigue, vomiting, eye and throat irritation, and rashes.

Intervention and prevention to exposure are at times identical. Elimination of the source is often the first step toward treatment. A major focus of prevention also is diminishing or eliminating the exposure, such as with ETS.

These prevention measures are divided into general and specific measures you can recommend to families that will improve the quality of air. Professional help may be needed in some instances, but many measures are based on common sense and are easy to implement. General prevention suggestions include the following:

- Stop smoking around children.
- Use doormats to decrease outdoor contaminants from coming inside.
- Test older homes for lead.
- Minimize/eliminate indoor pesticide use when possible.
- Maintain humidity levels between 35 % – 55 % to decrease molds and bacteria and minimize off gassing of formaldehyde.
- Minimize/eliminate the use of air fresheners to improve air quality; these simply add more chemicals.
- Eliminate the use of mothballs.
- Vacuum when children with allergies are not present.
- Improve ventilation to correct a problem short-term, i.e., opening windows, making needed repairs to HVAC (heating and air conditioning) systems.
- Begin to diminish the use of wall-to-wall carpet in schools and day care settings.
- Investigate safer cleaning products for all areas – homes, schools, day-care.

The Environment and Health Information System (EHIS) is an essential tool for policy making relevant to children's environmental health presented by WHO Regional Office for Europe.

6.2.2 Risks and health protection in adolescents

A huge proportion of the world's population – more than 1.75 billion – is young, aged between 10 and 24 years.

Adolescents (aged 10 to 19 years according to WHO definition) have specific health and development needs, and many face challenges that hinder their well-being, including poverty, a lack of access to health information and services, and unsafe environments. Interventions that address their needs can save lives and foster a new generation of productive adults who can help their communities' progress.

This fact file explores topics of concern to adolescents and strategies to improve their health across the globe.

1. The state of adolescent health

One in every five people in the world is an adolescent, and 85 % of them live in developing countries. Nearly two thirds of premature deaths and one third of the total disease burden in adults are associated with conditions or behaviors that began in youth, including tobacco use, a lack of physical activity, unprotected sex or exposure to violence. Promoting healthy practices during adolescence and efforts that better protect this age group from risks will ensure longer, more productive lives for many.

2. HIV and young people

Young people aged 15 – 24 accounted for an estimated 45 % of new HIV infections worldwide in 2007. They need to know how to protect themselves from HIV and have the means to do so. Better access to testing and counseling will inform young people about their HIV status, help them get the care they need, and avoid further spread of the virus.

3. Early pregnancy and childbirth

About 16 million girls aged 15 to 19 give birth every year – roughly 11 % of all births worldwide. The vast majority of births to adolescents occur in developing countries. The risk of dying from pregnancy-related causes is much higher for adolescents than for older women. Laws and community actions that support a minimum age for marriage, as well as better access to contraception, can decrease too-early pregnancies.

4. Malnutrition

Many boys and girls in developing countries enter adolescence undernourished, making them more vulnerable to disease and early death. Conversely, overweight and obesity – another form of malnutrition with serious health consequences – is increasing among other young people in both low- and high-income countries. Malnutrition can also result from dietary deficiencies at eating disorders such as anorexia nervosa and bulimia mainly in adolescent girls. Adequate nutrition and healthy eating and physical exercise habits at this age are foundations for good health in adulthood.

5. Mental health

At least 20 % of young people will experience some form of mental illness – such as depression, mood disturbances, substance abuse, suicidal behaviors or eating disorders. Promoting mental health and responding to problems if they arise requires a range of adolescent-friendly health care and counseling services in communities.

6. Tobacco use

The vast majority of tobacco users worldwide begin during adolescence. Today more than 150 million adolescents use tobacco, and this number is increasing globally. Bans on tobacco advertising, raising the prices of tobacco products, and laws that prohibit smoking in public places reduce the number of people who start using tobacco products. They furthermore lower

the amount of tobacco consumed by smokers and increase the numbers of young people who quit smoking.

7. Harmful drinking of alcohol

Harmful drinking among young people is an increasing concern in many countries. It reduces self-control and increases risky behaviors. Harmful drinking is a primary cause of injuries (including those due to road traffic accidents), violence (especially domestic violence), and premature deaths. Regulating access to alcohol is an effective strategy to reduce harmful use by young people. Bans on alcohol advertising can lessen peer pressure on adolescents to drink.

8. Violence

Among 15 – 19 year olds, suicide is the second leading cause of death, followed by violence in the community and family. Promoting nurturing relations between parents and children early in life, training in life skills, and reducing access to alcohol and lethal means such as firearms can help prevent violence. More effective and sensitive care for adolescent victims of violence is needed.

9. Injuries and road safety

Unintentional injuries are a leading cause of death and disability in adolescents; and road traffic injuries, drowning and burns are the most common types. Injury rates among adolescents are highest in developing countries, and within countries, they are more likely to occur among adolescents from poorer families. Community actions to promote road safety (including the passing of safety laws that are well enforced) and public education targeted to young people on how to avoid drowning, burns and falls can reduce injuries.

10. WHO response

Many adolescent health challenges are closely interrelated and successful interventions in one area can lead to positive outcomes in other areas. WHO is helping countries:

- to collect, analyse and use data on adolescent health to support and inform policy-making;
- to develop evidence-based policies and programmes that support adolescent health;
- to increase access to and use of health services for adolescents;
- to strengthen contributions from the education, media and other sectors to improve adolescent health.

6.3 HYGIENIC REQUIREMENTS ON THE ORGANIZATION AND EQUIPMENT OF CHILD'S COLLECTIVE FACILITIES

The **main task of all types of collective facilities** for children and adolescents is:

- to create proper outdoor and indoor space (hygienic requirements);

− to create proper social environment;
− to create suitable climate for educational process;
− to provide adequate diet;
− to care of high level of health service in particular preventive care.

All this measures should lead to promotion of children's physical, mental, behavioral and emotional health.

6.3.1 Day nursery

Day nurseries are facilities for the youngest age group. These nurseries were expanded in Central and Eastern European countries in the 50-ties. Currently the official policy is that mothers should take care of children less than three years at home. Only in those cases, e.g., a mother has to be employed, or she is in some distress, children less than 3 years of age are admitted into day nurseries.

During the development of one of the most sensitive and therefore most risky period is the infant period. The immunological defense reactions are not active until the 2nd – 4th year of age. For these reasons, high demands on hygienic level of conditions in the institutions for children of this age are required.

All children have to be medically examined on admission. Adequate health records must be kept. There should be a daily examination of the children to detect any signs of infectious disease. The incidence of infection, most of all acute respiratory diseases, is in these children higher than in those at home.

The number of children in each group should be no more than 15 (sucklings) or 20 (toddlers). Two professional nurses are needed for each group. A high standard of hygiene in the staff is very important. All of them should be healthy.

There are established hygienic requirements on the site, building an organization to prevent and promote the health of children.

The basic space's standard consists of a daily room, a room for repose, a small isolation room, a milk preparation room, toilets, a room for staff, a kitchen, laundry facilities and a storage for soiled garments.

An adequate diet has to be provided under aseptic condition at preparing food and child feeding. The children should be bathed regularly. Separate towels and toothbrushes should be kept for each child. The children should sleep in the open air if possible. The garden should be easy to access.

Besides material needs, the child requires affection, training, occupation and carrying from the professional nurses.

6.3.2 Kindergarten – nursery school

There are more or less day nurseries, but they are intended for older children between three and six years of age. The arrangements are made for providing education in addition to other advantages obtainable at a day nursery, therefore the staff consists of school nurses.

Health promotion of preschool children is aimed against known risk in this age: inappropriate nutrition, developmental disorders, frequent infection diseases, injures, torture and neglecting.

6.3.3 Prevention of communicable diseases in children facilities

Prevention of the spread of infectious diseases is the basic task in health protection of children in collective facilities. The risk is increasing with the number of children and is higher in younger children.

The **main principles of prevention** are:

- to stop transmission to facilities;
- to stop transmission inside the facility;
- improvement of the resistance of children.

Prevention of infectious transmission to facility

Only healthy children, medically examined, are admitted. They have to be also examined daily to detect any signs of infectious disease (temperature, observation of the skin, mouth cavity, conjunctivitis, etc.)

From the epidemiological point of view, the limitation of the entrance of the strange persons is important.

Prevention of the spread of infection in facility

The number of children in group is limited from this reason. It is needed to keep:

- principles of group isolation;
- separate objects of personal hygiene (towel, etc.);
- principles of personal hygiene in children and staff;
- provision of suitable ventilation;
- clean-up and disinfection of the rooms, toys;
- early isolation of sick children and their treatment;
- regular change of sand in a playground (once in a half a year) aimed at geohelminth prevention;
- provision of epidemiologically safe diet.

Promotion of the child immunity

Provision of improving of specific and nonspecific resistance is made by:

- vaccination;

− specific procedures of hardness (by air, sun shine and water). They are suitable for healthy children, regularly practicing from the age of infant with gradual increasing of doses;

− keeping proper daily regimen - education,
- intake of energetically and biologically suitable diet,
- stay in the open air,
- sufficient sleep.

Attention has to be paid in particular to acute respiratory diseases in the collective facilities. Their incidence is increasing in all age categories and can cause disability in adulthood.

6.4 HYGIENIC REQUIREMENTS ON EDUCATIONAL PROCESS IN CHILDREN AND ADOLESCENTS

For the optimal child development an appropriate sensor, motor and emotional loading in each developmental phase is needed. The lack of it, as well as overloading, causes some developmental difficulties. That means, the whole system of education has to be build **with regards to developmental and interindividual peculiarities of the child's organism.**

Preschool age is very important period of **personality formation**. In this period, the bases of the intellect and complicate emotional attitudes to social environment arise. They are the basis of the next character features. **Sufficiently stimulating environment** is needed for support of the motor development, manipulation with the hands (caused fast development of speech). The form, approach and creation of the impulses have to respect the developmental level of the child. The protection against psychic traumatization is very important. The education in a collective of the same aged children with present unrelated adult persons differs very much in comparison with the living conditions in family environment. In some cases, education in child collective can **compensate developmental backwardness** caused by unsuitable social, cultural and economic factors.

Toys support constructive and combinative ability of the child, incite to the motion, direct their imagination. They are important in developing social relationships. They have to comply not only with esthetic and pedagogic criteria, but also with hygienic requirements – from the point of view of maintenance (possibility of cleaning and disinfection) and from the point of view of material and safety to avoid the risk of injuries (durability, form) and risk of poisoning (colors).

The education by the toys should not take place of **personal contact** as the most effective means of language education. The creation of positive emotional relationship between adult and child has to be also realized in the preschool facility (kindergarten). Only at the end of the second year of age the child is interested in activities of other children. In the second half of the third year of age the children start to play in 2 – 3 member groups. Application of collective group games before 3d year of life is for children unnatural, inadequate for age possibilities. Gradual accustoming to concentrated activity is realized by game, which is not

only entertainment, but also an unavoidable assumption of the physical and mental development of a child, model of the future work.

Obligatory occupation in preschool children is painting, physical education and music, developing of the mother tongue, upbringing to hygienic habits. The time of learning has to be graded from 10 to 12 minutes in the youngest up to 20 – 30 minutes in the older children. In this age the child has to be an active participant in all activities, not a passive listener. For the preschool children it is characteristic to be very tired at standing and monotonous uniform loading (e.g. compulsory forced sitting, regular march etc.). There is free motion needed at this age with frequent changing of tempo and with frequent breaks. The most of children's activities should be organized in the open air.

The task of hygiene of the educational process is **to facilitate adaptation** and to reduce negative changes, which could arise in the organism of a child at contact with new environmental factors, particularly in social sphere. The adaptation will be optimal if the biological age is the same as calendar age. It is favorably influenced by performing of following requirements:

- To take care of **health promotion of children;**
- To accept the child's **evolutional readiness** and so to regulate his contact with new life factors and to enable this contact if the organism is ready – developmental levels of the functional systems are suitable;
- To **consider the sensitive periods** in ontogenesis, i.e. periods, which are the most open to influences and changes. It is difficult to compensate neglecting in some developmental period;
- To use the **principle of the gradual increase of intensity** at new stimuli. The adaptation to new conditions of social existence should be prepared at the former stage of socialization.

Stay of children in kindergarten facilitates their passing to school on the basis of accustoming to collective activity, of improving the speech, broadening the intellectual scope, cultivating some necessary habits and skills (drawing, possibility of well-discipline work). This is the reason why there is a need to attend the preschool facility during the last year in the preschool age.

Purposive developing of the pupil's personality in agreement with his individual potency and possibilities can be reached with the supposition that learning process will be realized with sensitive pedagogical forming, regulating and directing.

If the load of child's organism resembles physiological stress, school requirements are balanced with concrete possibilities and the child's adaptation power, and then there are created conditions for retaining high level of work performance. The ability of a child to overcome requirements of schooling is trainable.

At a proper work schedule and right organized rest, work performance recovers not only initial level, but can also reach higher value. That is so-called supercompensation of the

functional potential of the organism. The beginning of learning in this status of the organism is optimal. In that case, when the load is starting in a compensative phase and functional restitution has not yet come into being, the functional level of organism decreases and so chronic fatigue can arise. This creates conditions for overloading of pupils.

Fatigue is not only negative phenomenon. It has also protecting and stimulating function, safeguards the organism against excessive depletion of the functional potency and acts as a stimulus of restitutional processes.

School performance is determined by impact of many external and internal factors and by their mutual interaction. This depends not only on intelligence and ability of concentration, but also on the whole child's personality and environmental factors. The psychical status influences learning efficiency. The status of readiness to school activity and the level of motivation, which also can retain work performance on high level for a long time, have impact.

Passing **from loading to stress** begins at the time when the functional reserves are used to preserve the initial level of performance at high motivation. The child more often 'switches off ', stops to follow in learning, does short regenerative pause. That is why the magnitude of load can't be derived from teaching requirements. The performance also does not reflex loading. Two children at the same performance have different functional expense. One of them will overcome the requirements easy. Another one must use reserves for the same performance and without adequate rest; he can come to overloading causing long time dysregulation of the vegetative functions. Influences of the CNS, as well as many close influences of the environment, circadian rhythms, have been taken into consideration. We can divide the conditions influencing schoolwork as shown in Figure 6.2.

Negative effects of these conditions slow down and weaken adaptability of the pupils with consequent decrease of work efficiency and change of the health status.

There is a need to determine optimal parameters, admissible limits of their oscillation, and levels of their effect with regard to age and not to overstep adaptational possibilities of the organism.

Objective and subjective factors, which participate in **overloading the pupils**, act especially at passing from family environment to school and at the beginning of puberty.

Neuroendocrine rebuilding of the child's organism influences the ability of work and pupil's success in negative sense. Till the age of 13 – 15 in girls and 14 –16 in boys harmonic relations of both functional levels in activity of the central nervous system are created. Overloading can be higher in child's convalescents after diseases with changes in sympato-adrenal system – decrease of its functional activity.

In the classroom's collective are pupils, who differ in abilities – not only in talent, but also in features of temperament, type of higher nervous activity. These factors will influence to a considerable extent their tempo of work and therefore also their prosperity if the conditions for individual approach respectively differentiation in teaching process, are not used.

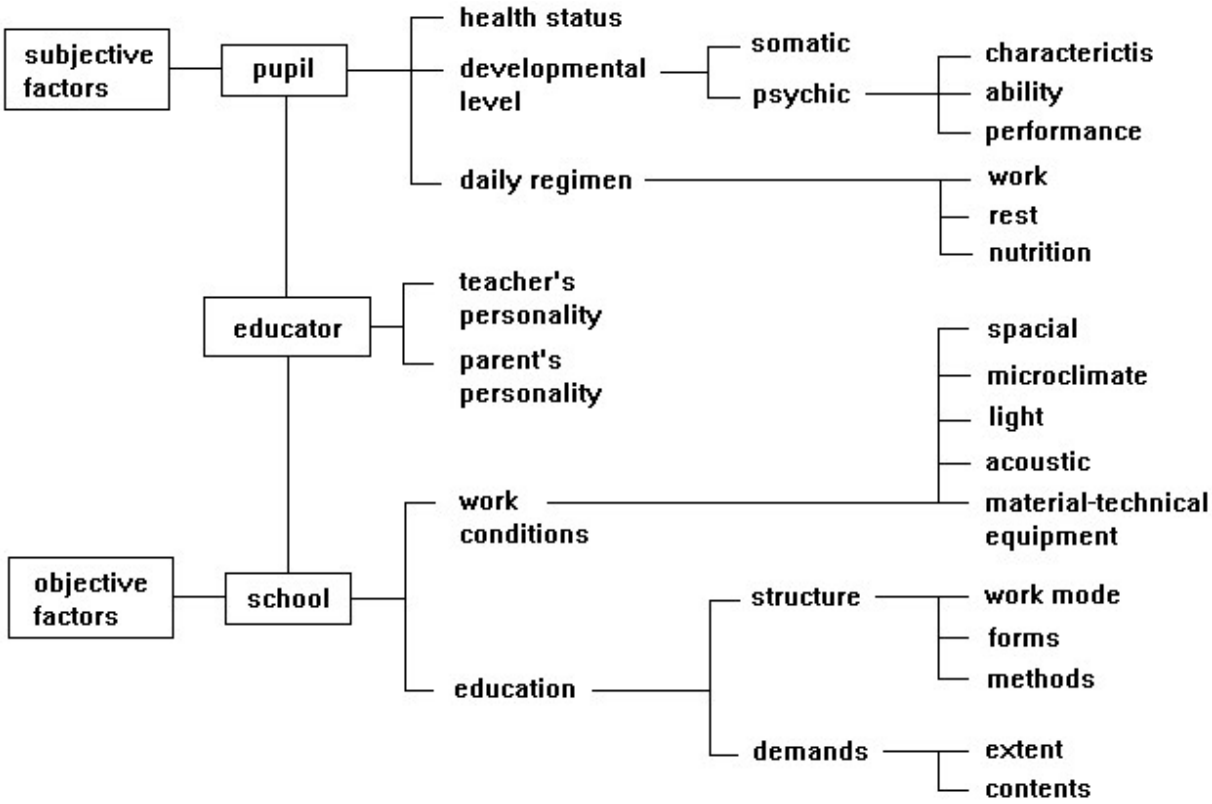

Figure 6.2 Factors of children's load in educational process

The teachers usually are free in solution of this problem from methodic – didactic point of view. At present day, the topic task is to rationalize, to make the educational process more effective. This aim is not available by improving traditional method. Using the new modern technical means in teaching process supports creative attitudes of pupils to obtained information. By this psycho-emotional tension is increasing. The saved time can't be used for following intensification of the child's work, but for the rationalization of the work's organization and leisure. The protection of the psychic health is one of the topical questions of prevention of the nervous and psychic diseases, which have a rising trend in child's morbidity**.** **Neurotic difficulties** cause reduction of work ability, increase of fatigue, difficulties of applying acquired knowledge. A worse evaluation by teachers, as well as an initiative of ambitious parents often can lead the pupils to inadequate effort. The absence of the gift and abilities is compensated by increase of work instead of the time of rest and recreation. The recommended time needed for the preparation of homework is often exceeded. Incorrect timetables regarding quantity and content of the subject matter and organization of the schoolwork have an important influence on the overloading of the pupil.

6.4.1 Requirements for the organization of the educational process

In pedagogical process, it is aimed at **delay of the beginning of fatigue** and at the **break of the fast decrease of the work performance** by right organization of the lessons. This

means using the knowledge from developmental physiology, of higher nervous activity at arrangement of work and rest intervals in pedagogical process. This is reached by:

- optimal duration and right organization of the each lesson;
- suitable breaks mode;
- proper alternating teaching subject;
- setting a norm of the total number of day's and week's lessons;
- positive influence of the total pupil's daily regimen;
- optimal duration and insertion of holiday in the school year.

Duration and organization of lessons

The length of lesson has been determined up to 45 minutes based on many years of experiences of the pedagogues established on duration of centripetal concentration of children at schoolwork. This time is not uniform for all pupils. It is conditional on the age, on the type of the higher nervous activity, on the health status, on the way of the learning conditions, on the environment and on the motivation of a pupil. The time of the concentration moves from 10 to 30 minutes.

The initial period of learning in school is the critical period in the child's life. Children have not been adapted to specific conditions of the learning process in school, yet, i.e. to:

- long-term paying attention (it is only 12-20 minutes);
- long-term sitting in the desk which restricts the motor activity and increase static load;
- requirements on coordination and differentiation of movements (filling graphic tasks);
- systematic evaluation of their work;
- tempo under pressure of strictly planned work;
- competitiveness.

The principle of increase of doses of the school load has to be respected. This requirement refers not only to the duration of a lesson, but also to the rational use of different forms of work in it. In the first classes, short lessons (30 – 35 minutes) are effective. Monoblock system of schoolhouse is less suitable for broader use of different-mode of teaching with regard to age group.

For impaired children in specific schools 35 minutes lessons are proper. 40 minutes lessons have been recommended in the second half of the session usually in the last lessons and in the afternoon sessions of older classes.

Work efficiency is also influenced by proper **structure of lesson,** especially in the first class. At the beginning 5 – 10 minutes of every lesson the teacher should pay attention to concentration and checking the pupils' knowledge. The following time of the highest activity of the children has to be dedicated to submission of the new subject – matter.

This time should not exceed duration of concentration ability:

- at the age of 5 – 7: 15 minutes;
- at the age of 7 – 10: 20 minutes;
- at the age of 10 – 12: 25 minutes;
- at the age of 12 – 15: 30 minutes.

In the last part of the lesson, the teacher should verify the understanding of the new teaching material, conversion of information to knowledge. Forming of the psychohygienic aspect is an important level of

motivation in pupils' learning activity. The teacher should know not only the extent of pupils' knowledge but also their attitude towards it, their approach to learning.

In the first class, a system of so-called combined lessons is applicable. The difficult fundamental educational material is gone over during the first half of the lesson and after the respite a different activity is started (e.g. lesson of the mother tongue is combined with music).

Effective work can be increased by inserting **little physical exercises** in to a lesson. These breaks inhibit rapid reduction of the work efficiency.

Work ability of the child during the lesson is influenced by **teaching methods**, which depend on the teacher's masterhood, on the ways learning material is interpreted, on the ability to motivate the schoolchildren. Positive motivation activates subcortical centers, tonisates cerebral cortex, elevates functional ability to work, delays protective inhibition and this can considerably reduce the functional potential after some time. This undesirable influence of emotions has to be restricted by keeping a proper length of a lesson.

Verbal teaching mode is not suitable for younger schoolchildren, because it influences second signal system and the fatigue increases more quickly.

It is important to use **visual methods** exercising mainly the predominant first signal system in younger schoolchildren. Rational organization of the lesson and use of audio-visual aids help to maintain psychic work ability and to accept learning material at less strain of visual and auditory analyzers and nervous system. These favorable conditions for realization of pedagogical tasks and also for keeping the health status of pupils are created.

Breaks mode

The question of rational organization of work in school cannot be resolved without the proper organization of breaks during session. Restitution effect of breaks is influenced by initial level of functional status of organism (depends on former loading), duration of rest interval, its contents, conditions of its realization.

Recovery from fatigue is more effective at more frequent and shorter breaks. The effect "of incorporating" is not disturbed. Lengthening of lessons instead of breaks is a crude violation of sessions.

The **breaks mode** is organized at schools as follows: 10-20-10 minutes or 10-10-20, i.e. short breaks take 10 minutes, main break 20 minutes (it is inserted after second or third lesson). The schoolchildren should spend all breaks outside in the open air. A sufficient ventilation of the rooms during the breaks is needed. This is very important particularly in winter months. At schools where milk is served the breaks mode is 10-15-20 minutes. 15-minute break is dedicated to eating diary products. According to current opinions for quick recovery of the decreased functional potential in work process most suitable is an active rest in short and long breaks.

It is a short-time change of activity, which considerably differs from recent activity. This is more effective in functional recovery of work ability than in passive rest. Particularly when the moderate motor games are included during breaks in the open air after lessons with psychic and static loading. That organization of breaks increases not only work ability, but also lengthens all-day stay of children in the open air and provide possibility for physical activity which is a physiological need of school children.

The technical problems with realization of an active rest in the open air during the breaks have caused that schools don't use this effective means for increase of work ability.

Changing of school-subjects

Hygienic principles for constructing the lessons timetables have resulted from the knowledge of circadian rhythm – biorhythmic daily periodicity of the physiological functions, which is relatively stable.

The daily time of physiological optimum for work is from 9 to 11 a.m. and the second efficient interval is from 3 to 5 p.m. The fall of work efficiency is detected from midday to 3 p.m. (Figure 6.3).

This physiological minimum is unsuitable for position of difficult subjects. The basic principles at assembling a timetable are:

- To respect the dynamics of their natural performance. Subjects which demand maximal concentration should not be put as the first and the last lessons.
- To join lessons with regard to equal loading of all analyzers, do not link lessons with the same content or the same methods.
- To respect the principle of gradual loading at introducing new subjects.
- To use the effect of the active rest (e.g. suitable introducing of physical education to lessons timetable).

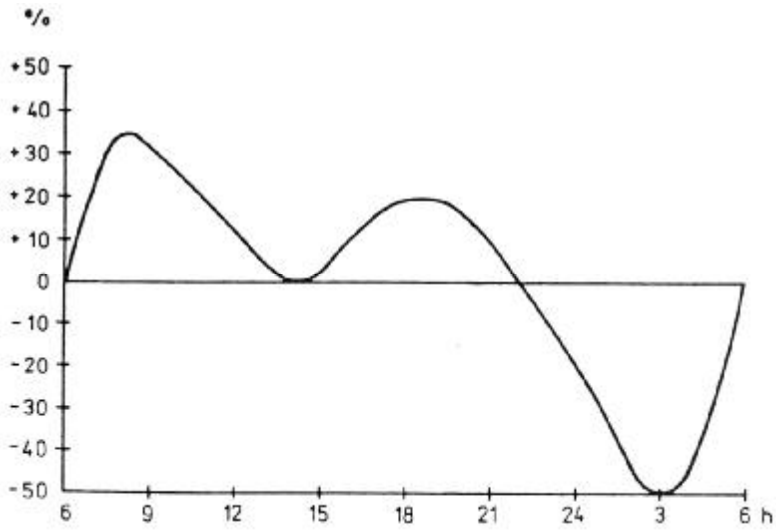

Figure 6.3 Curve of daily physiological efficiency

Number of lessons must be determined with regard to age. From the hygienic point of view there are 4 lessons as a daily maximum for the youngest school children, for the older ones 5 lessons, eventually 6 lessons, but only 2-3 times weekly.

The efficiency of the work in schoolchildren is changing **during a week**. There has been found the **lowest level is on Monday** in particular, at the first lessons (these are the consequences of the regimen of the previous

days). The efficiency reaches **maximum on Tuesday and Wednesday** and **on Thursday there is deep decrease** and on Friday there is increase. This knowledge should be used in creation of the lessons timetable.

The school education contents a lot of negative elements, increasing of the psychic loading and reduction of the physical activity, which brings increase of static loading of the child organism. The possible negative influence of unsuitable conditions of the school environment, as well as the whole regimen of work and leisure time, can be considered as a cause of the high incidence and high increase of some diseases, e.g. sensory disorders, in particular impaired eyesight, orthopedic defects (scoliosis, defective posture) and neuropsychic derangements.

6.4.2 The healthy school

Health prevention requires harmony of school and out-of-school activities of children, proper balance of psychic and physical activities, and correction of the daily regimen and surroundings of the pupils' life. Children's behavior can be influenced by health education, which should be a stable part of the teaching process. Health educational activities in schools usually realized under supervision of the practitioners have been not sufficiently effective.

It has been shown that positive changes are possible only when all sectors of the society have a role to play in the educational process: teachers, parents, local authorities and children themselves will participate in protection and promotion of their health.

The importance of school in health protection and promotion in children is confirmed by realization of international project 'The healthy school' from the initiative of WHO started in the year 1986. According to WHO, the health promoting schools care of pupils and staff and provide a stimulating but safe environment, proper work's conditions and healthy school meals. The effective and lasting health education should be integrated into curriculum of key subjects. The school has a responsibility to put sound information about health in front of its pupils. However, the school is only one significant influence on the development of healthy lifestyles, other include the family, peer group, advertising, the media, legislation and social circumstances of young people.

School health education and services have undergone dramatic changes within the past generation. There is general agreement among European countries about the broad areas of content needing to be including in school health programme. These include:

- Personal Health Care-including hygiene and dental health.
- Personal and human relationships including sexual education also aspects of mental and emotional Health.
- Nutrition education / healthy eating.
- The use and abuse of medicaments and drugs (legal and illegal) - tobacco, alcohol, illegal drugs.
- Environment and Health – increasingly now including reference to nuclear energy and issues relating to the balance of gases in the atmosphere.

− Safety education and accident prevention including First Aid.

− Consumer Education.

− Community Health Care and its use.

− Family Life – sometimes is included in sex education.

− Prevention and control of disease.

School-based interventions can be significant in motivating young people to modify their behaviors.

School-based intervention efforts have been aimed to:

1. Health promotion and preventing childhood obesity through **regular physical activity and improved nutrition**

Schools should provide a consistent environment that is conducive to healthful eating behaviors and regular physical activity.

Extensive reviews of the literature on children and adolescents (ages 6 through 18) indicate that moderate-to-vigorous activity is related to decreased adiposity, improvement in metabolic syndrome (abdominal obesity, elevated blood pressure, elevated fasting glucose, and reduced high density lipoproteins), decreased triglyceride levels, increased high density lipoproteins, bone density, muscular strength and endurance, and aerobic fitness, and improved mental health (anxiety, depression, self-concept). The establishment of healthy patterns of physical activity during childhood and adolescence is important because physical activity habits established early are maintained during adolescence and from adolescence to adulthood. Furthermore, national surveys confirm the negative relationship between physical activity during childhood and both childhood and subsequent adult obesity. Physical activity appears to improve both short- and long-term physical and mental health status; general health, bone health, health-related quality of life, and positive mood states have all been associated with higher levels of daily physical activity. In addition, there is ample evidence that increased physical activity improves academic and cognitive performance.

The 2008 U.S. Department of Health and Human Services recommendation for children is that they should engage in 60 minutes or more of moderate-to-vigorous physical activity every day (including expanded opportunities for physical activity through classes, sports programs, clubs, lessons, after-school and community use of school facilities, and walking and biking to-school program).

Energy balance in children – equality between energy intake and energy expenditure supports normal growth without promoting excess weight gain.

Increasing opportunities for physical activity and healthy eating are through assessment of parks and recreational activities, environmental characteristics conducive or not conducive to physical activity, improving negative attitudes, and providing healthy and affordable food choices in communities. Develop and implement nutritional standards for all competitive

foods and beverages sold or served in schools. Ensure that all school meals meet the dietary guidelines.

The body of knowledge related to physical activity, nutrition and other health promotion behaviors is steadily increasing. There is a continued need for research in this area, particularly with diverse populations and in different environmental settings. Individual approaches will continue to be important to understand how individual behaviors change. The socio-ecologic perspective has added a broader dimension to health promotion research and promises to have an impact on whole communities with environmental and policy changes.

2. Goal of the U.S. Centers for Disease Control and Prevention and WHO is to **prevent children from smoking,** or to delay the onset of smoking in order to increase the chance that children will not become addicted or, at the very least, to reduce the number of years of exposure to cigarette smoke.

The earlier children begin smoking, the more likely they are to become addicted to tobacco, making it difficult to quit, and the more likely they will suffer its long-term consequences. In addition, most smokers begin during adolescence, making this time a focus for efforts to prevent the addiction to tobacco. Intervention consists in increasing smoke-free and tobacco-free environments in schools, including all school facilities, property, vehicles, and school events.

3. Alcohol use has been related to some of the leading causes of mortality in children: accidental injuries, suicide, and homicide. Frequent or heavy adolescent alcohol use has been associated with tobacco and illegal drug use, risky sexual behavior, behavioral problems, depression, anxiety disorders, eating disorders, and obesity.

4. Victims of bullying experience a range of problems such as depression, anxiety and, in extreme cases, suicide. Being bullied is also associated with poor academic achievement, low self-esteem, problems making friends, loneliness, and higher levels of substance use. Generally, victimization from bullying decreased with age and appeared equally in boys and girls. In addition to connections with other forms of youth violence, bullying has been associated with substance use, delinquency, emotional disturbance, and physical health symptoms. Students who bully other students may report more problems with family communication, negative perceptions of school, and health-risk behaviors, such as smoking and excessive drinking. How the local schools deals with bullying, violence and racism is an important indicator of the school climate.

5. Perception of stress in school has been reported in average at 40 % of students, which increases with students' age, and was not related to SES.

6. School health education

Schools provide an opportunity for students to learn objective information about a variety of important health topics. Healthy People 2010 set goals for school health education programs. The HBSC administrator survey provides information on school health education programs.

A relatively high percentage of youth rate their health as fair or poor, high percentage of youth mainly girls report having two or more health complaints, such as backache, stomachache or headaches, at least once a week or daily.

Many experiences have confirmed that the care of children and youth is the most important and the most rewarding field in health protection and promotion in population.

National surveys of children and adolescents health are the basis for interventions in families, and schools and health system.

7. HOSPITAL HYGIENE

One of the major environmental health problems is the specific problem of health facilities. This problem has been caused by complicated interactions among the environment and its inhabitants (medical staff, nurses, patients and visitors), complex relations in the hospital environment and surrounding area (e.g. wastes, location of hospitals in relation to residential buildings, industry, etc.).

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7.1 RISK FACTORS IN HOSPITALS AND PROTECTION OF HEALTH

Problems of risk factors in health facilities include six basic areas:

- problems of infectious diseases;
- effects of ionizing and other types of radiation;
- unfavourable effect of chemical materials;
- psychosocial problems (psychology of work, drug addictions etc.);
- issue of occupational physiology;
- risk of accidents, menace of personal safety.

7.1.1 Problems of infectious diseases

Problems of infectious diseases are regarding hospital staff, patients and visitors. The average working inability of medical staff is lower than in other groups of employees, but on the other hand their illnesses last longer. The medical staff does not use working inability because drugs are easy to access. In general, health-care workers are absent very rarely.

Although the risk of infection is possible in any health-care facility, the major hazard is in hospitals, microbiology and virology research centres. The professional damage of health may be caused by various types of microorganisms. The most frequent professional disease of medical staff is hepatitis B. The highest incidence of hepatitis B is during the first year of practice, mainly in hospital departments with the frequent contact with blood, blood derivatives and the other biologic material (haemodialysis, oncology, transplantation surgery, haematology and biochemical laboratories, surgery, stomatology departments). In the other departments the incidence of hepatitis B is higher than in the population of the same age.

The direct contact with patients seems to be less important. Each admitted patient is a potential source of infection and that is the reason for strict keeping of the hygienic-epidemiological regimen. Besides physical and chemical barriers (using of disposable gloves, disposable syringes and disinfection) the biological barriers have been also used in prevention (hyperimmune gammaglobuline, vaccination).

The infections, which represent a traditional hazard, are still important for medical staff, examples include scabies, Legionnaire's disease, Marbur’s disease, infection Ebola, Lassa fever and so on.

Nowadays, there is increasing concern about AIDS in the general population. In scientific literature, this stated that medical staff is not exposed to a higher risk than other people are. The mechanisms of HIV virus transmission are physical contact (sexual intercourse), inoculation (blood) and transplacental transmission. The risk of HIV infection in the hospital results also from use of commercial diagnostic products, which are prepared from serums of multiple individuals.

There are 5 basic standard procedures to prevent HIV virus transmission in health-care facilities:

1. Secure manipulation and disposal of used sharps.
2. Secure decontamination of instruments and apparatus.
3. Hand washing and hygienic disinfection.
4. The use of protective barriers preventing direct contact with body fluids of patients.
5. Secure liquidation of waste contaminated with biologic material.

Medical staff has also been threatened by bacterial diseases (especially tuberculosis).

Nowadays, not only patients treated for tuberculosis, but also those admitted to the hospital with the other diagnoses, represent the most common risk. The major sources of infection are patients and their biological products. The risk of tuberculosis is also present at autopsy departments.

Rubella represents a health hazard for medical staff in OB-GYN departments and in pediatric departments (the cause of hereditary effects, infection of pregnant women in the first months of pregnancy).

Measles are not a major problem because only a small part of population is susceptible to it. The risk of parotitis is small. The medical staff members of pediatric departments, who are the most threatened, have to be vaccinated. Respiratory syncytial virus has often affected paediatric staff. In the framework of preventive measures against infections transmitted by air the decontamination of the environment is very important.

Pharyngoconjunctival fever, an adenoviral disease, has often occurred in medical staff. It is transmitted by fingers, by ophtalmological instruments, by contaminated drugs and by eye secretions of patients. This infection is frequent in central reception and in the ophthalmologic outpatient departments for eye injuries. Medical staff from intensive care units, stomatological and anaesthesiologic departments often suffers from herpetic paronychium. This staff has been mostly in contact with infected oral secretions of patients.

There is a small hazard for medical staff to be infected by virus Varicella zoster, because the prevalence in the general population is high. This infection may have teratogenic effect during first three months of pregnancy. Prevention includes physical, chemical and biological barriers (specific immune-globulin applied to staff after exposure).

Also cytomegalovirus may be a cause of congenital infections. The risk of transmission of this infection to adults, who take care of infected children, is probably small. There is a theoretical possibility of infection in pregnant women through excreta from upper respiratory system or through urine of the children. Laboratory staff working with Creutzfeldt-Jakob virus or with the virus of the illness kuru should take preventive measures as in the protection against hepatitis viruses. The cases of viral gastroenteritis (rotaviruses, enteroviruses, adenoviruses) should be taken into consideration.

The possibility of variola infection in a laboratory and the following risk of its spread will exist as long as it is preserved in laboratories. The menace of using the virus variola like a biological weapon should not be forgotten.

Work in a laboratory is very hazardous for many reasons. Processes, like centrifugation, opening of test tubes with cultures, inoculation of bacteria on media, production of aerosols, using of oral pipettes and even bad habits such as smoking, eating and drinking in a laboratory could increase the risk of inhalation and ingestion of infectious particles.

Working with laboratory animals has been increasing the possibility of skin infection in the laboratory staff. The proper management of microbiological procedures and wearing of personal protective equipment has reduced the hazard of laboratory infections significantly.

7.1.1.1 Nosocomial infections

From an epidemiological point of view, nosocomial infections are considered to be one of the major problems in hospitals. Nosocomial infections are by definition those acquired in the course of stay in health care facility or social care facility. Generally, patients acquire hospital infections with common organisms because of their own increased susceptibility to infection or because of procedures performed in the hospital. The acquisition of nosocomial pathogens depends on a complex interplay of the host, pathogen, and environment. All environments except those maintained under sterile conditions may harbour pathogenic micro-organisms. It is not surprising, therefore, that the hospital environment is contaminated with micro-organisms. Nosocomial infections may result from either endogenous flora (i.e. microbes that are normal commensals to the skin, respiratory tract, gastrointestinal tract, or genitourinary tract) or exogenous flora (i.e. microbes with an environmental reservoir). Many epidemics of nosocomial infections have also stemmed from reservoirs of pathogens in the inanimate hospital environment.

Nosocomial infection is an infectious disease, which arises with causal continuity of a stay in a hospital. The damage of a patient, prolongation of hospital stay, the need of additional examinations and changes in the antibiotic treatment can be due to nosocomial infections.

In the USA, 3-7% of patients acquire nosocomial infection. NI can be attributed to the following aspects of contemporary medical care:

1. The widespread use of antimicrobial drugs, selection of drug-resistant micro-organisms (in the patient or in the hospital environment)

2. The use of invasive techniques for diagnosis, monitoring and therapy (indwelling urinary catheter, intravascular lines, drainage tubes, shunts)

3. Many hospitalized patients (tertiary care hospitals) are immunocompromised (deficiencies in immunologic responses or impaired host defence – skin ulcers, aspiration tendencies). The very young and the elderly are particularly susceptible to infection.

In order to categorize place an infection as nosocomial **the place of infectious transfer** is important (not the place where the infection was found out). Included in nosocomial infections are infections manifested after dismissing of a patient to home care (e. g. hepatitis B, staphylococcus' infection of a new-born). On the contrary, infections manifested in the hospital, where a patient was admitted with an infection in an incubation period, are not categorized as nosocomial. Nosocomial infections from the epidemiological, preventive and therapeutic point of view are divided into diseases that are specific or non-specific for hospital facilities.

Nosocomial infections belong to the first group. They can affect groups of people susceptible to all kinds of germs (school, work, army), for example respiratory diseases of various aetiology, children's exanthematic diseases, alimentary infections etc.).

The occurrence of these infections can usually be related to the epidemiological situation in the region of a hospital or to its hygienic level. These infections can have more serious progress and worse prognosis than a group of otherwise healthy people.

Nosocomial infections, resulting from diagnostic and therapeutic methods belong to the 2nd group. They spread frequently by inoculation and by implantation of infective agents, often by unknown way, seldom by faecal-oral spread or by respiratory route. Those infections have a special epidemiology as well as prevention and therapy. Among those infections rank post-operative infections, wound-infections, staphylococcal infections of mothers and new-born children, infections of burns, infections of the urinary tract after instrumental examinations, infant and new-born diarrhea, hepatitis B and partially hepatitis A, pneumocystosis, some mycoses after transplantation of kidneys, and a long-time therapy by antimicrobial drugs. Most frequently identified infection agents are – *Staphylococcus aureus*, *Staphylococcus epidermidis* and other, potentially pathogenic micro-organisms affecting susceptible and debilitated patients.

The data about the incidence of nosocomial infections are often very different; they depend on a searching method, type of hospital department and on a choice of followed patients. Average data from American hospitals are from 2% to 7%, but they are more prevalent in surgical departments. The reports on nosocomial infections from clinical departments represent probably only a part of the real nosocomial infections prevalence.

In general, etiological agents causing nosocomial infections may be any micro-organism which is able to evoke infectious disease. In addition to classic pathogens like *Staphylococcus aureus*, that cause hospital infections, the most important effective threat in hospitals at present are the enteral micro-organisms. These include **Gram-negative bacteria** such as

Enterobacteriaceae, Enterococcus, Pseudomonas aeruginosa and Klebsiella strains. At present, organisms that cause nosocomial infections are Gram-negative sticks (about 55% to 70%) and staphylococci (about 30% to 45%). During the last several decades, the prevalence of **multi-drug-resistant organisms** in hospitals and medical centers has increased steadily. *Methicilin-resistant Staphylococcus aureus* (MRSA) first recognized in the 1960s became endemic in many hospitals during the 1990s.

Infection control programs have been important in the control of emerging threats. Following the terrorist attacks on September 11, 2001, and the subsequent outbreaks of anthrax, health-care facilities developed plans to address bioterrorism preparedness and response. In 2003, health-care facilities were at the center of the severe acute respiratory syndrome (SARS) outbreak – a newly discovered respiratory disease caused by *SARS-Corona virus* that emerged in China and spread globally.

Infection control issues to be addressed in response to natural or intentional infectious threats include preventing transmission among patients, health-care personnel, and visitors; identifying persons who may be infected or exposed; providing treatment and prophylaxis; protecting the environment; and providing appropriate staffing.

A special group of nosocomial infections is the group of **nosocomial mycoses**. The most frequent etiological agent is *Candida albicans*. There are many patients susceptible to this microscopic yeast infection. They include patients with chronic diseases, bad nutritional conditions, or treated with cortisone, antibiotics and on immunosuppressive treatment, chemotherapy, radiotherapy, patients after organ transplantations, after accidents, patients with burns, etc. There is also microbial colonisation of donor corners, determining to transplantation. The direct transmission of infectious agents from ill donor to receiver has been proved. In the department for prematurely born babies, medical staff also participates in the transmission of the *Candida albicans* germs, (mainly nurses, who come into contact with the children under attendance). The germs subsist on the surface of their hands and it is not possible to remove them by washing. That's why the nurses have to use disposable gloves during nursing of risk groups and premature babies.

The nosocomial infections have arisen as a result of subjective and objective factors, which are:

- lack of hospital beds and insufficient hygienic equipment of health-care facilities;
- some features of character in medical staff and patients (lack of discipline, irresponsibility, superficiality) resulting in hygienic, sanitary and maintenance shortages – unsatisfactory nursing techniques lagging behind the level of surgical techniques (enables to use invasive techniques for diagnosis, monitoring, and therapy, that are very hazardous for infection);
- the hazard of infection increases with any kind of injection, infusion of solutions or drugs, transfusion, indwelling urinary catheter, endoscopy, drainage tubes and shunts, intravascular lines used for measurements, endotracheal anaesthesia, dialysis, etc.;

- relatively high susceptibility of patients to infections is related to their older age, to immunosuppressive therapy, to invasion of the skin and mucous membrane barriers, to the presence of artificial solids and materials in the body, etc.;
- the underestimation of the aseptic principles, sterility and disinfection with regard to the widespread use of antimicrobial drugs, etc.;
- the selection of drug-resistant micro-organisms rises, etc.;
- disinfection of modern diagnostic and therapeutic equipment and apparatuses is getting more difficult.

In the hospital all known transmissions of an infection contribute to nosocomial infections. Considering the specific conditions of hospitals, transmission by contaminated hands, apparatus, utensils and equipment is very frequent. In the practice of a physician, especially a physician providing out-patient medical care, the attention to the problem of nosocomial infections is important. The manifestation of nosocomial infections is more likely in persons discharged from the hospital (e. g. women after deliveries, newborn babies), but also in patients getting out-patient care and treated for basic illnesses decreasing their immunity response.

In relation to problems of infectious diseases, it is necessary to emphasize the very important problem of antibiotic resistance. The resistance of various kinds of bacteria against older or more recent antibiotics and the discovery of the transmitted resistance of bacteria has followed in the last two decades causing many unexpected problems in practice and in research.

The origin of the polyresistance of every so-called problematic bacteria (pathogens or opportunists) requires continual supplementation of antibacterial drugs with new antibiotics.

In relation to conditions and susceptibility of hospitalized patients, some kinds of nosocomial infections are extraordinarily frequent. Prevalence of nosocomial infections is most frequent in urology departments, intensive care units and surgical departments.

The most prevalent nosocomial infections in Slovakia are respiratory infections, infections of the urinary tract, infections of surgical wounds and gastrointestinal infections. **Surgical wound infections** comprise approximately 13% of all nosocomial infections and are historically the oldest. They originate from endogenous microorganisms (e. g. carriers of *Staphylococcus aureus*), from acute infections in other parts of the patient's body (bacteriaemia from urinary tract infections), from contamination in an operating room or from postoperative wound infections. Local resistance of tissues in the body to infection decreases during the surgical traumatization, and only small infective doses can cause inflammation. The risk of getting a nosocomial infection is proportionate to the extent and the duration of a surgical performance.

Infections of urinary tract are very frequent; they comprise about 19 % of all nosocomial infections. Most of them are mild, but the ascendant infection can lead to more serious complications (bacteraemia, pyelitis etc.). Affected patients are very important source

of infection. The principle causes are in the urinary bladder catheterization, dialysis, in the immunosuppressive therapy and in the other therapeutic and diagnostic manipulations. Pathogenic microorganisms come from the intestinal flora of the patient or from the other patients. The risk of infection is related to the length of catheterization duration.

If the permanent catheter is essential, the sterility of the system must be secured and the catheterization should be kept closed during the whole period.

Infections of the lower respiratory tract (pneumonia, lung's abscess, empyema, bronchitis) arise mostly by aspiration of oropharyngeal secretion; therefore, their prevention is difficult. Some patients are extremely susceptible to such events (e.g. some neurological abnormalities, troubles with deglutination, disorders of consciousness caused by illness or by medication). The very important hazard is due endotracheal intubation, where normal defensive mechanisms are eliminated, the bronchial mucous membrane is drained and it may result in small injuries. The prevention is aseptic manipulation, humidifying and treating of inhaled air. Special attention is needed in cleaning equipment and in checking inhaled air in the anaesthesiology respirators.

Frequent nosocomial diseases are skin infections, infections of mucous membranes and infections of upper respiratory tract.

Very frequent are also bacteraemia and sepsis after some procedures with direct entering into the vascular system (injections, infusions, heart catheterization, intra-arterial measurement of blood pressure, etc.).

Some departments and treatments represent specific hazards:

- departments for burned patients; infections, affecting various parts of body surface can occur;
- departments for newborn babies (pyodermatitis and enteritis);
- neurosurgical departments (meningitis);
- haemodialysis and transplantation (infectious hepatitis may occur);
- blood and blood derivatives transfusions, transplantation of organs represents a higher risk of AIDS transmission.
- The main principles of prevention of the nosocomial infections are:
- early detection of the diagnosis;
- respecting the epidemiological history of the patient;
- isolation of patients considered to be a source of infection and protective isolation of patients with increasing possibility of susceptibility to infection (protective isolation in taking care of newborns, hospitalization of mothers together with children);
- sanitary filter in waiting-room of hospital facilities;

- hygienic safety of an operational regimen (constructional conditions of the workplace, system of cleaning, personal hygiene, etc.);
- epidemiological operational regimen (immunization of the staff, sterilization, disinfection procedures, wearing of protective clothes, protective devices, isolation of different operations);
- barrier nursing to keep the principles of asepsis and antisepsis, clean zones, thrifty attend procedures, limitation of the invasive techniques for diagnosis, monitoring and therapy, manipulation with biologic material.

Nosocomial infections are under evidence and there is duty to report them.

Because of the evolution of health-care, the term “health care-associated infection” (HAI) has been used by some authors more than “nosocomial infection”, since the latter is restricted to the hospital setting.

7.1.2 Effects of ionizing radiation and other types of radiation

The ionizing radiation and other types of radiation in hospital facilities represent further hazard for medical staff. This hazard can manifest immediately or later after a certain period of time.

Medical staff members are exposed to low doses of radiation for a long time and therefore it could damage their health.

At present, the main risk of ionizing radiation is not only in X-ray and radiology departments, but also in departments with occasional special examinations (e.g. operating theatres, orthopedic and pediatric departments). The most hazardous use of X-ray for medical staff is diagnostics (fractures, adventitious bodies, catheterization, passage of intestine, etc.). Biological effects of ionizing radiation and principles of prevention are described in the chapter Radiation and health hazards.

The non-ionizing radiation e.g. ultraviolet light, laser, airwaves and electromagnetic fields also represent the risk of health damage in hospitals. Ophthalmologists, who work several hours with lasers during a week, could suffer from central vision reduction and from changing of colour perception.

7.1.3 Unfavourable effect of chemical substances

Many risk factors to which the medical staff is exposed are chemical substances including disinfectants. The impact on skin forms a relatively serious part of professional diseases in hospitals. The majority of cases are caused by chronic irritable substances, the remainder has allergic character.

The professional allergic eczema occurs frequently in nurses and other medical staff, and physicians, who are in continuous contact with medicaments, anaesthetics and antiseptics. The skin resistance is reduced owing to repetitive soap washing especially with brushes.

Surgical and orthopedics staff members suffer from a syndrome of dry hands. Dentists and their assistants suffer from contact eczema, evoked by using acrylic-monomer materials, local anaesthetics, essential oils, epoxide resins and by amalgam. Laboratory assistants are also in the contact with many chemical substances that cause eczema.

The most frequent chemical substances, that could damage health, are formaldehyde and ethylene oxides.

Formaldehyde has been used since 1894 for disinfecting of hospital wards, beds, instruments and as an agent of conservation in pathological anatomy. Apart from that it forms a part of parquet floor glues, plywood, polishes, thermos insulators, etc. Cigarette smoke also contains formaldehyde. The reception of formaldehyde is through the respiratory and digestive systems. The main effect of formaldehyde in low concentrations is irritation of the eyes, of the skin (allergic dermatitis, contact eczema) and of the respiratory tract. The increasing mortality of prostate cancer, skin cancer, brain cancer, cancer of the large intestine, bladder cancer and cancer of kidneys has been described.

Characteristics of the colourless gas **ethylene oxide** have been discovered in 1929. Since this year it has been frequently used for sterilization of materials in health service in specialized apparatuses. The gas is explosive and it needs to be mixed with inert gases. In our country they use the mixture with carbon dioxide in the ratio of 1: 9. Because the gas remains in the sterilized materials, the material needs to be thoroughly ventilated, at least 72 hours. The contact with unsatisfactory ventilated articles (gloves, masks, clothes, tampons, endotracheal pipes, etc.) evokes irritation of the skin, conjunctivitis and irritation of the cornea. After exposure to a high concentration of the gas, cataracts of the cornea can arise. The frequent contact with it can cause allergic sensitivity. The chronic poisoning by ethylene oxide can cause encephalopathy, polyneuritis and neurovegetative changes. After exposure to ethylene oxide during pregnancy, abortions and premature childbirth have been observed. Ethylene oxide can cause allergic and mutagenic diseases and it is considered to be a potential carcinogen.

The undesirable side effects of some **cytostatic drugs** have been known for a long time. Recent studies have shown the carcinogenic risk of the cytostatic drug presence in the urine of nurses and technical staff who prepare or apply the cytostatic drugs to patients. The hazard is not only in physical contact but includes inhalation of the vapour and micro-drops that are spread during the preparation and application of solutions. Smoking strengthens the carcinogenic effect. In order to eliminate the risk, the cytostatic drugs need to be prepared and again divided into special rooms, where the personnel have to use laboratory protective clothes, gloves and masks. The same rules are recommended at examination and manipulation of the patient's urine.

The first harmful effects of **anesthetic gases** on medical staff were described in the year 1893. Symptoms of chronic poisoning are divided into three categories:

1. Alteration of behaviour and ability to execute psychometric tests.

2. Diseases of organs with biotransformation of xenobiotics.

3. Disorders in cellular replication.

The increase in hepatic transaminase activity, frequent occurrence of hepatitis and cirrhosis of the liver has been found in the staff working in operating rooms. The significantly higher occurrence of spontaneous abortions in the exposed women and more congenital anomalies in their children has been mentioned. Anesthesiologists and employees at surgical departments should be informed about hazards of working with anaesthetics. It is necessary to control the apparatuses and indoor air of the departments.

7.1.4 Psychosocial problems

During an assessment of the work of the medical staff it is important to take into consideration the high level of neuro-psychological load and effort. It results mainly from the demands of the work itself, from emotional tension that results from the great responsibility of caring for the health and life of patients, from contact with patients, from the focused attention, from the three-shift work and from the length of working time.

The high hazard to medical staff, mainly to medical students and young nurses, is emotional stress. It is caused particularly by contact with dying patients, contact with very sick children, with patients who are in pain, have feelings of anxiety and anguish or with those who tried to commit suicide. The work at ICU (intensive care unit) is especially very tedious; it can evoke pathological mental disorders. In this case, the relationship between a physician and a patient is passive. A physician and a nurse are in permanent psychic stress, because they have to make critical decisions important for the patient's life.

The signs of stress in the ICU medical staff have been manifested with psychosomatic disorders (mainly gastrointestinal disorders), with inadequate psychosocial reactions, with various types of neuroses, state of depression, etc. In the case of monotonous, boring and inconclusive work of medical staff the psychopathologic stress has a tendency to increase. The shifts bring personal, family and social problems to the staff. The insufficient synchronization among outdoor stimuli (periodic change of light, noise, temperature and atmospheric ionization) and endogenous clock can cause disorders evoked by dysrhythmia. In these cases, a human organism programmed to daily activity, receives contrary impulses to its physiological demands. Disorders like insomnia, irritation, dyspepsia result from this.

Shift work is a factor, which goes against the genetic, professional and social characteristics of human organism. Work during the night, change of activity, requires twofold effort from a human being and it may cause higher fatigue than usual daily work. The fatigue is not eliminated completely, because man during daily sleep is not able to rest during night sleep. This status of chronic fatigue confirms a decrease in motoric responses to optical and acoustic stimuli and decrease in working efficiency. In the staff working the night shift they found a higher prevalence of digestive disorders and higher addiction to tobacco and alcohol than in the staff working the day shift. The family life of the night shift workers is damaged, because they have less time with their families. Night shift work brings isolation

and less participation in group activities (sport, hobby, cultural performances), though people working the morning shift and in the afternoon have also some social disadvantages.

The chance of dependence on toxic substances in medical staff increases due to their exposure to stress and to anxiety and due their easier access to drugs. The stress from work is often compensated for using stimulants and high consumption of coffee, alcohol, sedative drugs, etc. Many studies show that alcoholism, excessive use of drugs and depression occur more among doctors compared to the wider population.

A job, representing the means to individual satisfaction, can influence the psychic comfort. The excessive overload, work in an unsuitable profession, or shift-work can provoke psychic disorders (disorders of personality, social conflicts) and disorders in relation to occupation.

7.1.5 Issues on occupational physical load

One of the major problems of occupational physiology is the issue of lifting and transporting of patients. It has been estimated that approximately one third of all nurses handle patients. The work of nurses is connected with a large physical and neuropsychic load. It has been estimated, that about 75% of working time requires standing and walking, 11% concerns personal hygiene and handling of immobile patients.

Each nurse looks after several patients and the majority of them are immobile. The weight of immobile patients is often very high. In some cases the nurse alone lifts a patient; sometimes the other workers help her. Manipulation of patients is often done without assistance of apparatuses, mechanisms and without the active assistance of a patient (immobile patient).

In hospital wards where there is a large percentage of immobile patients, the effort of work is increasing due to many unfavourable factors. This applies mostly to medical institutions with long stay patients, geriatric patients, physiotherapy departments, rehabilitation centers and other special medical care departments.

The work effort and responsibility of nurses have been increasing with the total number of immobile and incontinent patients, with the high number of psychically altered patients, inhabitants or charges and with the number and the effort of rehabilitation performances.

The situation has been worsened by architectonic barriers; unsuitable dispositional solutions; unsuitable furniture, a shortage of lifting and transporting apparatuses. It could be possible to improve the work of nurses by equipping the hospitals with special beds, mechanisms, equipment and apparatuses to make the manipulation of patients easier.

7.1.6 The risk of an accident and a menace to personal safety

Accidents caused by explosion, fire, electrical currents, noise, etc. can damage the health status of medical staff and patients.

Lifting of heavy objects, including patients, causes some injuries. Dentists can be injured by sharp metal instruments, metal crowns, etc. They can hurt their face or eyes with fragments of teeth during drilling.

It is necessary to pay special attention when in contact with mentally impaired patients, because the "verbal" attack or even the physical violence can arise.

During work in a hospital, as in any other job, cut-wounds and fractures may occur. The risk of accident can increase with increasing number of shifts.

7.2 THE ROLE OF HOSPITAL HYGIENIST (EPIDEMIOLOGIST)

The role of the hospital hygienist as a chief member of the infection control team in the hospital is very important. The traditional duties of hospital hygienist are:

- **Monitoring** – collection and analysis of surveillance data, mapping of nosocomial infections and ATB resistance.
- **Decision-making** – assisting in the development of infection control policies and procedures, consulting with attending physicians about the isolation and discharge of patients with nosocomial infections.
- **Preventive-control** – regular microbiological monitoring of sterility and cleanliness in the hospital environment.
- **Protective** – protects health of patients and health personnel, recommends and controls preventive measures.
- **Education** – providing education and consultation to other hospital personnel.

The infection control team (hospital hygienist and one or more infection control practitioners) also plays a critical role in advising the hospital's medical staff and administration about the clinical implications of patient-care practices, occupational infections and quality improvement.

7.3 REQUIREMENTS ON HEALTH FACILITIES

Recommended building and space equipping of health facilities have to be efficient. The health facilities are composed of outpatient departments and inpatient departments (the hospital wards where patients are admitted for treatment). The outpatient departments have to have minimal space for waiting rooms (8 m^2), examination rooms for physicians and nurses (20 m^2), examination rooms only for physicians (18 m^2) and examination rooms only for nurses (16 m^2) (Table 7.1).

Inpatient departments have to take into account uniqueness of patients, creation of optimal conditions for their treatment, prevention of nosocomial infections and creation of the suitable work conditions for hospital staff.

Table 7.1 Requirements on surface of basic and supplementary spaces in out-patient departments

Room	Surface [m^2]
Basic spaces:	
Out-patients without preparatory room	15
Preparatory room	12
Waiting room	8
Toilets for patients	2
Toilets for personnel	2
Supplementary spaces:	
Storeroom	2
Cleaning material chamber	1.5
Hygienic filter for employees (wardrobe, toilet, sink, shower)	8

Requirements on microclimate, lighting and acoustic comforts are important and differ from patients' rooms to operating rooms and other rooms in the hospital ward. Temperature is recommended to be 22 °C – 25 °C, moisture of indoor air 35% – 70%; from the safety point of view in the operating room moisture is recommended to be no less than 55 % (risk of anesthetic gas explosion) (Table 7.2).

The highest permissible concentrations of dust particles and microbiological factors in clean spaces of the health-care facility are in Table 7.3.

Intensity of ventilation depends on the number of patients and type of activities and on concentration of indoor air pollutants. In spaces where indoor air pollutants are produced, underpressure air-conditioning is required. Overpressure air-conditioning is needed in operating rooms and in spaces needed to be kept in aseptic and in sterile conditions (production of infusions, etc.).

Table 7.2 Microclimate and acoustic requirements on out-patients and hospital wards

Room	Temperature [°C]	Relative Humidity [%]	Number of air exchanges/h	Pressure	Noise level L_{Aeq} [dB (A)]
Basic rooms:					
Consulting room	22 – 24	30 – 70	5	overpressure	40
Doctor's Office	20 – 22	30 – 70	5	overpressure	40
Patient's room	20 – 24	30 – 70	5	underpressure	35/25 night
Waiting rooms	18 – 20	30 – 70	3	underpressure	50
Supplementary rooms:					
Stroreroom					
Offices for employess	10 – 17	30 – 70	10	underpressure	50
Wardrobe and	20 – 22	30 – 70	5	underpressure	40
accessories	20 – 22	30 – 70	10	underpressure	50

From the hygienic and epidemiological point of view, waste management is very important; problems of waste removal may be responsible for epidemic, technical, aesthetic and economic problems, not only to hospital, but also to the surrounding environment

The prevention and protection against physical, chemical and the other risk factors has been confirmed in Slovak legislation, which is in accordance with the European law. Hygiene of health facilities and nosocomial infections are under the control of Public Health Institutes.

Table 7.3 The highest permissible concentrations of dust particles and microbiological factors in clean spaces of the health-care facility

Grade	The highest permissible concentrations				Classification of spaces according cleanliness requirements
	Dust particles / m^3		Non-pathogenic micro-organisms	Pathogenic micro-organisms	
	< 0,5μm	< 5μm	KTJ/m^3	KTJ/m^3	
M 3.5	3,530	0	< 1	< 1	Superaseptic operating theatre for transplantation, neurosurgical, osteal and burn surgeries, intraocular surgeries, heart surgeries, aseptic ICU after transplantation, aseptic box for patients with radiation syndrome and burn unit.
M 4.5	35,300	247	5	< 1	Surroundings of operating tables in superaseptic operating theatre, operating theatre for aseptic and septic performances, spaces for manipulation with sterile health-care tools
M 5.5	353,000	2,470	100	< 1	Background of cleanliness grades M 3,5 and M 4,5; aseptic and septic operating theatre including operating theatre for laparoscopic and arthroscopic procedures, delivery and section room, clean part and storeroom for aseptic medical devices in central sterilisation department, ward in the department of anaesthesiology and intensive medicine, ICU of patients with serious immunity weakening and pathological newborns, consulting room of angiography using intravascular catheters and probes
M 6.5	3,530,000	24,700	500	< 1	Operating theatre background M5,5; Surgical room, neonatal unit, nuclear medicine applications, consulting room for endoscopy, room for small and superficial surgical procedures

Commments: The cleanliness grade is appointed by common logarithm of the highest permissible number of dust particles (size from 0.5 μm in 1 m^3 of the air); The numbers of particles have been measured out of operation at first 15 – 20 minutes after activity

7.4 HEALTH CARE WASTES

Health care activities are producing a growing amount of waste; most of this waste is the same as domestic waste and has no elevated risk of infection. However; a small part of all health care waste is contaminated by infectious pathogens.

Health care waste is defined as the total waste stream from a health care establishment, research facilities and laboratories, including health-care provided at home.

Health risks of health care wastes:

The risk of infection The most dangerous infections are AIDS and hepatitis B and C. Other conditions (tetanus or general infections) may also appear after an injury involving infectious waste. Health care professionals and those responsible for the collection and processing of waste are most at risk of injury. Preventive measures for these persons are accurate information about the risks, appropriate vaccination cover, protective clothing for collection personnel.

The risk of poisoning Medicines may cause poisoning when they are placed in dustbins or dumps accessible to the public. Children are particularly at risk. Special attention must be paid to waste from cytotoxic products used in the treatment of cancer, which are carcinogenic, mutagenic and teratogenic.

Categories of health care waste:

Non-risk health care waste – same kinds of materials as urban domestic waste.

Risk (hazardous) health care waste:

- **"Sharp waste",** mainly consists of syringe needles. Scalpels, other sharp medical instruments and contaminated broken glass are also in this category.
- **Infectious waste** comprises blood and blood products, items contaminated with blood, serum or plasma, cultures and stocks of infectious agents from diagnostic and research laboratories, wastes from highly infectious patients.
- **Anatomical waste** comprises human tissues, biopsies and autopsies.
- **Chemical waste** may consist of solvents, reagents, film developers, mercury from old thermometers, batteries.
- **Pharmaceutical waste.**
- **Radioactive waste.**
- **Pressurized containers** include cylinders containing gases or aerosols which, when accidentally punctured or incinerated could explode.

Measures should be adopted in all countries to meet the risks of infection among workers and the population resulting from health care waste:

- The first priority is to dispose of sharps, which are the greatest public health problem. This waste must be collected and processed in such a way as to eliminate any risk of accidental injury and prevent its retrieval by drug addicts.
- Incineration in a collective installation is the most reliable method for destroying hazardous health care waste. Great care must be taken to ensure the operational quality of incinerators, not to become a source of pollution.

- Waste must be collected as safely as possible; hazardous health care waste must be disinfected at the site of production.
- On-site disinfection of hazardous health care waste for small producers and pre-incineration waste processing.
- Landfilling of untreated waste is an acceptable short-term method of disposal when the economic and social conditions of a country are such that no other solution is possible.
- The operation of processing plants must be entrusted to qualified personnel.
- Hospitals and other health care establishments should be legally responsible for the management of their waste.
- Preventive vaccination against hepatitis B, as a priority, should be established for medical, nursing staff and personnel responsible for waste collection and processing.

7.5 OUT-PATIENT DEPARTMENTS

Health-care facilities providing ambulatory care are established and operate as individual out-patient departments for general practitioners, or as the ambulatory health-care centers including more out-patient departments for general practitioners and some out-patient departments for specialists. They can also operate as health centers including more out-patient departments for general practitioners and some out-patient departments for specialists and laboratory examinational components.

Services for adults and for children should be divided from the epidemiological point of view. Services for infectious and non-infectious patients should have separate entrances and waiting rooms.

The entrance to out-patient departments should be without barriers, enabling disabled patients to move.

Requirements for space and surface area for out-patient health care facilities are in Table 7.1.

7.6 DEPARTMENT OF STOMATOLOGY

Many hygienic and epidemiological problems exist also in the Department of stomatology. Apart from problems as in the other hospital departments, there are specific conditions that need special attention. Specific risk factors include posture at work of the staff, infections, chemical risks – risk of allergy, exposure to mercury, noise and vibration, disinfection and sterilization.

There should be sufficient space conditions in the each work-place, suitable microclimate, lighting and reduction of noise and vibration in the department of stomatology (minimal surface requirements for a stomatological workplace are 18 m^2).

The long-time unsuitable position of physicians – stomatologists at work can lead to health disorders (discopathy and spondylosis, impairment of nerves and vessels in upper and lower extremities).

Chemical risk factors In stomatology departments many chemical substances are used in prosthetic materials, anesthetics, antiseptics, etc. They can cause an irritation or an allergic reaction and affect skin and mucous membranes.

In stomatology department nosocomial infections can occur as well. The sources of nosocomial infections in stomatological departments are: 1. stomatologic patients, spreading pathogenic microorganisms by lung secretions, 2. stomatological personnel and 3. visitors.

Prevention of stomatological nosocomial infection includes constructional and technical measures, hygienic and epidemiological measures, proper disinfection and sterilization practice.

The physical risk factors in the stomatology department are noise, vibration, and radiation.

8. HOUSING AND HEALTH

Housing is one of the most powerful social and environmental determinant of health. Encompassing the social and physical environment, the inside and the outside of the dwelling, housing influence the personal and collective capacity to attain and maintain a high level of health and physical, mental and social well-being.

8.1. DEFINITIONS

The house According to WHO, the house covers different spaces: The first is the inner space, the dwelling, and the private home; a strictly delineated area, in which only the inhabitants are allowed to come in. The second space is geographically larger: it includes the spaces outside the dwelling, the common space in buildings, the closed physical and human environment, the neighbours and the neighbourhood.

Housing is a basic need for humans: everyone, regardless of age, socio-economic and cultural conditions, or physical conditions, has the right to have an adequate house that promotes his health, and his physical and mental well being. Housing is a complex construct that cannot be represented merely by the physical structure of the home. The WHO understanding of 'housing' is, therefore, based on a four-layer model of housing, taking into consideration the physical structure of the dwelling as well as the meaning of home (for a family and each individual), and the external dimension of the immediate housing environment, and the community with all neighbours (Figure 8.1).

Figure 8.1 The four dimensions of housing (Source: Bonnefoy, 2007)

Dwellings should be lighted, heated and ventilated, connected to a water supply and a sanitation system, allow for the storage and preparation of food and allow satisfactory maintenance of personal hygiene. Inadequate dwelling conditions may trigger many direct health problems. Within the community, a range of health-relevant aspects depends on factors that seem independent of housing conditions. One example is health effects with social etiology, which strongly depend on education, socioeconomic characteristics, or ethnic composition of the people building a community within a neighbourhood or a city quarter. Still, a large number of studies provide sufficient evidence that the social cohesion of the community, and the sense of trust and collective efficacy is to some extent dependent on the

quality of a neighbourhood, which can promote or impede the social interactions through the provision of diverse public places and facilities for social life. Finally, the immediate housing environment has an impact on health through the quality of urban design. Poorly planned or deteriorated residential areas, often lacking public services, greenery, parks, playgrounds, and walking areas, have been associated with lack of physical exercise, increased prevalence of obesity, cognitive problems in children, and a loss of the ability to socialize.

Housing and health is a conceptual domain that covers the relationship between the health of the people and how they are housed. It also refers to the theory and practice of evaluation and to the prevention and correction of risk factors originating from inappropriate conditions, which may have a negative impact on the health.

Urbanization refers to the process by which urban areas increase over time in population density and/or size. It can be planned or unplanned. Planned urbanization occurs when the urban infrastructure (houses, schools, public parks, sustainable drainage systems, roads etc.) is installed. The infrastructure can be extended as the need arises. Unplanned urbanization leads to overcrowding, establishment of shanty-towns, and a breakdown of existing infrastructure. These factors can aggravate poverty and health problems

8.2 THE PROCESS OF URBANIZATION AND THE RISK OF HEALTH

Towns are agents for change and mirrors of society. Currently three quarters of the population of Europe live in towns and cities, and the greatest part of human activity takes place in them. In recent years, each stage in urban development has been represented by a different urban form and by planning policies which have increasingly stressed the problems of health and the environment.

Building of flats in the past had not been always managed by optimal urbanisation or by optimal hygienic principles. In the period after Second World War, the principles that had been accepted on the World Congress of Architects in 1933, well known as the Charter of Athens, were enforcing in construction. The cities, built under these guidelines were strictly divided into functional zones - e.g. the residential and the industrial districts, the business and the administrative centers, the recreational and the suburb regions separated by a protective zone. This organization can lead to formation of less attractive districts (e.g. hostels, industrial districts). Isolation in space can lead into the isolation of vital functions in time and in the rhythm of a day. The next consequence is excessive and opposing movement of inhabitants and the increasing demands on traffic. Climatic conditions and other specifics in common housing construction are not often respected. Some problems had been manifested at reevaluation of demands on individual types of comforts, (e. g. overevaluation of illumination at the expense of acoustic comfort, deterioration of the microclimate) in relation to the new construction elements and their parts (glues, cement, etc.).

From 1971 to 1985, 625, 000 flats have been built in Slovakia. It means that 3/4 of inhabitants live in flats that were built after the Second World War This undoubtedly positive trend has been decreasing by the retardation of facilities, low quality of work and the level of "small environment". For the majority of inhabitants a relatively quick satisfaction of housing need has been fulfilled, the main shortcomings of dwellings in the past have been eliminated (humidity, insufficient illumination and facilities of a flat). Standards of dwellings have been raised; the number of persons living in one room has been decreased from 2.5 to 1.8 person/room, the area of habitable part of a flat increased from 7.8 m^2 to 14 m^2 /person, the basic equipment of flats has been improved

(bathrooms, toilets, kitchen units, laundries, drying rooms, etc). The residential environment represents a system with direct and indirect effect on health of human being.

The panel block buildings represent a large part of the housing stock in Central and Eastern European Countries, in the Commonwealth of Independent States, and the Russian Federation. These blocks have often been called “legacy of the past“. Low-quality materials and inadequate construction methods were often used, resulting in poor quality, anonymous and identical blocks. The cities of Eastern Europe escaped the invasion of the motorcar, which was still a luxury item. Subsequent changes after November 1989 can be illustrated by new laws on private land ownership, the gradual privatization of housing, and by a rapid growth in the number of cars, with little chance in controlling its consequences. After 1990 the development rate of housing has markedly decreased. Some improvement has started just recently with home building (building of above standard flats and polyfunctional houses).

A Pan-European housing and health survey has been undertaken from 2002 to 2003 in eight European cities (Vilnius, Geneva, Bratislava, Angers, Bonn, Budapest, Forli, Ferrera) at the initiative of the WHO housing and health programme following a proposal of the WHO European Housing and Health task force. The LARES Survey (Large Analysis and Review of European Housing and Health Status), coordinated by the European Centre for Environment and Health, Bonn Office of the WHO Regional Office for Europe was designed to achieve the following objectives:

- to improve knowledge of the impacts of existing housing conditions on health and mental and physical well-being;
- to assess the quality of the European housing stock in a holistic way and to identify housing priorities;
- in each of the surveyed cities, and possibly common trends;
- to develop a “practical” instrument to evaluate the effects of housing conditions in health in cities or regions in Europe.

8.3 HOUSING, HEALTH, RISK FACTORS

An average European citizen born today will spend two thirds of their whole life inside their dwelling. People spend most of their life indoors and the amount of time spent inside the house increases with the aging of the population and changes in lifestyles.

It is through the constant relationship that human beings have with their housing, that they can build their social and individual identity.

Housing is an indispensable environment for human life. Its possible dangers, insufficiencies and other defects together with the fact that housing is present all life long, make it a risk factor capable of having considerable consequences on health, physical, mental and social well being.

Indoor climate and indoor air pollution, biological exposure factors, and various physical and chemical hazards encountered inside the home are encompassed by the term indoor

environment. The indoor climate may be the same as that outoors, or in sealed modern buildings, it may be modified by heating, cooling, or adjusting of humidity levels.

8.3.1 Physical and chemical hazards

Physical and chemical hazards in the indoor environment include toxic gases, respirable suspended particulates, asbestos fibers, ionizing radiation, notably radon and "daughters," nonionizing radiation, and tobacco smoke.

Indoor air may be contaminated with dusts, fumes, pollen, and microorganisms. The principal indoor air pollutants in industrially developed nations are summarized in Table 8.1). Many of these pollutants are harmful to health. Some occur mainly in sealed office buildings, and others, such as tobacco smoke, in private dwellings.

Table 8.1 Sources and possible concentrations of indoor pollutants (Source: Last, 2008)

Pollutant	**Sources**	**Range of concentrations**
Respirable particles	Tobacco smoke, stoves, aerosol sprays	0.05 – 0.7 mg/m^3
Carbon monoxide	Combustion equipment, stoves, gas heaters	1 – 115 mg/m^3
Nitrogen dioxide	Gas cookers, cigarettes	0.05 – 1.0 mg/m^3
Sulfur dioxide	Coal combustion	0.02 – 1.0 mg/m^3
Carbon dioxide	Combustion, respiration	600 – 9,000 mg/m^3
Formaldehyde	Particle board, carpet adhesives, insulation	0.06 – 2.0 mg/m^3
Other organic vapors (benzene, toluene, etc.)	Solvents, adhesives, resin products, aerosol sprays	0.01 – 0.1 mg/m^3
Ozone	Electric arcing, UV light sources	0.02 – 0.4 mg/m^3
Radon and "daughters"	Building materials	10 – 3,000 Bq/m^3
Asbestos	Insulation, fireproofing	> 1 fiber/cm^3
Mineral fibers	Appliances	100 – 10,000/m^3

The toxic gases specified in Table x come from many sources. **Formaldehyde** is emitted as an off-gas from particle board, carpet adhesives, and **urea-formaldehyde** foam insulation; it is a respiratory and conjunctival irritant and sometimes causes asthma. It is not emitted in sufficient concentrations to constitute a significant cancer risk. Although rats exposed to formaldehyde do demonstrate increased incidence of nasopharyngeal cancer, there is only weak evidence of elevated cancer incidence or mortality rates even among persons occupationally exposed to far higher concentrations than occur in domestic settings. Gases and vapors from volatile solvents, such as cleaning fluids, have diverse origins. There is a wide range of other pollutants, such as many organic substances, oxides of nitrogen, sulfur, carbon, ozone, benzene, and terpenes. All such toxic substances can be troublesome, especially in sealed air-conditioned buildings and most of all when the air is recirculated to conserve energy used to heat or cool the building. In combination with fluorescent lighting, these gases and suspended particulate matter can produce an irritating photochemical smog that may cause chronic conjunctivitis and nasal congestion.

Imperfect ventilation can become a serious hazard if it leads to accumulation or recirculation of highly toxic gases such as **carbon monoxide**. Carbon monoxide is a

colorless, odorless, and non-irritating gas. It can be inhaled in large quantity without any warning symptoms for the victim. The inhalation of even small amounts may become fatal because the carbon monoxide combines with hemoglobin in the blood and forms an insoluble compound. This is especially likely when coal or coke is used as cooking or heating fuel in cold weather, and vents to the outside are closed to conserve heat.

Asbestos was used for many years as a fire retardant and insulating substance in both domestic and commercial buildings. Its dangers to health have led to restriction or banning of its use and to expensive renovations aimed at removing it. Fibrous glass insulation may present hazards similar to those of asbestos but less severe.

Ionizing radiation, in particular **radon and "daughters**," can be a health hazard, especially if houses are sealed and air recirculated, in which case there is greater opportunity for higher concentrations to accumulate. Sources of radon include trace amounts of radioactive material incorporated in cement used to construct basements. Radon can also be emitted from soil or rocks in the environment where the houses are built. Exposure to elevated levels of the radioactive gas radon may cause lung cancer. Radon is formed by the natural radioactive decay of uranium in rock and soil. Once produced, radon moves through the ground to the air above and may be 'captured' and concentrated in indoor air. It has been estimated that exposure to indoor radon (radon decay products) is, on average, the most important source of ionising radiation from any natural or man-made source

Extremely **low-frequency electromagnetic radiation (ELF)** has attracted much attention since the observation of cancer incidence at higher rates than expected among children living close to high-voltage power lines. No convincing relationship has been demonstrated between childhood cancer and exposure to ELF from domestic appliances, with the possible exception of electric blankets.

The nature of the relationship between ELF and cancer remains controversial.

Tobacco smoke is often the greatest health hazard attributable to physical factors in the indoor environment. **Environmental Tobacco Smoke (ETS)** can be harmful to human health, in particular children's health. Effects include asthma, sudden infant death syndrome (SIDS), bronchitis and pneumonia, and other respiratory diseases. It has also been suggested that ETS also has an adverse effect on the developing fetus. Exposure to ETS may also cause lung cancer, eye, nose, and throat irritation, and may affect the cardiovascular system. Infants and children and nonsmoking spouses are at special risk when living in the same house as a habitual cigarette smoker. Cigarette smoking is a hazard in another way as well: about 20 – 25 % of deaths in domestic fires are a result of smoking.

The results of the recent study involving a nationally representative US sample demonstrates impaired mental and physical health of non-smoking mothers who live with smokers. The risk is discernible with the presence of a single adult smoker in a household and increases with the number of smokers.

Lead has also been widely used in buildings during this past century for drinking water pipes, in paints, and sometimes in other coating materials. The health risks from lead are

severe, particularly with children. It can cause reversible symptoms such as anemia and digestive problems, but can also cause irreversible damage to nervous system.

Community **noise** (also called environmental noise, residential noise or domestic noise) is defined as the noise emitted from all noise sources except the industrial workplace. Main sources of community noise include road, rail and air traffic, industry, construction and public work, and the neighbourhood. The main indoor noise sources are ventilation systems, office machines, home appliances and neighbours. Road traffic noise represents a frequent, unavoidable and continuously increasing environmental factor in big cities throughout the world. In the European Union countries about 40 % of the population are exposed to road traffic noise with the equivalent sound pressure level exceeding 55 dB (A) daytime and 20 % are exposed to levels exceeding 65 dB (A).

According to the results of the LARES study in panel block buildings in three cities of Eastern Europe sponsored by WHO, noise represents a traditional urban problem and noise annoyance was recognized as one of the most prevalent problems affecting residential health and well-being. Health effects were identified also for selected physical and stress-related symptoms, such as hypertension and migraine, which showed significantly increased relative risks. The results also indicated that particular attention must be paid to night time noise exposure in homes

Natural illumination. Daylight, if properly arranged, may be a very effective source of good illumination in a room. Much more difficulty is encountered in designing for daylighting than for artificial lighting. The amount of daylight reaching a room varies with the location and orientation of the building, with the presence of surrounding buildings, and with the time of day, season, weather, and degree of atmospheric pollution. Furthermore, while artificial lighting can be evenly spaced throughout a room and directed as desired, daylight is available only from certain areas, and its distribution is more difficult to control. Because of these variable factors, only a few general recommendations for providing daylight illumination can be given. Natural light (sunlight) acts beneficially upon health, stimulates the metabolism of the body, assists in the oxygenation of the blood. It is also a powerful germicide and disinfectant. Habitations without direct sunlight are damp, cold and unhealthy.

Artificial illumination is obtained from electricity, or from oils, alcohols, water gas, coal gas and acetylene gas. All illuminants, except electricity, produce much heat and give off some impurities, such as CO, CO_2, sulphur compounds, ammonia compounds, smoke, soot and moisture.

8.3.2 Biological hazards

Biological hazards in the indoor environment include many varieties of pathogenic microorganisms. **Mycobacterium tuberculosis** survives for long periods in dark and dusty corners. **Legionella** lives in dilapidated water-cooled air-conditioning systems, stagnant water pipes, and shower stalls, especially in warm moist environments. **Mites** that live on mattresses, cushions, and infrequently swept floors cause asthma, as may many organic dusts

and pollens. Many other infections, especially those spread by the fecal-oral route, occur most often when homes are dirty, open to flies, or infested with cockroaches or rats. Food storage and cooking facilities should be kept scrupulously clean at all times because many varieties of disease-carrying vermin are attracted by filth and because food scraps can be an excellent culture medium for many pathogens that cause food poisoning or other diseases.

The droppings, body parts, and saliva of **cockroaches** can be asthma triggers. Cockroaches are commonly found in crowded cities. Allergens contained in the feces and saliva of cockroaches can cause allergic reactions. In the WHO LARES, it was indicated that the existence of cockroaches strongly depended on the housing characteristics and was favoured by, for example, inadequate bathroom installations, problems with the water drainage system, dirty waste chutes located outside the dwelling, leaky roofs, kitchen windows that do not close tightly, poor bathroom ventilation, litter, graffiti, and poorly-kept open spaces between buildings. Regular and adequate maintenance work of the building was, therefore, identified as one of the major control mechanisms for the prevention of infestations.

When **moulds** find favourable, damp conditions, they will develop and this may happen in buildings. Moulds are microscopic, plant-like organisms, composed of long filaments. They can grow over the surface and inside nearly all substances of plant or animal origin. When moulds find favourable, damp conditions, they will develop and they may affect health through different routes:

- emission of volatile organic compounds (microbial volatile organic compounds (MVOC)- responsible for many of the irritant symptoms associated with dampness and mould in population studies);
- release of spores that may vary according to the climatic conditions (spores may carry allergens and toxic substances);
- production of mycotoxins (toxigenic mould types like Stachybotrys chartarum, Fusarium, Trichoderma produce toxins called trichothecenes, which can be at the origin of serious health effects).

In addition to general symptoms such as headache, tiredness, fatigue, fever and nausea, the health effects associated with mould growth in the building can be divided into three categories:

- irritant symptoms of airways and eyes;
- recurrent respiratory infections;
- chronic diseases (allergic diseases – bronchial asthma, allergic extrinsic alveolitis, rhinitis, urticaria, eczema, acute allergic conjunctivitis).

The WHO LARES survey showed that there is a considerable amount of European homes that may be affected because of mould growth and dampness. Substantial mould growth was detected in 32 % of all surveyed homes associated with health effects such as asthma, bronchitis, migraine, and depression.

8.3.3 Psychosocial and socioeconomic conditions and mental health

Many descriptive studies by social epidemiologists and psychiatrists have demonstrated a consistent association between mental disorders and urban living conditions. There is also a close relationship between mental health and social class.

One of the primary functions of housing is to provide a shelter from outside aggression. Beyond that function, however, a dwelling is defined as a holding space, a physical and psychological envelope within which intimacy will appear and develop and where each and every individual will find an opportunity to be himself or herself. Thus, what was just a house will become a home. Integrity of body and mind are dependant upon this possibility of living in intimacy.

The need for a private space differs from one individual to another and varies according to culture, but the pathogenic effects of homelessness, lack of control, deportation, being uprooted, and intrusion are indications of the real importance of this need. Poor quality housing, providing insufficient protection from the outside, from noise, from scrutiny, and intrusion can be the source of major suffering. Such events may generate pathological manifestations such as anxiety, depression, insomnia, paranoid feelings, and social dysfunction.

Bad circumstances in neighbourhood relations may generate social pathologies: aggressiveness, vandalism, depression, anxiety, somatic complaints, and even paranoid feelings and ideas. Social tensions arise when common spaces fail to act as buffer zones between private and public space or when neighbours try to use them as private spaces, encumbering them with personal items such as prams or bicycles, using them as private meeting places (groups of noisy adolescents), and so forth. Feeling safe in the intimacy of one's home, good neighbourhood relations, respect for the boundaries provided by those parts of buildings common to all, are all essential to the feeling of well-being in housing.

Loss of control over the residential environment or difficulties in appropriating space will unsettle individuals and groups. Several studies, particularly in the field of social and environmental psychology have shown the influence of environmental factors such as pollution, level of noise and crowding on mental health, depression symptoms, and social well-being. In addition, symptoms of stress, anxiety, irritability, depression, even social misconduct (violence, vandalism), and alteration of attention capacities at school in children may be related to noise exposure in relation to the housing conditions. It is also accepted that stressful housing conditions can aggravate pre-existing psychiatric pathologies.

The WHO LARES study has confirmed such findings by identifying increased prevalence of mental health symptoms in relation to selected housing problems such as (a) missing daylight, (b) bad view from buildings, (c) noise disturbance, and (d) inadequate privacy perception.

8.3.4 Sick building syndrome and building-related illness

The most frequent constellation of building-associated complaints is called **sick building syndrome SBS.**

SBS related to housing describes a medical condition in which people in a building suffer from symptoms of illness or feeling unwell for no apparent reason. It consists of mucous membrane irritation of eyes, nose, and throat; headache; unusual tiredness or fatigue; decreased concentration capacity and, less frequently, dry or itchy skin. In some cases, annoyance owing to odours and smells are possible. The symptoms tend to increase in severity with the time people spend in the building, and improve over time or even disappear when people are away from the building. SBS results in substantial disruption of people's work performance and personal relationships, and considerable loss of productivity.

These health symptoms usually cannot be traced back to a specific cause, although it is widely accepted that heating, ventilation, and air-conditioning systems (HVAC), thermal discomfort, draught, or chemical emissions are closely related to the expression of SBS. However, the symptoms are unspecific; they can be triggered by many other causes and do not lead to the manifestation of a classic disease. SBS occurrence is mainly limited to newly-built and refurnished buildings, or buildings with sophisticated HVAC systems. Thus, SBS is mostly a concern for occupational buildings and offices, but similar aspects can also be observed in modern residential buildings. Even though the cause-effect relations are unclear, it is possible to modify buildings with SBS problems, and new buildings have a good chance of avoiding these problems.

Sick building syndrome is distinguished from more medically serious **building-related illness (BRI)** by its subjective nature, reversibility, and high prevalence within implicated buildings and across the nonindustrial building stock in North America and Europe. Building-related illnesses include asthma, hypersensitivity pneumonitis, inhalation fever, rhinosinusitis, and infection. In contrast to sick building syndrome, these building-related illnesses are less common and may result in substantial medical morbidity. Building-related asthma, hypersensitivity pneumonitis, and rhinosinusitis are usually accompanied by sick building syndrome symptoms among coworkers. Whether similar etiologies contribute to sick building syndrome and building-related illnesses is still speculative.

SBS and BRI are also occupational health issues as is presented in the Chapter 3.

8.4 HOUSING STANDARDS

Public health workers are directly concerned about the quality of housing because of the many ways it can affect health. Local health officials have special powers to intervene when health is threatened by inadequate housing conditions. There are minimum housing standards, with specific details on basic equipment and facilities, fire safety, lighting, ventilation, thermal requirements, sanitation, space requirements (occupancy standards), and the special requirements for rooming houses.

Special housing needs

The need for hygienic housing conditions includes a requirement for $30m^3$ of fresh air per hour for adults. This means that the height of the flat should be 2.8 m, or at least 2.6 m. It is necessary to provide 16 m^2 of room per individual ($6m^2$ for bedrooms, $6m^2$ for dining rooms, 1.5 m^2 for the kitchen, 1.5 m^2 for sanitary facilities and 1 m^2 for communications per tenant).

The maximum level of noise from sources in the building that is allowed in flats with closed windows is 35 dB(A) during the day and 30 dB(A) during the night.

The flooring in bedrooms and dining rooms should be parquet, while kitchen, bathroom and supporting rooms should have terrazzo material flooring, which is a good isolator and easy to clean.

It is important to have good illumination, both natural and artificial, with a photo-coefficient (relation between the surface of window glass and the ground) between 1:6 and 1:8 in flats. The requested illumination of residential environments range from 50 to 600 lx, depending on the purpose of the room (the bedrooms and bathroom should be 50 – 60 lx, the library and working-rooms should be 300 – 600 lx).

The children's room must have enough space for children to play or learn if they are students. Children of different sexes should also have separate rooms: if they are of the same sex, there should not be more than two children in the same room.

Another important aspect of environmental hygiene is climate control (climate and microclimate). Many facilities use air-conditioning or similar control systems to maintain proper ventilation, humidity, and temperature control. In facilities without air-conditioning, windows that can open from the top and bottom provide cross ventilation. In addition to maintaining a healthy climate, good ventilation is necessary in controlling and eliminating disagreeable odors. In cases where airflow does not control odors, room fresheners should be used discretely. Objectionable odors such as bad breath or perspiration are best controlled by proper personal hygiene and clean clothing.

All rooms should correspond according to needs and purposes, sufficiently correlated to number, arrangements, structure, and equipment.

The aged, chronically ill, and disabled, whether living in marginal or affluent circumstances, have special needs for health protection, safety, access to services and the means of pursuing as active and rewarding a life as possible. Generally limited in their mobility, these groups have diverse needs that may have to be met through special arrangements for housing, equipment and appliances, care and supervision, employment, protection against physical hazards (fires, crime, natural disasters), and social activities.

Elderly and disabled people require accommodation that has been adapted to enable easier access (ramps, handrails, wide doors to permit passage of wheelchairs), to facilitate storage and preparation of food (low-placed cupboards and stoves with front-fitted switches, which are inadvisable in homes where there are small children), and with special equipment for bathing and toileting (strong handrails, wheelchair access).

Special accommodation of this type is often segregated, which tends to set the occupants apart in an urban ghetto for the elderly and disabled. Integrated special housing is preferable, as examples in Denmark, Sweden, and the United Kingdom have demonstrated; in this setting, elderly, infirm, and younger disabled persons live among others who are not disabled, a situation that many of them prefer and that helps to accustom these other people to making allowances for their disabled fellow citizens.

Statistical indicators of housing conditions Health planning requires every kind of information pertinent to community health, including statistics on housing conditions. Useful information is routinely collected at the census on density of occupancy (persons per bedroom), cooking and refrigerating facilities, and sanitary conditions. Tables derived from small-area analysis of census data showing housing statistics enable health planners to identify neighborhoods at high risk of diseases associated with crowding and poor sanitation.

Census tables also enable health planners to identify less obvious health hazards, such as proportions of elderly persons living alone, whether in small apartments or multiple-room dwellings that were family homes before others in the family moved away or died, leaving an elderly person as sole resident. Once such neighborhoods are identified, public health nurses and other community health workers can more easily locate and visit individuals at risk, who may need but have not yet asked for help.

In addition to census tables, there are other useful sources of information on neighborhoods with a high incidence of social pathology. Fire departments record false alarms and fires deliberately; police departments' record details of vandalism and calls to settle domestic disturbances; and schools record absenteeism and truancy.

8.5 HEALTHY COMMUNITIES AND HEALTHY CITIES

The WHO European Healthy Cities program was established in 1986 to provide a local basis for implementing the principles of the WHO strategy for Health for All and the Ottawa Charter for Health Promotion. It has since evolved into a global movement with a strong European-wide involvement.

The WHO European Healthy Cities Network engages local governments in developing better health through a process of political commitment, institutional change, capacity-building, partnership-based planning and innovative projects. It promotes comprehensive and systematic policy and planning with a special emphasis on inequality in health and urban poverty, the needs of vulnerable groups, participatory governance, and the social, economic and environmental determinants of health. It strives to include health considerations in urban economic, regeneration and development efforts.

More than 1,000 cities and towns from more than 30 countries in the WHO European Region are linked through national, regional, metropolitan and thematic networks, as well as the WHO European Healthy Cities Network.

Cities are working on three core themes: healthy aging, healthy urban planning and health impact assessment. In addition, all participating cities focus on physical activity and active living.

From modest beginnings, the Healthy Cities movement has spread all over the world and in some places has extended beyond cities to embrace rural communities. Since the

environment in which people live, grow, work, and play so manifestly influences their health and happiness, the Healthy Cities initiative is potentially among the most valuable means at our disposal to make this environment healthy.

The domestic environment should be the setting in which the family lives and grows together, where bonds of affection and mutual trust are formed and strengthened, where socialization into the prevailing culture and intellectual stimulation are occurring, and where privacy is available when it is wanted and needed.

9. CHRONIC NONCOMMUNICABLE DISEASES PREVENTION

Noncommunicable diseases represent the greatest burden of mortality and morbidity all over the world as well as within the European region; noncommunicable disease rates are high and increasing. The factors affecting an individual's susceptibility to developing noncommunicable diseases are genetic, biological, behavioural and environmental. The reduction and control of behavioural and environmental risk factors remains the cornerstone of action to reduce the incidence and alter the course of noncommunicable diseases. Risk factors such as smoking, alcohol, obesity, a fatty diet, lack of exercise, and exposure to stress can be linked epidemiologically to specific individual diseases. Collectively, they offer the opportunity for an integrated approach which can contribute to the reduction of several of the most important noncommunicable diseases (e.g. cardiovascular disease, certain cancers, chronic obstructive pulmonary diseases, mental disorders, etc.). The knowledge therefore exists to prevent, and also to diagnose and treat many cases of noncommunicable diseases. In addition, screening and case-identification strategies allow for their detection and diagnosis across populations and within individuals. Treatment has also become increasingly effective for some conditions such as coronary artery disease. Lastly, rehabilitation remains an important component of disease management, for all conditions. Several noncommunicable diseases are considered in more detail below. The situation analysis indicates several cost-effective and high-quality strategies, both for public health and at the individual, clinical level.

9.1 CARDIOVASCULAR DISEASES PREVENTION

Cardiovascular diseases (CVD) are one of the most serious health and social problems of industrialized countries of the world and their importance is increasing also in the developing countries. It is an important cause of disability and contributes substantially to the escalating costs of health care. However, since the 1980s, CVD mortality rates have halved in many industrialized countries (Figure 9.1). Studies in the USA, Europe, and other countries consistently suggest that 50 – 75 % of the falls in cardiac deaths can be attributed to population-wide improvements in the major risk factors, particularly smoking, cholesterol levels, and blood pressure. Medical and surgical treatments were considered to account for only 40 % of the reduction in coronary deaths. Recent studies concluded that even up to 80 % of the fall in coronary mortality was caused by favourable changes in risk factors. However, CVD still remains the largest cause of death in the United States, Europe, and Australia.

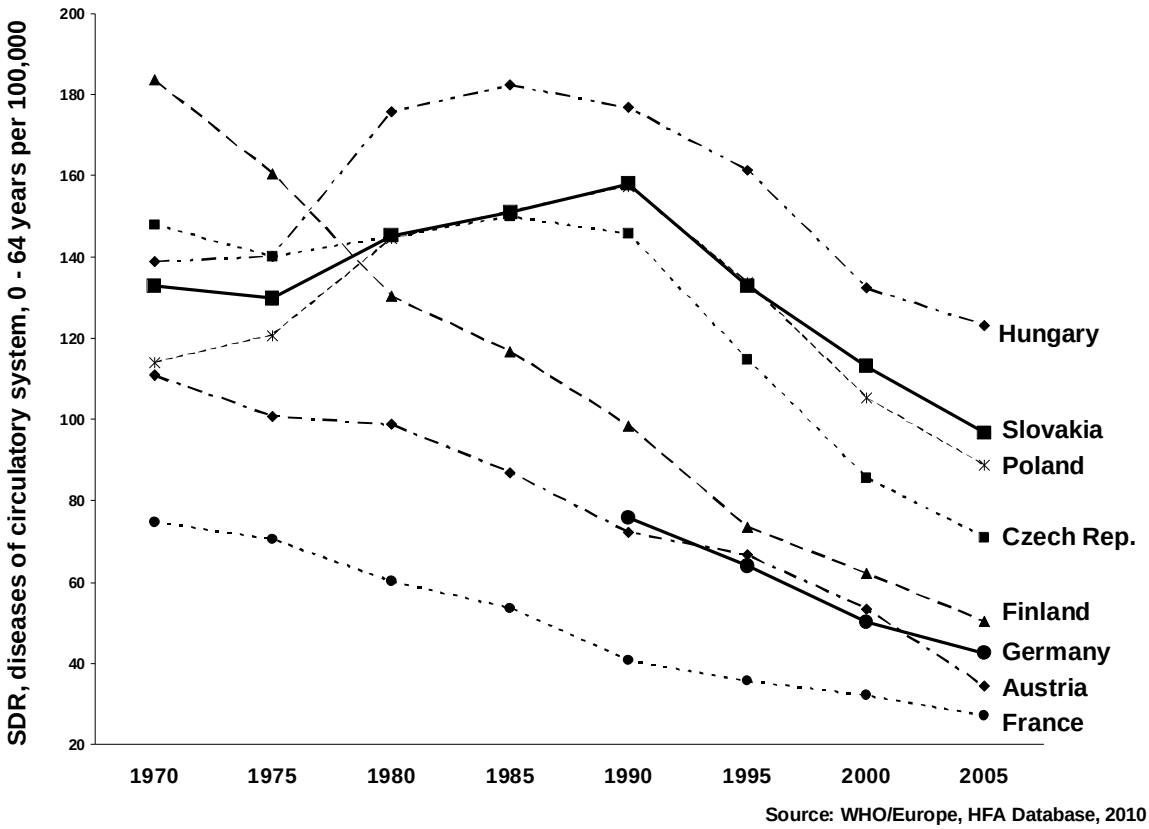

Figure 9.1 Standardized death rate (SDR), diseases of circulatory system, 0 – 64 years in selected European countries during the years 1970 – 2005 (Souce: WHO, 2010)

The main forms of CVD are coronary heart disease (CHD) and stroke. Just under half of all deaths from CVD are from CHD and nearly a third are from stroke. Each year CVD causes over 4.3 million deaths in Europe and over 2.0 million deaths in the European Union (EU):

- CVD causes nearly half of all deaths in Europe (48 %).
- CVD is the main cause of death in women in all countries of Europe and is the main cause of death in men in all countries except France, the Netherlands and Spain.
- Death rates from CHD and stroke are generally higher in Central and Eastern Europe than in Northern, Southern and Western Europe.
- CVD mortality, incidence and case fatality are falling in most Northern, Southern and Western European Countries but either not falling as fast or rising in Central and Eastern European countries.

In Slovakia the statistical data are even more unfavourable. From the group of deaths caused by circulatory diseases, which participate on total mortality with 53.6 %, most deaths fall on myocardial infarction and vascular diseases of brain. Most of the male deaths, according to last available statistical data, resulted from diseases of circulatory system (46,9 %) and cancers (24,6 %). Highest mortality on diseases of circulatory system (61.0 %) was

observed in females as well. Next groups of female deaths were malignant diseases with 20.3 % (Figure 9.2).

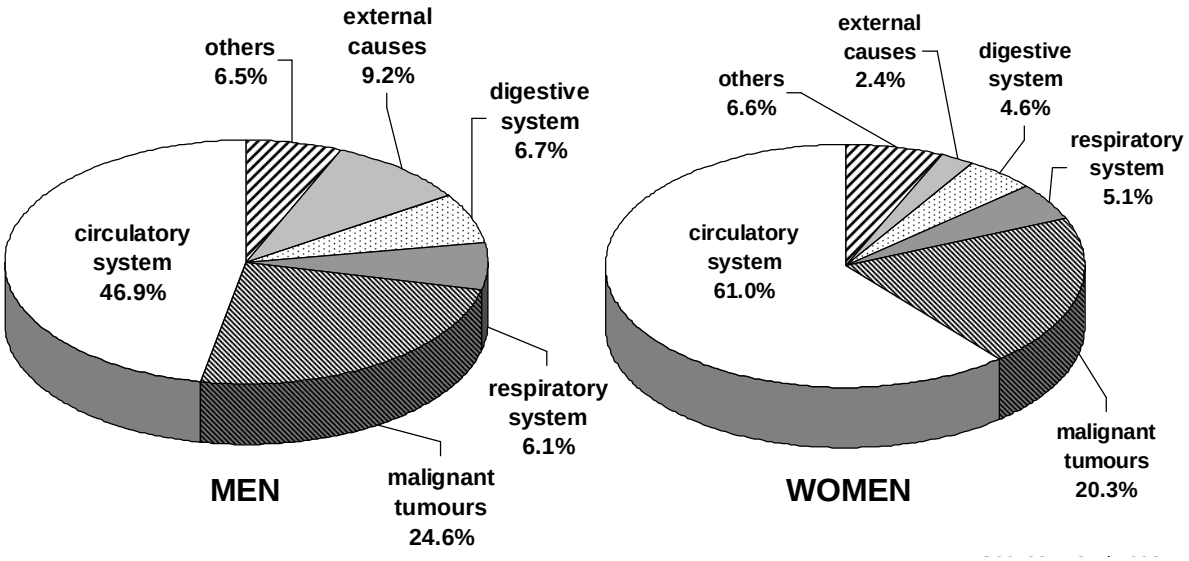

Figure 9.2 Mortality rate by main causes of death in males and females in Slovakia in the year 2008 (Source: NCZI, 2008)

Both main CVD diseases, coronary heart diseases and stroke, are caused by atherosclerosis. The underlying atherosclerosis develops insidiously over many years and is usually advanced by the time that symptoms occur. Death from CVD often occurs suddenly and before medical care is available, so that many therapeutic interventions are either inapplicable or palliative. The mass occurrence of CVD relates strongly to lifestyles and to modifiable physiological and biochemical factors.

The goals of some long-time epidemiological studies were to find out the prevalence of main risk factors in different populations, and their relationship to cardiovascular morbidity and/or mortality.

In 1948, the **Framingham Heart Study** – the first, longest, and the most known and citied study of the world – embarked on an ambitious project in health research. At the time, little was known about the general causes of heart disease and stroke, but the death rates for CVD had been increasing steadily since the beginning of the century and had become an American epidemic. The Framingham Heart Study became a joint project of the National Heart, Lung and Blood Institute in Boston University. The objective of the Framingham Heart Study was to identify the common factors or characteristics that contribute to CVD by following its development over a long period of time in a large group of participants who had not yet developed overt symptoms of CVD or suffered a heart attack or stroke.

The researchers recruited 5,209 men and women between the ages of 30 and 62 from the town of Framingham, Massachusetts, and began the first round of extensive physical examinations and lifestyle interviews that they would later analyze for common patterns related to CVD development. Since 1948, the subjects have continued to return to the study every two years for a detailed medical history, physical examination, and laboratory tests, and in 1971, the Study enrolled a second generation – 5,124 of the original participants' adult children and their spouses – to participate in similar examinations.

Over the years, careful monitoring of the Framingham Study population has led to the identification of the major CVD risk factors – high blood pressure, high blood cholesterol levels, smoking, obesity, diabetes, and physical inactivity – as well as a great deal of valuable information on the effects of related factors such as blood triglyceride and HDL cholesterol levels, age, gender, and psychosocial issues. The importance of the major CVD risk factors identified in this group have been shown in other studies to apply almost universally among racial and ethnic groups, even though the patterns of distribution may vary from group to group. The concept of CVD risk factors has become an integral part of the modern medical curriculum and has led to the development of effective treatment and preventive strategies in clinical practice.

Other well-known study – **The Seven Countries Study** was the first to examine systematically the relation among lifestyle, diet, and the rates of heart attack and stroke in contrasting populations. It has been one of the finer scientific adventures of our time and of the field of cardiovascular disease epidemiology. The idea of the study arose in various forms in the minds of imaginative individuals capable of integrating clinical, laboratory, and population evidence.

Between 1958 and 1964, 12,763 men aged 40 through 59 years from seven countries were enrolled in the study. A total of 16 cohorts were examined in the following countries: the United States, Finland, the Netherlands, Italy, Greece, Croatia and Serbia (the former Yugoslavia), and Japan. In 11 rural cohorts all men aged 40 through 59 years from official registries were invited.

The purpose of the Seven Countries Study was to study associations between risk factors and CHD mortality both at the population level and at the individual level. After 5 years of follow-up, it had already been reported a strong ecological correlation between serum total cholesterol and mortality from CHD in the 16 cohorts of the Seven Countries Study. On the individual level, the 5- and 10-year follow-up data suggested strong associations between serum total cholesterol and CHD mortality in the United States and Northern Europe, but much weaker associations in Southern Europe and Japan. This could have resulted in part from small numbers of CHD deaths in these cultures. These data provided a unique opportunity to examine in detail the relationship between serum total cholesterol level and CHD mortality in different cultures. The large difference in absolute CHD mortality rates at a given cholesterol level, however, indicates that other factors, such as diet, that are typical for cultures with a low CHD risk are also important with respect to primary prevention. Differences in nutritional factors may play an important role because dietary patterns differ greatly between the cohorts.

The WHO project – **MONICA** (*MONI*toring trends and determinants in *CA*rdiovascular diseases project), established in the early 1980s, an international collaboration of researchers, collected data from over 100,000 individuals, from 38 populations in 21 countries, mostly in Europe. More than seven million men and women aged between 35 and 64 years of age were monitored to examine if and how certain coronary risk factors and new treatments for heart disease contribute to the decline or rise of heart disease rates in these communities. The risk factors studied by MONICA included cigarette smoking, blood pressure, blood cholesterol

and body weight. Treatments taken into consideration included aspirin, beta blockers, ACE-inhibitors, thrombolytics (clot-busters) and coronary artery surgery. All of these are known from other research studies to determine risk or survival from heart disease in individuals.

The first results from the study, released in May 1999, showed that deaths from cardiovascular disease had fallen by more than 20 % in men and women between the mid-1980s and the mid-1990s.

Heart disease rates fell in most of the populations studied, as did cigarette smoking in men, blood pressure and blood cholesterol. Smoking in women showed a mixed picture and weight rose in both men and women in most populations. Taking all populations as a whole, decline in smoking seems to have contributed most to the reduction in the risk of heart disease in men. In women, decrease in blood pressure emerged as the strongest determinant. However, the increase in obesity, and in smoking among women, requires immediate public health action. Overall, it was found that the relation between the fall in heart disease rates and the change in risk factors was more apparent in men than in women.

Results also showed that around two-thirds of the decline in CHD mortality during this period was due to a decline in CHD incidence rates and the remaining one-third was due to improvements in survival because of better treatments.

The results of the MONICA project also show that incidence of coronary events is falling rapidly in most of the MONICA project populations in Northern and Western Europe but is not falling as fast in the populations in Southern, Central and Eastern Europe and in some cases is rising in these populations.

Other well-known, large WHO project – **The CINDI** (Countrywide Integrated Noncommunicable Diseases Intervention) programme, established in 1982. The CINDI programme aims to reduce modifiable risk factors, such as smoking and high blood pressure, by integrating health promotion and disease prevention, and to reduce the burden of noncommunicable diseases on society by controlling their major risk factors. At present, 27 countries participate in the programme. Thanks to long-term collaboration a unique body of knowledge and experience has been built up of the prevention of noncommunicable diseases through integrated approaches at the community level.

Programme supports prevention and control of chronic diseases through an integrated approach towards risk factors such as unhealthy diet, reduced physical activity, tobacco use and alcohol abuse. This issue of CINDI highlights focuses on activities implemented by countries participating in the CINDI programme. Particular focus is made on the actions aimed at counteracting obesity.

The most impressive results were achieved in Finland, with a 73 % reduction in CHD mortality over a 25-year period. One of the important factors contributing to this dramatic decrease is dietary change; the Finnish nutrition policy recommends increasing the intake of low saturated fat foods and vegetables (e.g. a free salad with meals contributes to doubling

vegetable intake). Food and nutrition policies are needed in all population groups to help reduce high levels of premature mortality and morbidity due to noncommunicable diseases.

Slovakia was involved in the CINDI programme in the year 2003; it is managed by the Public Health Authority's departments for health education and health consulting centers.

The most wide-ranging preventive programme in Slovakia was Cardiovascular Programme of the Slovak Republic in the years 1978-1989. Representative samples of 484,185 subjects 30 – 59 years were examined within this project. The detected trends of selected cardiovascular diseases and their risk factors were published: 20 % of the population were found to suffer from one or more cardiovascular diseases, from that arterial hypertension in 10.7 %, myocardial infarction in 0.6 %, and angina pectoris in 0.9 %. The selected risk factors exhibited the following prevalence: diabetes mellitus in 4.0 %, obesity in 32.3 %, smoking in 28.3 %, and hypercholesterolemia in 17.6 %. Information on the occurrence and trends of cardiovascular diseases as well as on their interrelationship with risk factors is an essential prerequisite for efficient primary and secondary prevention.

Current preventive population-wide programmes in Slovakia, focused on health improvement, come out from WHO Program Health 21 – Health for all in 21st century (National Program of Health Support, Healthy towns, Healthy schools, Healthy workplaces, The Nutrition Improving Program of Slovak Citizens, Obesity Prevention Program, etc.).

The Health 21 policy's one constant goal is to achieve full health potential for all people, with two main aims: to promote and protect people's health throughout their lives; and to reduce the incidence of the main diseases and injuries and alleviate the suffering they cause. Three basic values form its ethical foundation: health as a fundamental human right, equity in health and solidarity in action, and participation and accountability for continued health development. Four main strategies for action have been chosen to ensure that scientific, economic, social and political sustainability drive the implementation of Health 21.

Target 8 deals with reducing noncommunicable diseases: By the year 2020, morbidity, disability and premature mortality due to major chronic diseases should be reduced to the lowest feasible levels throughout the region. In particular 8.1 – mortality due to cardiovascular diseases in people under 65 years should be reduced on average by at least 40 %, particularly in countries with currently high mortality.

Prevention strategies and policy issues Studies in Europe, the USA and other countries consistently suggest that 50 % – 75 % of the decrease in cardiac deaths can be attributed to population-wide improvements in the major risk factors, particularly smoking, total cholesterol and blood pressure. The remaining 25 % – 50 % of the decreased mortality fall is generally explained by modern cardiology treatments for known CHD patients, such as thrombolysis, ACE inhibitors, statins, and coronary artery bypass surgery.

Three WHO strategies for the prevention of CVD can be distinguished: *population*, *high-risk* and *secondary prevention*. The three strategies are necessary and complement each other. The population strategy is the essential way to reduce the incidence and the burden of CVD,

and in particular is critical to reducing the overall incidence of CVD since it aims to reduce risk factors at population level through lifestyle and environmental changes that affect the whole population without requiring the medical examination of individuals. This type of strategy is mostly achieved by establishing ad hoc policies and community interventions.

Risk factors modifications have been shown to reduce CVD mortality and morbidity, particularly in high-risk subjects. CVD mortality rates vary with age, gender, socio-economic status, ethnicity, and geographical region. Mortality rates increase with age, and are higher in men, in people of low socio-economic status, in Central and Eastern Europe. There are marked socio-economic gradients in CVD morbidity and mortality within European countries, which are partially explained by socio-economic differences in conventional risk factors, such as smoking, blood pressure (BP), blood cholesterol, and glucose.

As well as health promotion and disease prevention strategies to control and manage risk factors, strategies for treatment and rehabilitation are also required. These must start at population level, with emergency services providing rapid intervention for acute events, followed by rapid transfer to hospital and effective management (e.g. of coronary thrombolysis). Later treatment options include a range of medical and surgical interventions, with the latter increasingly being based on less invasive procedures. Finally, well planned rehabilitation services are essential.

All disease control strategies require a sufficient evidence base, testifying to their effectiveness and efficiency, as well as to the accessibility and quality of the services provided. Such strategies should therefore be supported by a population-based health information system. This system should allow for:

- identification of the whole population and its epidemiology, i.e. mortality, morbidity, lifestyle and behavioural characteristics;
- planning and management of preventive and intervention strategies for noncommunicable diseases;
- management of individuals' involvement with such strategies, i.e. registering initial contact; recording the results of screening and case-finding interventions; monitoring follow-up; and recording outcomes;
- monitoring and evaluation of programmes in terms of their quality, focusing on the health outcomes achieved.

9.1.1 Cardiovascular diseases risk factors

There are some modifiable and non-modifiable risk factors.

Non-modifiable factors include:

Age The prevalence of many cardiovascular diseases increases exponentially with ageing, especially coronary heart disease, heart failure, atrial fibrillation, hypertension and aortic

stenosis. The risk age is considered > 55 years in men, and > 65 years in women. Specific attention is needed for guideline development and adherence with respect to elderly patients.

Gender Generally, the risk of CVD (especially CHD) development is larger in men; middle-aged men have high prevalence of main CVD risk factors, more frequent abdominal obesity and/or metabolic syndrome occurrence. On the other hand, more women than men die from CVD, although they do so at an older age (stroke is markedly more common as a cause of death in women). CVD risk in women is deferred by 10 years compared with that of men (a 55-year-old woman is near identical in term of risk to a 45-year-old man). The decline in CVD mortality in recent years has been greater in men than in women, and CVD incidence has actually increased in women, especially in the oldest groups.

Race The highest CHD mortality rate is among black race people (in USA), mainly due to higher prevalence of main risk factors (hypertension, diabetes, smoking, obesity etc.). The differences among other races are not significant.

Family history The risk of CHD increases when an individual is closely related to a family member who has developed CHD. A history in a first degree relative (parents, brothers or sisters, children) is more important than a similar history in a second degree relative. The younger the age at which family members develop CHD, the higher is the risk. Based on this, a detailed family history of CHD or other atherosclerotic disease should be part in the identification of high-risk individuals.

The main modifiable risk factors are as follows:

Plasma lipids The relationship between a raised plasma cholesterol and atherosclerotic vascular disease fulfils all of the criteria for causality. There is a strong and graded positive association between total as well as LDL cholesterol levels and the CVD risk. The evidence that reducing plasma cholesterol reduces risk is equally unequivocal. A 10 % reduction in plasma total cholesterol is followed by a 25 % reduction in incidence of CHD after 5 years, and a reduction of LDL cholesterol of 1 mmol/l is accompanied by a 20 % reduction in CHD events. The results of epidemiological studies and clinical trials confirm that the reduction of LDL cholesterol must be of prime concern in both primary and secondary prevention of atherosclerotic disease.

Hypertriglyceridaemia is also associated with CVD risk, but the association is not as strong as it is for hypercholesterolaemia. Raised plasma triglycerides signal the need to look for those other factors that may be associated with the so-called metabolic syndrome (see below).

Low concentration of HDL cholesterol is clearly associated, as an important cardiovascular risk factor, independent of LDL-cholesterol, with early development of atherosclerosis. Smoking, sedentary lifestyle, obesity and type 2 diabetes can cause lower HDL cholesterol level.

In general, total plasma cholesterol should be below 5 mmol/l and LDL cholesterol should be below 3 mmol/l. The classification of plasma lipid levels is shown in Table 9.1.

Table 9.1 Blood lipids classification

LDL-cholesterol [mmol/l]			**Total cholesterol [mmol/l]**	
< 2.6	Optimal		< 5.2	Desirable
2.6 – < 3.4	Near optimal		5.2 – < 6.2	Borderline high
3.4 – < 4.1	Borderline high		≥ 6.2	High
4.1 – < 4.9	High			
≥ 4.9	Very high			
HDL-cholesterol [mmol/l]			**Triglycerides [mmol/l]**	
men		women	< 1.7	Normal
< 1.0	Low	< 1.2	1.7 – < 2.2	Borderline high
1.0 – 1.4	Near optimal	1.2 – 1.6	2.2 – < 5.6	High
> 1.4	Optimal	> 1.6	≥ 5.6	Very high

The issue in the management of dyslipidaemia in primary prevention is lifestyle factors modification, especially:

- smoking cessation,
- healthy food choices – lower total fat intake (< 30 % of energy), lower intake of saturated fats, cholesterol (< 300 mg daily), trans-fatty acids, and higher intake of mono- and polyunsaturated fats from vegetable and marine sources, fruits, vegetables, wholegrain cereals, low fat dairy products,
- weight reduction in obese people and weight maintenance in normal weighting people,
- higher frequency and/or intensity of regular physical activity.

Hypertension BP is a strong, consistent, continuous, independent, and etiologically relevant risk factor for cardiovascular and renal disease. CVD risk is directly related to both systolic and diastolic blood pressure levels. CHD and stroke mortality increase progressively and linearly from blood pressure (BP) levels a slow as 115 mmHg systolic and 75 diastolic upward. In addition, data indicated that BP values in the 130 – 139/85 – 89 mmHg range are associated with a > 2-fold increase in relative risk from CVD compared with those with BP levels below 120/80 mmHg.

It has also been shown that, compared to normotensive individuals, those with an elevated blood pressure are more likely to have other risk factors for CVD such as diabetes, insulin resistance and dyslipidaemia and various types and degrees of target organ damage. Because risk factors may interact positively with each other, the overall cardiovascular risk of hypertensive persons may be high even if blood pressure is only moderately raised.

The classifications of hypertension is shown in Table 9.2.

Hypertension can be prevented and BP can be reduced primarily by lifestyle interventions (also as an essential component of hypertension patients' treatment):

- smoking cessation (smoking causes an acute increase in BP and heart rate);
- weight loss in overweight or obese individuals (body weight is directly associated with BP; greater weight loss leads to a greater BP reduction);

- moderation of alcohol consumption (< 20 g pure alcohol daily in men and < 10 g in women); the higher alcohol consumption is associated with high stroke risk;
- increasing of habitual physical activity level (there is an inverse relationship between physical activity and BP; adequate dynamic physical training and greater fitness are associated with a reduced incidence of hypertension). It is recommended a moderate aerobic exercises in frequency 30 – 45 min 4- to 5-times weekly;
- salt intake reduction (< 5 g daily);
- well-established dietary modifications – dietary patterns based on DASH diet (i.e. diet rich in fruit, vegetables, low fat dairy products, with a reduced content of dietary cholesterol as well as saturated and total fat and increased potassium intake.

Table 9.2 Definition and classification of blood pressure levels in adult people (18 years and more) (according to US and European criterions)

a) according to The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure			
BP Classification	**Systolic BP** [mmHg]		**Diastolic BP** [mmHg]
Normal	< 120	and	< 80
Prehypertension*	120 – 139	or	80 – 89
Stage 1 hypertension	140 – 159	or	90 – 99
Stage 2 hypertension	≥ 160	or	≥ 100

* Prehypertension is not a disease category; rather it is a designation chosen to identify individuals at high risk of developing hypertension

b) according to European Society of Hypertension		
Category	**Systolic BP** [mmHg]	**Diastolic BP** [mmHg]
Optimal	< 120	< 80
Normal	120 – 129	80 – 84
High normal	130 – 139	85 – 89
Grade 1 hypertension (mild)	140 – 159	90 – 99
Grade 2 hypertension (moderate)	160 – 179	100 – 109
Grade 3 hypertension (severe)	≥ 180	≥ 110
Isolated systolic hypertension	≥ 140	< 90

Note: When a patient's systolic and diastolic BP fall into different categories the higher category should apply for the quantification of total cardiovascular risk.

Combination of two or more lifestyle modifications can achieve better results.

Careful identification of higher BP subjects in population in CVD prevention and their adequate hypertension treatment with target BP levels achieving is necessary.

Smoking There is overwhelming evidence for an adverse effect of smoking on health. This adverse effect of smoking is related to the amount of tobacco-smoked daily and to the duration of smoking. In long-term smokers, smoking is responsible for 50 % of all avoidable deaths and one half of these are due to CVD. The risk of CVD is particularly high if smoking starts before the age of 15 years. It has been found that the mortality from vascular disease is

higher in female smokers than in male smokers. The effects of smoking on CVD interact synergistically in the presence of other CVD risk factors such as age, gender, arterial hypertension, and diabetes. Women under oral contraceptive treatment should specifically avoid smoking as smoking has a synergistic effect on the risk of both CHD and cerebral tromboembolism.

Although the exact mechanism by which tobacco smoking increases the risk of atherosclerotic disease are not yet fully understood, smoking enhances both the development of atherosclerosis, the occurrence of superimposed thrombotic phenomena and leukocyte activation.

The long-term risk of smoking to individuals has been quantified in a 50-year cohort study of British doctors. Observing deaths in smokers and non-smokers over a 50-year period, the study concluded that "about half of all regular smokers will eventually be killed by their habit". In Europe, smoking causes 32 % of CVD deaths in men aged 35 to 69 years and 6 % of CVD deaths in women of the same age.

The benefits of smoking cessation are indisputable and there is no age limit to profit from the benefits of smoking cessation. Stopping smoking leads to a quicker reduction in the risk of subsequent CHD events in patients with established CHD than in asymptomatic individuals. The physician's firm and explicit advice that a person should stop smoking completely is the most important factor in getting the smoking cessation process started. Smoking cessation is also economically the most efficiency intervention process.

In many European countries a favourable development has occurred with the creation of "smoke-free" environments, including restrictions of smoking at work sites, in public transport vehicles restaurants etc. These changes provide an improved atmosphere for smoking cessation attempts by individuals.

Passive smoking has been also shown to increase the risk of CHD and other smoking-related diseases. The relationship between passive smoking and various non-communicable diseases has been studied since the mid 70s and a number of relationships between passive smoking and a variety of health problems – including CVD and cancer – have been observed.

Obesity Overweight and obesity increase the risk of CVD, as well as being an independent risk factor. Obesity is also a major risk factor for high blood pressure, raised blood cholesterol, diabetes and impaired glucose tolerance. Obesity is becoming a worldwide epidemic in both children and adults. Currently it is estimated that, worldwide, over 1 billion people are overweight, and over 300 million are obese. Over one-third of children are overweight or obese. In Slovakia approximately two thirds of population age 25 – 64 years are overweight or obese.

Overweight and obesity have become a well recognized problem in many Western countries since the 1950s, mostly as a consequence of improved living conditions. Plentiful availability of food and less physically demanding jobs typical of industrialized and globalized societies are deemed to be the major determinants of the "obesity epidemic". In

many Western countries the prevalence of obesity has been increasing steadily. In the USA it rose from 12 % in the early 1990s to more than 17 % in 1998 and to 33.8 % in 2007/08 with the highest increase in the youngest age groups. Europe as well is experiencing a marked increase in obesity rates, which have doubled over just a few years. The burden of obesity is generally considered to be a correlate of mortality and to lead to an increase in the prevalence of chronic diseases. The impact of these diseases in terms of morbidity and mortality, health-care expenditure and individual health-related quality of life is far from negligible.

It is now clear that fat, and in particular intra-abdominal visceral fat, is a metabolically active endocrine organ that is capable of synthesizing and releasing into the bloodstream an important variety of peptides and non-peptide compounds that may play a role in cardiovascular homeostasis. Fat is associated with increased secretion of free fatty acids, hyperinsulinaemia, insulin resistance, hypertension, and dyslipidaemia. This impacts on CVD risk factors and hence on risk.

Excess central (visceral abdominal) fat in particular has been shown to be strongly associated with metabolic and cardiovascular risk. This has led to increased interest in anthropometric measures of risk. Most data are available for BMI, waist–hip circumference ratio (WHR), and, more recently, simple waist circumference (WC). Such measures of risk are cheap and universally available. WC, while simple, may be more prone to measurement error than BMI.

BMI has been extensively used to define the groups of body weight [kg]/height $[m]^2$ using classifications suggested by WHO. In adults, overweight is defined by an increased BMI ranging from 25 to 29.9 kg/m^2 and obesity by BMI $\geq$ 30 kg/m^2. Increasing BMI is highly associated with CVD. The association between both increasing WC and WHR and greater risk of development of CVD has been demonstrated and it has been shown that the measurement of WC in addition to BMI gives additional information for CVD risk estimation.

Within BMI categories the finding of elevated WC indicates a greater probability of the presence of risk factors and CHD mortality. The added predictive ability has been shown to be more marked in women and in younger age groups.

Weight reduction is an important first step to control risk factors for CVD and weight loss is the major target in primary prevention. The control of overweight is dependent upon achieving the appropriate balance between energy intake and expenditure. Behaviour modification inducing long-term lifestyle change leading to a gradual weight loss is the basis of the obesity control.

Diabetes Epidemiological studies demonstrate a linear association between increasing glucose levels and the risk of developing CHD as well as other atherosclerotic diseases. This is true for diabetes as well as for individuals with impaired glucose tolerance. Diabetes not only substantially increases the risk of CVD but also magnifies the effect of other risk factors for CVD such as raised cholesterol levels, raised blood pressure, smoking and obesity.

The incidence and prevalence of type 2 diabetes increases by age, but the condition is heavily associated with obesity and lack of physical activity. An important underlying mechanism leading to type 2 diabetes is insulin resistance, which again is associated with a long list of cardiovascular risk factors including hypertension, dyslipidaemia, endothelial dysfunction and microalbuminuria. This clustering of risk factors partly explains the increased risk of CVD associated with diabetes and glucose intolerance. The relative impact of type 2 diabetes on the CVD risk is much stronger in women than in men.

It is important to emphasize that the conventional, modifiable major cardiovascular risk factors (elevated BP, elevated LDL cholesterol, and smoking) show in diabetic patients similar relationship with the risk of CVD as in nondiabetic persons. Because diabetes itself increases the absolute risk of CVD, the additional impact of conventional risk factors leads to a more dramatic increase in absolute risk than in nondiabetic persons and thus the modification of these risk factors offers a great potential for prevention. Consequently, individualized global risk assessment and individualized prevention strategies are even more important in individuals with diabetes than in nondiabetic individuals.

With the exception of glucose management, prevention of CVD follows the same general principles as for people without diabetes. A multifactorial approach to treatment and achieving low BP (< 130/<80 mmHg), low total cholesterol level (< 4.5 mmol/l), and low LDL cholesterol (< 2.5 mmol/l) are particularly important. Weight loss, physical activity increasing and low fat diet are the most important concerns from lifestyle factors.

Metabolic syndrome In most people with glucose intolerance or type 2 diabetes, there is a multiple set of risk factors that commonly appear together, forming what is now known as the metabolic syndrome. This „clustering" of metabolic abnormalities that occur in the same individual appear to confer a substantial additional cardiovascular risk over and above the sum of the risk associated with each abnormality. The more components of the metabolic syndrome that are evident, the higher is the cardiovascular mortality rate.

The combination of factors that tend to cluster together are the follows: central obesity, hypertension, low HDL cholesterol, raised triglycerides an raised blood sugar (Table 9.3). This implies that, one component is identified, a systematic search for the others is indicated, together with an active approach to managing all of these risk factors. Lifestyle has a strong influence on all the components of the metabolic syndrome and, therefore, the main emphasis should be in professionally supervised lifestyle changes, particularly efforts to reduce body weight and increase physical activity. Elevated BP, dyslipidaemia, and hyperglycaemia may, however, need additional drug treatment.

Physical inactivity is a growing public health problem and will have a major impact on the prevalence of CVD in the coming decades as a lack of physical activity is apparent in the young generation in several European countries: children have become less physically active and only in a few countries do children have access to the recommended daily dose of physical activity. More than half of adolescents become physically inactive after leaving school. Adults face a significant decrease in physical demands at their place of work and,

during leisure time, fewer people are physically active. Prospective epidemiological studies have shown that a sedentary lifestyle is associated with a doubling of the risk of premature death and with an increasing risk of CVD.

Table 9.3 Definition of the metabolic syndrome according to NCEP-ATP III[1] (2001) and IDF[2] (2005)

Risk factors:	**Defined levels:**
Central obesity men women	waist circumference IDF (2005): ATP III (2001): > 94 cm > 102 cm > 80 cm > 88 cm
Elevated triglycerides	≥ 1.7 mmol/l
Low HDL cholesterol men women	< 1.0 mmol/l < 1.3 mmol/l
Raised BP	systolic BP ≥ 130 mmHg diastolic BP ≥ 85 mmHg (or treatment of hypertension)
Impaired fasting glycaemia	> 5.6 mmol/l (or previously diagnosed type 2 diabetes)

[1] National Cholesterol Education Program – Adult Treatment Panel III – at least three of the five further components occurrence
[2] International Diabetic Federation – central obesity and any two of four further components occurrence

Physical fitness has both a direct protective effect on the development of vascular lesions and an indirect effect through influencing other risk factors: lowering plasma LDL cholesterol and triglycerides, increasing plasma HDL cholesterol and insulin activity, reducing body fat and lowering blood pressure. A lack of physical fitness will have a reverse effect. Thus, the promotion of regular physical activity is an important target for preventive cardiology as it may effectively improve the future course of CVD. Avoiding a sedentary lifestyle during adulthood may even substantially extend the total life expectancy and the CVD-free life expectancy for women as well as for men (by 1.3 – 3.5 years).

It is recommended to have 30 minutes of moderately vigorous exercise on most days of the week to reduce risk and increase fitness. A heart rate during peak exercise of 60 – 75 % of the average maximum heart rate is preferred.

Heart rate Elevated heart rate has been shown to be associated with increased risk of all-cause mortality, CVD mortality, and development of CVD in the general population. However, no trial has investigated the effect of lowering heart rate on prognosis in asymptomatic people. In the general population, avoidance of elevated heart rate through lifestyle measures can be recommended. These included regular physical activity, avoidance of psychological stress, and excessive use of stimulants such as caffeine.

Inflammation markers and haemostatic factors There is strong evidence from pathological and epidemiological studies that the circulating markers of activated inflammation and haemostasis are closely associated with the development of fatal and nonfatal myocardial infarction. A recent report from Europe (MONICA study) has shown that

population levels of certain haemostatic factors differed between participating countries, and has shown significant associations with the incidence of coronary heart disease in the countries. Some studies have demonstrated that risk prediction for CHD and stroke can be improved by the addition of these newer risk factors to risk model which include all established risk factors. C-reactive protein (CRP) should be as an “option” in current guidelines but this proposal has been questioned. Incorporation of CRP and other emerging risk factors into routine practice for prediction of cardiovascular risk may be premature.

Psychosocial factors There is increasing evidence that psychosocial factors contribute independently to the risk of CHD. Analyses of the WHO MONICA data suggested that classical risk factors could explain only a part of the temporal changes and differences between populations. Similarly, studies within populations, both in the east and the west of Europe, showed that only part of the socio-economic differentials in CVD risk was explained by standard risk factors.

The following psychosocial risk factors have been shown to influence both the risk of contracting CHD and the worsening of clinical course and prognosis in patients with CHD:

- Low socio-economic status (SES) – people with low SES (low education, holding a low status job, living in a poor residential area) have an increased all-cause as well as CHD mortality risk, which is only in part mediated by traditional risk factors.
- Social isolation and lack of social support – people isolated or disconnected from others are at increased risk of dying prematurely from CHD. Social support has a beneficial effect on lifestyle and health behaviour.
- Stress at work and in family life – stress at work, prolonged exposure to work at irregular hours, as well as conflicts, crises and long-term stressful conditions in family life, increase CHD risk.
- Negative emotions including depression and hostility – clinical depression, depressive symptoms and other negative emotions have been shown to predict incident CHD, and worse its prognosis, independently of standard risk factors.

It is now evident that psychosocial risk factors do not occur in isolation from one another, but tend to cluster in the same individuals and groups. Evidence is also accumulating of therapeutic and preventive intervention methods that counteract psychosocial stress and promote healthy behaviours and lifestyle. Stress management programs have repeatedly been shown to improve not only subjective well-being but also risk factor levels and CVD outcomes.

9.1.2 Total cardiovascular risk estimation

Total risk estimation means the likelihood of a person developing an atherosclerotic cardiovascular event over a defined period of time. Cardiovascular risk is a continuum and usually reflects the combined effects of several risk factors that may interact, sometimes multiplicatively (Table 9.4, Figure 9.3). The overall objectives of cardiovascular prevention

are to reduce mortality and morbidity in those at high absolute risk and to assist those at low absolute risk to maintain this state, through a healthy lifestyle.

Table 9.4 Impact of combination of risk factors on total cardiovascular risk according to SCORE project

Risk factors	Age [years]	Sex	Cholesterol [mmol/l]	Systolic BP [mmHg]	Smoking	Risk [%]
Sex	60	F	5	120	-	1
	60	M	5	120	-	3
Sex + smoking	60	F	5	120	+	3
	60	M	5	120	+	7
Sex + smoking + high systolic BP	60	F	5	180	+	9
	60	M	5	180	+	21
Sex + smoking + high systolic BP + high cholesterol level	60	F	8	180	+	13
	60	M	8	180	+	33

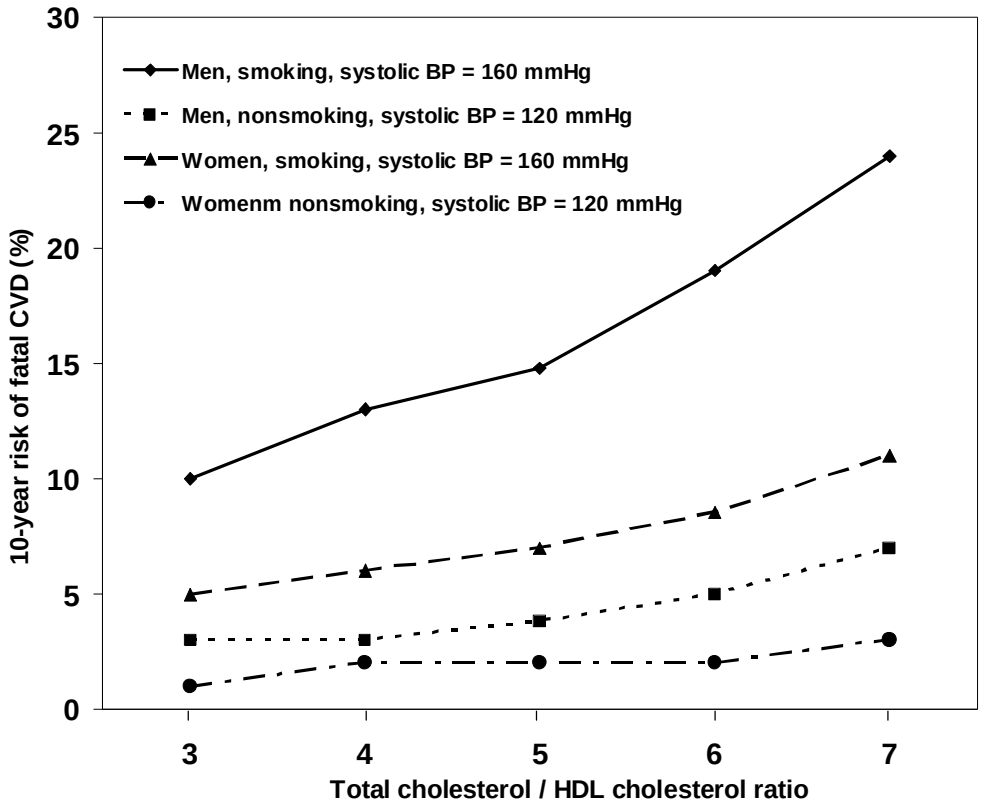

Figure 9.3 The relationship of total cholesterol : HDL cholesterol ratio to 10-year fatal CVD events in men and women aged 60 years with and without risk factors, based on a risk function derived from the SCORE project (Source: Graham et al, 2007)

The most widely used method to assess CVD risk is based on equations derived from the Framingham study in the USA. The risk factors included in the Framingham calculation are age, total cholesterol, HDL cholesterol, systolic BP, treatment for hypertension, and cigarette smoking. The total risk score sums the points for each risk factor. The 10-year risk for

myocardial infarction an coronary death is estimated from total points, and the person is categorized according to absolute 10-year risk (high risk category > 20 %; moderate risk 10 - 20 %, and low risk < 10 % or 0 – 1 risk factor presented).

However, there is conflicting evidence as to whether the Framingham calculation estimates CVD risk accurately in European populations. There were several problems with this chart. First, it was derived from American data and the applicability of the chart to all European populations was uncertain. Secondly, the data set used was fairly small.

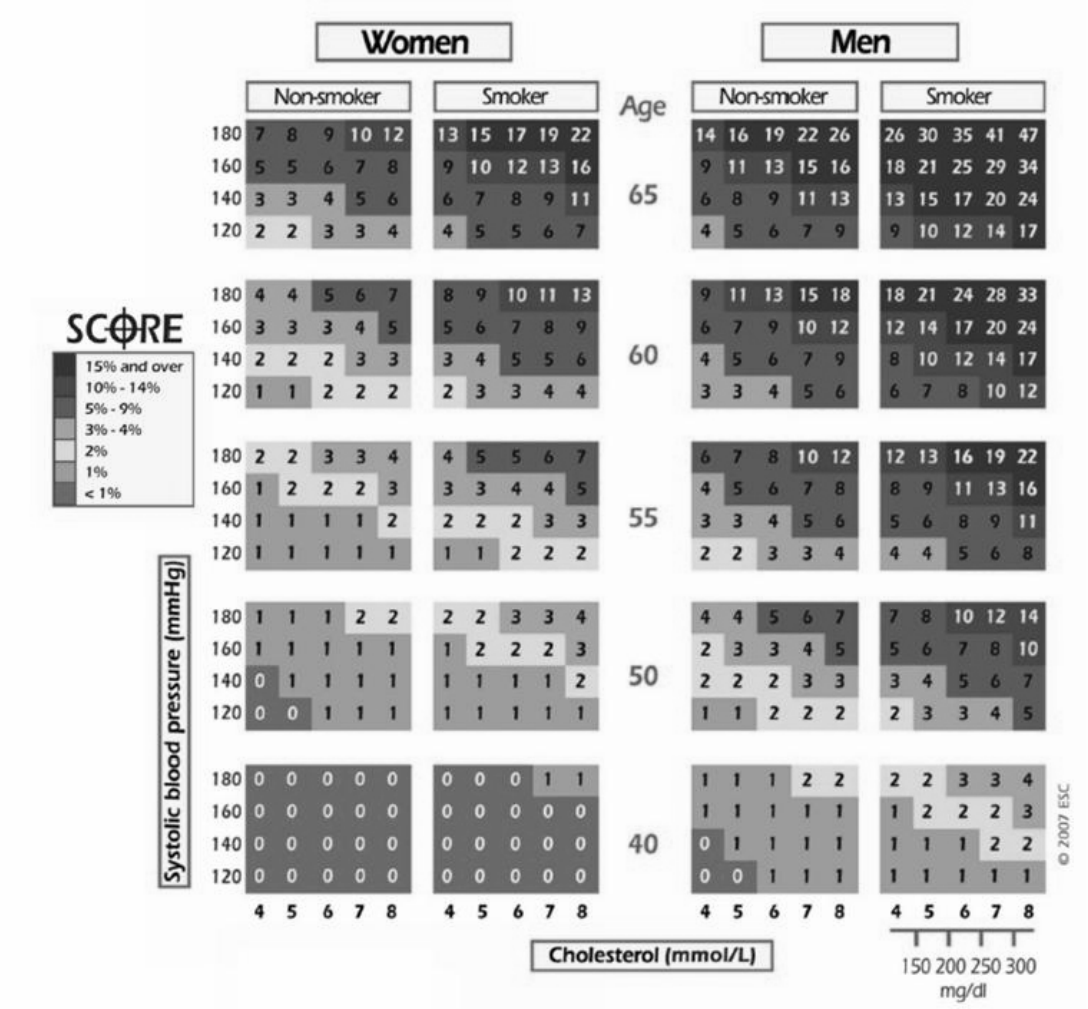

Figure 9.4 SCORE chart: 10-year risk of fatal CVD in populations at high CVD risk (ESC, 2007)

The Framingham system does not include information on family history, triglycerides or LDL cholesterol. However, another risk-scoring programme based on the Prospective Cardiovascular Münster (PROCAM) Study in Germany includes these variables. PROCAM estimates the probability of coronary death or first myocardial infarction (hard endpoints) within the next 10 years. Some studies also found that both the PROCAM and Framingham calculations overestimate risk in various European subjects (e.g. German, French, Italian, Irish and British).

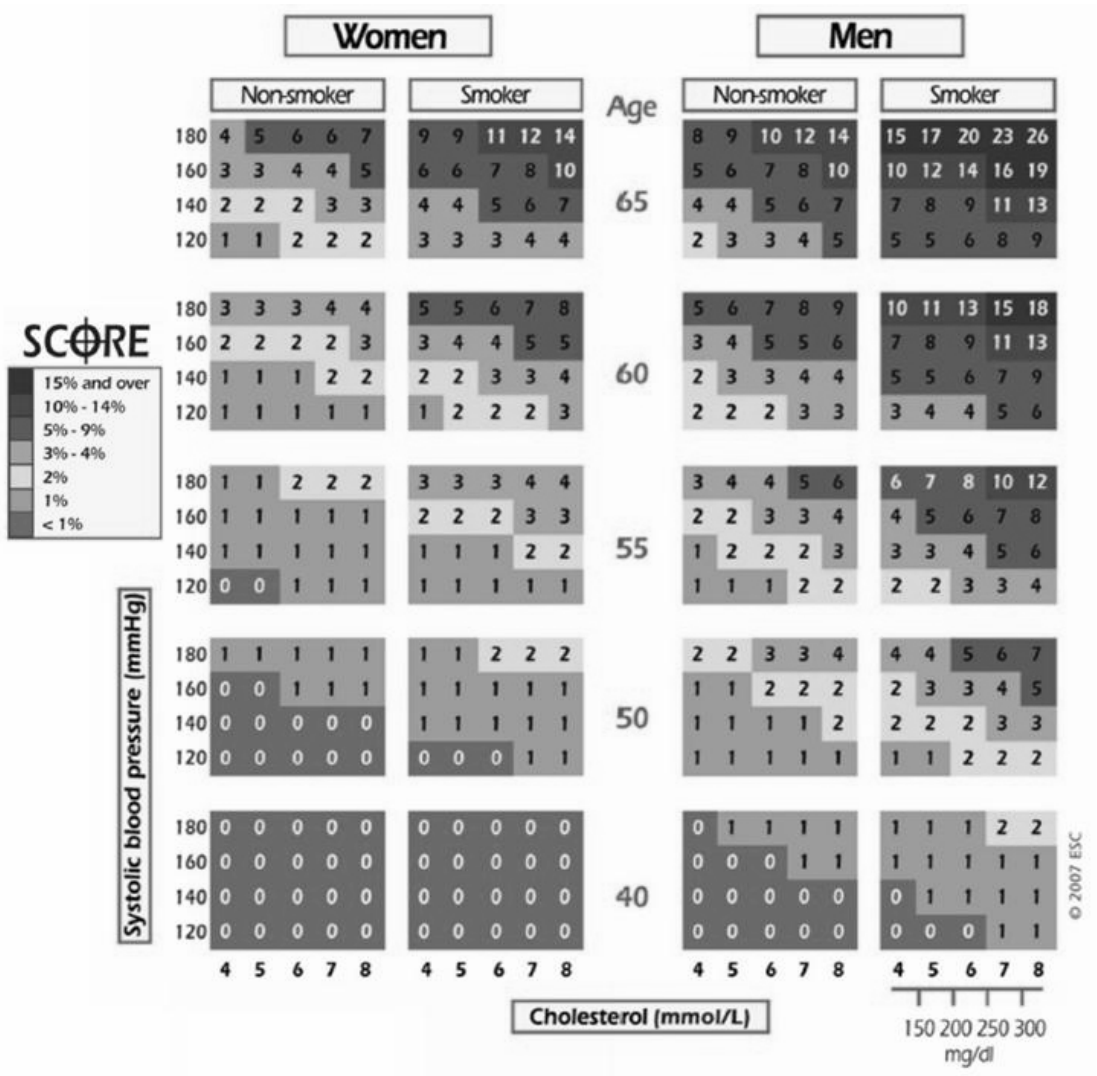

Figure 9.5 SCORE chart: 10-year risk of fatal CVD in populations at low CVD risk (Belgium, France, Greece, Italy, Luxembourg, Spain, Switzerland, Portugal) (ESC, 2007)

The need to assess total risk easily and quickly led to the development of the risk chart used in Europe. Now it is used a new system for risk estimation called SCORE (**S**ystematic **Co**ronary **R**isk **E**valuation), based on data from 12 European cohort studies, and includes 205, 178 subjects examined at baseline between 1970 and 1988, and allowed the estimation of 10-year risk of cardiovascular death. SCORE charts are based on the following risk factors: age, gender, smoking, systolic blood pressure, and total cholesterol (or total cholesterol : HDL cholesterol ratio). Separate charts were produced for high and low risk regions of Europe (Figure 9.4, 9.5). The low risk charts should be recommended for use in Belgium, France, Greece, Italy, Luxembourg, Spain, Switzerland and Portugal and also in countries which have recently experienced a substantial lowering of the CV mortality rates. The relative risk chart in (Figure 9.6) is useful in explaining to a younger person that, even if their absolute risk is low, it may still be 10–12 times higher than that of a person of a similar age with low risk

factors. This may help to motivate decisions about avoidance of smoking, healthy nutrition and exercise, as well as flagging those who may become candidates for medication.

Figure 9.6 Relative Risk Chart (SCORE) for younger people at low absolute risk (ESC, 2007)

All risk estimation systems, including SCORE, will overestimate risk in countries that have experienced a decline in CVD mortality, and underestimate risk if mortality has increased. Therefore the development of national guidance and recalibration of the SCORE charts to allow for time trends in both mortality and risk factor distributions in individual countries is recommended.

SCORE risk charts are intended to facilitate risk estimation in ostensibly healthy persons. In general, a middle aged person with a 10-year risk of CVD death of 5 % or more is regarded as at high risk and they are qualifying for intensive advice. Patients who have had a clinical event such as an acute coronary syndrome or stroke, who have type 2 diabetes or type 1 diabetes with microalbuminuria, or who have a markedly increased level of a single risk factor have already declared themselves to be at markedly increased risk and automatically qualify for intensive risk factor evaluation and management. Low risk persons should be offered advice to maintain their low risk status.

The Luxembourg Declaration (2005) defined the characteristics that are necessary to achieve cardiovascular health:

− Avoidance of tobacco,
− Adequate physical activity (at least 30 min per day),
− Healthy food choices,
− Avoiding overweight,
− BP below 140/90 mmHg,
− Total cholesterol below 5 mmol/l.

9.1.3 Nutrition in cardiovascular prevention

Diet plays an important role in the primary and secondary prevention of CVD and the role of nutrition in the etiology and prevention of atherosclerosis and cardiovascular diseases has been extensively investigated. Epidemiologic studies have led to the identification of key dietary components that are etiologic factors in the pathogenesis of CHD. Of the dietary components examined, both total and saturated fat, as well as cholesterol, have shown the most consistent significant associations with CHD mortality. Dietary intervention trials with cardiovascular end points have evaluated the effects of reducing fat.

Fatty acids regulate cholesterol homeostasis and concentrations of blood lipoprotein, and affect the levels of other cardiovascular risk factors, such as BP, haemostasis, and body weight, through various mechanisms.

Food lipids are made up of 3 major classes of fatty acids (FA): saturated (SAFA), monounsaturated (MUFA) and polyunsaturated (PUFA). This classification is based on the number of double bonds between carbon atoms.

The sources of SAFAs in human diet are mainly derived from animal products (i.e. meat and dairy products, butter and lard, coconut and palm oil, some cooking fats and a large number of processed foods).

PUFAs belong to two major groups having different chemical compositions: n-6 and n-3. Linoleic acid is the main representative of the n-6 group (originate from vegetable oils). α-linolenic acid (ALA) is the precursor in the n-3 group and is an essential fatty acid; the main food sources are certain vegetable oils (soybean, safflower and linseed oils). Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are two significant representatives of the n-3 group; these are mainly derived from fish and special n-3 rich vegetable oils (rapeseed, canola, soybean).

There are strong, consistent, and graded relationship between saturated fat intake, blood cholesterol levels, and the mass occurrence of CVD. Reducing SAFAs intakes result in lower LDL cholesterol level. N-3 PUFAs, in contrast, showed protective effects. There is much evidence suggesting that consumption of EPA and DHA are beneficial for triglycerides, blood pressure, haemostatic balance and heart rhythm.

Trans fatty acids – TFAs (isomers of MUFAs or PUFAs) increase LDL cholesterol concentration and, to a lesser extent, they reduce plasma HDL cholesterol concentrations. Prospective epidemiological studies have found associations between the intake of TFAs and cardiovascular morbidity and mortality. Trans FAs are found in animal based foods (dairy and beef fat typically contains around 3 – 6 % TFAs). The TFA content of bakery products as well as some breakfast cereals with added fat, French fries, soup powders and some sweet, snacks products and hard margarine may vary considerably from below 1 % up to 30 %.

Dietary **cholesterol** intake appears to have relatively little effect on serum lipids. Reduction of 100 mg dietary cholesterol per day appears to reduce total serum cholesterol by only 1 % (0.06 to 0.07 mmol/l).

Fruit and vegetables are significant sources of minerals, vitamins and fibres, and there is a negative correlation between the consumption of fruits and vegetables and the occurrence of coronary events or stroke. Fruits and vegetables are also the most important sources of potassium. It is recommended to increase the consumption of fruit and vegetables to at least five portions a day.

Plant sterols, flavonoids, and sulfur-containing compounds represent three classes of compounds found in fruits and vegetables that may be important in reducing risk of atherosclerosis.

Plant sterols are naturally occurring constituents of plants that differ from cholesterol only in the structure of their side chain (sitosterol, campesterol); they reduce cholesterol absorption (by 30 – 50 %).

Flavonoid intake has been inversely associated with coronary heart disease. They are present in fruits, vegetables, nuts, and seeds. The major flavonoid categories are flavonols, flavones, catechins, flavanones, and anthocyanins. The main dietary sources of these compounds are tea, onions, soy, and wine. The link between flavonoids and atherosclerosis is based partly on the evidence that some flavonoids possess antioxidant properties and have been shown to be potent inhibitors of LDL oxidation in vitro. For example, the phenolic substances in red wine inhibit oxidation of human LDL. Flavonoids have also been shown to inhibit platelet aggregation and adhesion, which may be another way they lower the risk of heart disease. Isoflavones in soy foods have been reported to lower plasma cholesterol and also to have estrogenlike effects.

Naturally occurring **sulfur-containing compounds** (the allium family) may influence plasma cholesterol and atherosclerosis. These substances are found especially in garlic, onions, and leeks, the most prominent of these being garlic.

Whole grain consumption at least three servings per day could cause a CVD risk reduction of about 25 – 30 %.

Sodium intake increases blood pressure and therefore the risk of arterial hypertension, stroke, CHD and heart failure. In societies with low salt intake there is no age-related increase in blood pressure. On the other hand, the high **potassium** intake is associated with reduced blood pressure.

Alcohol is not an essential nutrient. Alcohol consumption is linked with an increase of haemorrhagic cerebrovascular accidents and, to a lesser extent, ischaemic stroke which depends on the dose. It has been consistently demonstrated a direct, dose-dependent relationship between alcohol intake and blood pressure. There is no reliable proof showing any higher cardiovascular benefit of any drink, compared with another. Besides, alcohol is a major source of calories and reduction may be an important part of weight control.

9.1.3.1 Dietary pattern in cardiovascular prevention

Diet modification can clearly decrease CVD risk, especially when the food supply is altered. It is recommend decreasing saturated fat and total fat, decreasing dietary cholesterol, sugar intake, increasing PUFAs intake, minimizing trans FAs intake, and increasing the intake of vegetables, fruit, and whole grains.

Although the vast majority of research studies have focused on individual nutrients and foods, it is well recognized that multiple dietary factors influence the risk of developing CVD and its major risk factors. To a much lesser extent, research has examined the health effects of the whole diet. These data have documented that healthy dietary patterns are associated with a substantially reduced risk of CVD, CVD risk factors, and noncardiovascular diseases. An emphasis on whole diet is also appropriate to ensure nutrient adequacy and energy balance. Hence, rather than focusing on a single nutrient or food, individuals should aim to improve their whole or overall diet. In some observation studies, specific dietary patterns have been identified that are associated with increased or decreased incidence of cardiovascular events.

In some studies a dietary pattern characterized by higher intake of vegetables, fruits, legumes, whole grains and fish was inversely associated with the occurrence of coronary heart disease. In contrast, the Western dietary pattern, characterized by a higher intake of processed meat, red meat, butter, high fat dairy products, eggs and refined grains was associated with an increased risk. Several observational cohort studies support the benefit of a Mediterranean diet, characterized by an abundance of plant food, minimally processed foods, fresh fruit and vegetable, olive oil, dairy products, red meat and eggs consumed in moderate amounts, and a moderate consumption of wine.

General recommendations are as follows (see also Table 9.5 and 9.6):

Table 9.5 Nutritional risk factors in CVD prevention

Nutritional factors	**Effects**
Saturated fatty acids	on serum lipids levels and glycaemia
Dietary cholesterol	on serum lipids levels
Trans fatty acids	on serum lipids levels and thrombogenesis
Animal proteins	on homocysteine level
Sugar (sucrose)	on serum lipids levels and glycaemia
Salt (sodium)	increases blood pressure
Alcohol (in high dose, > 30g pure ethanol/day)	on serum lipids levels and glycaemia, increases blood pressure
High energy intake, low daily meals frequency	obesity on serum lipids levels and glycaemia

- Eating food from each major food group will ensure the appropriate supply of basic nutrients, minerals and vitamins.
- Reducing total fat intake to < 30 % of energy, of which less than 1/3 is saturated.

- The intake of fish, fruit and vegetables, cereals and whole grain products, low fat dairy products, low salt and lean meat is encouraged.
- Energy intake should be adjusted to maintain ideal weight.
- Eating oily fish may be associated with a reduction in risk of fatal cardiovascular accidents.
- Replacement of SAFA and trans-FAs with MUFAs or PUFAs of vegetable origins decreases LDL cholesterol.
- Eating fruit and vegetables and restricting salt (by avoiding table salt, salt in cooking, and by choosing fresh or frozen unsalted foods) is associated with lower BP.

Table 9.6 Protective nutritional factors in CVD prevention

Nutritional factors	**Effects**
Monounsaturated (n-9) and polyunsaturated (n-6, n-3) fatty acids	on serum lipids levels and thrombogenesis, antihypertensive
Plant sterols (sitosterol, campesterol) Plant lecithins (phospholipids)	on serum lipids levels
Fiber (in particular soluble)	on serum lipids levels and glycaemia
Vitamins C, E, A	antioxidant
Folic acid, vitamins B_6, B_{12}	on homocysteine level
Magnesium, potassium, calcium	antihypertensive
Selenium, copper, manganese, chrome	antioxidant
Phytochemicals (allium compounds, polyphenols, carotenoids, some fungi substances etc.)	antioxidant, antithrombotic
Low energy intake, higher daily meals frequency	obesity prevention on serum lipids levels and thrombogenesis

9.2 CANCER PREVENTION

Cancer, or malignant tumors, is a term for diseases in which abnormal cells divide without control and can invade nearby tissues and can also spread to other parts of the body through the blood and lymph systems. Cancer is not a single disease but a group of related diseases. Many things in genes, lifestyle, and the environment may increase or decrease risk of getting cancer.

In Western Europe, cancer mortality started to decline in the 1990s (Figure 9.7), but the total number of new cases of cancer in Europe appears to have increased (Figure 9.8). The most common form of cancers in EU is breast cancer, followed by colorectal cancers and lung cancer. Lung cancer is the most common cause of death from cancer, followed by colorectal, breast and stomach cancers. Cancer death percentage of total cancer deaths in EU in men and women is in Figure 9.9. There are great differences in standardized death rate of all malignant neoplasms among European countries (Figure 9.10). Cancer remains an important public

health problem in Europe and the ageing of the European population will cause these numbers to continue to increase even if age-specific rates remain constant.

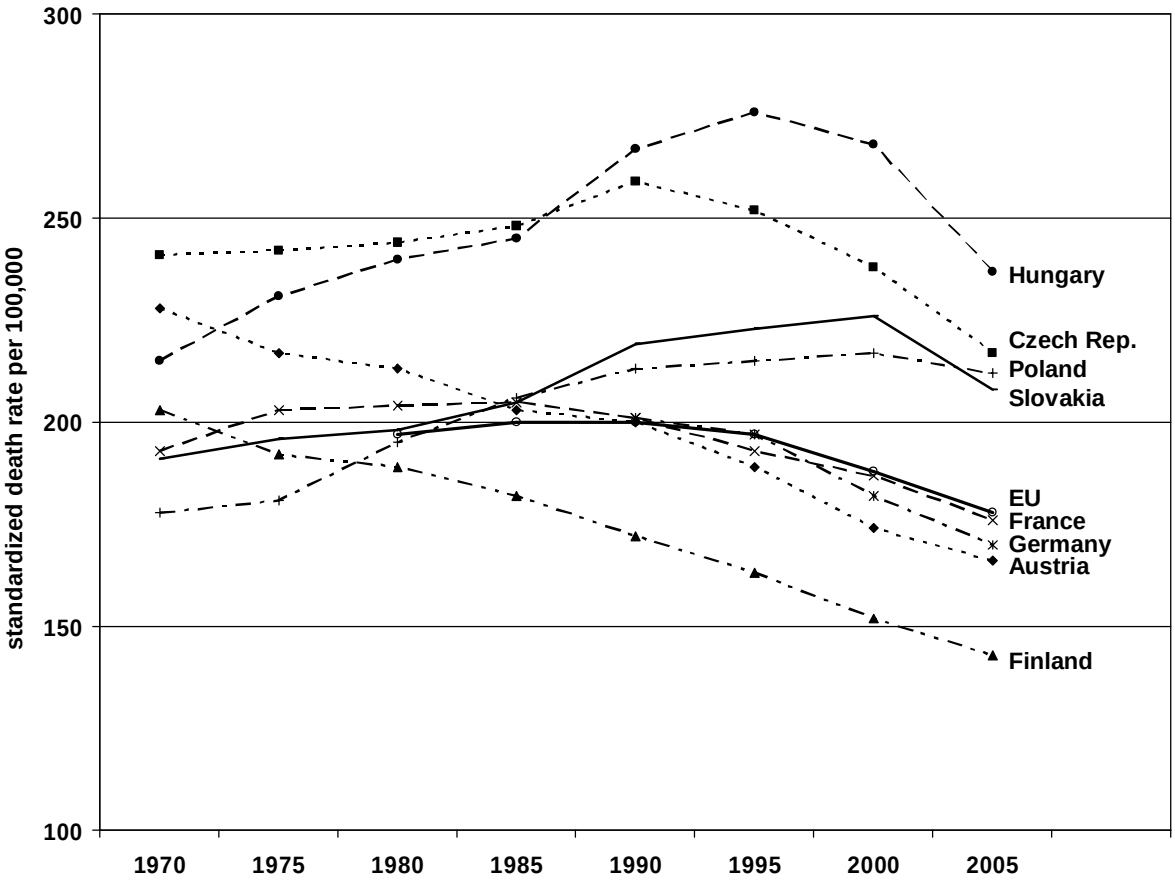

Figure 9.7 Trends of standardized death rates of all malignant neoplasms per 100,000, all ages, in selected European countries during the years of 1970 – 2005 (Source: WHO, 2010)

The single most important risk factor for cancer is smoking, which is responsible for about a third of all cancers in the European region. Lung cancer mortality among women in the eastern part of the region is lower than elsewhere, because of less exposure to tobacco smoking in the past. Diet, especially lack of fruit and vegetables and high saturated fat intake, is an important risk factor for certain types of cancer. Other risk factors include infectious agents (e.g. human papillomavirus for cervical cancer), hazardous industrial chemicals and occupational factors.

At least one-third of all cancer cases are preventable. Prevention offers the most cost-effective long-term strategy for the control of cancer. By preventing cancer, the number of new cases of cancer in a group or population is lowered.

Primary prevention is focused on risk factors prevalence lowering and/or risk factors impact restriction. Secondary prevention means looking for high risk persons or for individuals in initial stage of malignant disease, by using reliable biomarkers. The biomarkers have to be extremely sensitive, high correlating with disease, and identifiable in initial, reversible stage of disease.

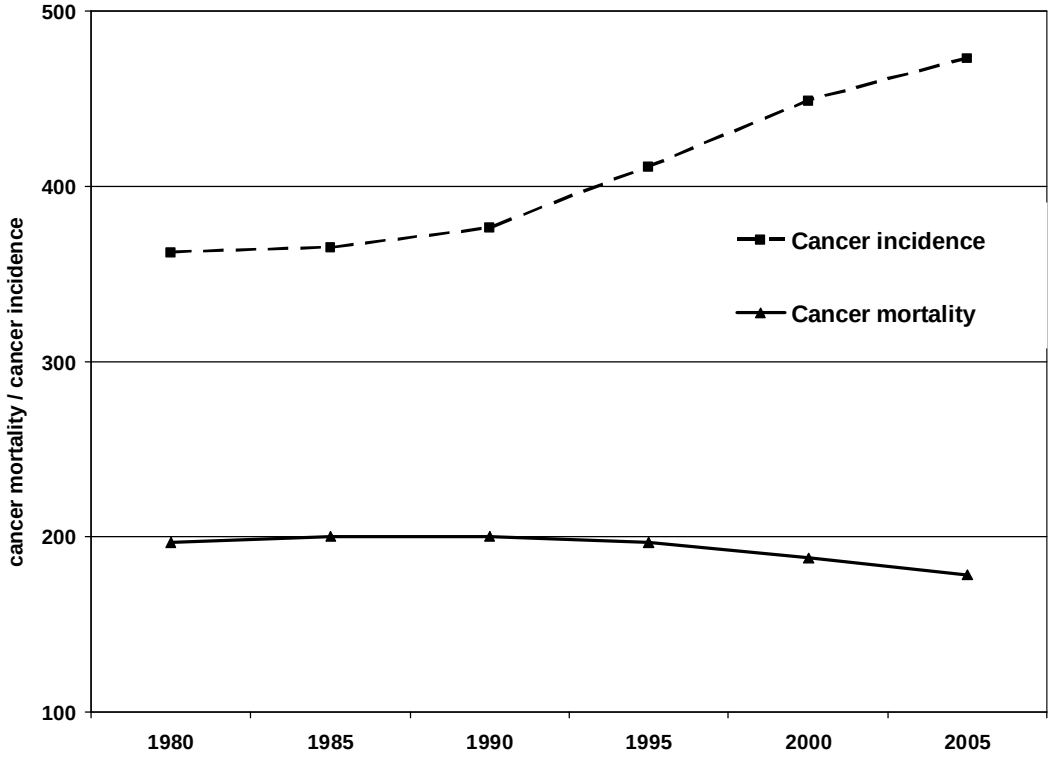

Figure 9.8 Cancer incidence and cancer mortality per 100,000 in EU during the years of 1980 – 2005 (Source: WHO, 2010)

9.2.1 Cancer risk factors

Cancer is a group of more than 100 different diseases, each with their own set of risk factors. Environmental and/or lifestyle factors have the crucial role among preventable risk factors in cancer etiology (i.e. smoking, nutrition, occupational exposure, radiation, alcohol consumption, sexual behaviour, environment quality, infections, etc.); genetic proportion in cancer development is relatively low – around 5 %.

The risk of developing cancer increases with age, gender, race and personal and family medical history. Certain types of cancer do occur more often in some families than in the rest of the population. For example, melanoma and cancers of the breast, ovary, prostate, and colon sometimes run in families. Several cases of the same cancer type in a family may be linked to inherited gene changes, which may increase the chance of developing cancers.

1. Smoking. Tobacco is the single largest preventable cause of cancer in the world today; tobacco use is strongly linked to an increased risk for many kinds of cancer. Using tobacco products or regularly being around tobacco smoke (environmental or secondhand smoke) increases the risk of cancer. It causes 80 – 90 % of all lung cancer deaths, and about 30 – 40 % of all cancer deaths in developing countries, including deaths from cancer of the oral cavity, larynx, oesophagus and stomach. People who use smokeless tobacco (snuff or chewing tobacco) are at increased risk of cancer of the mouth.

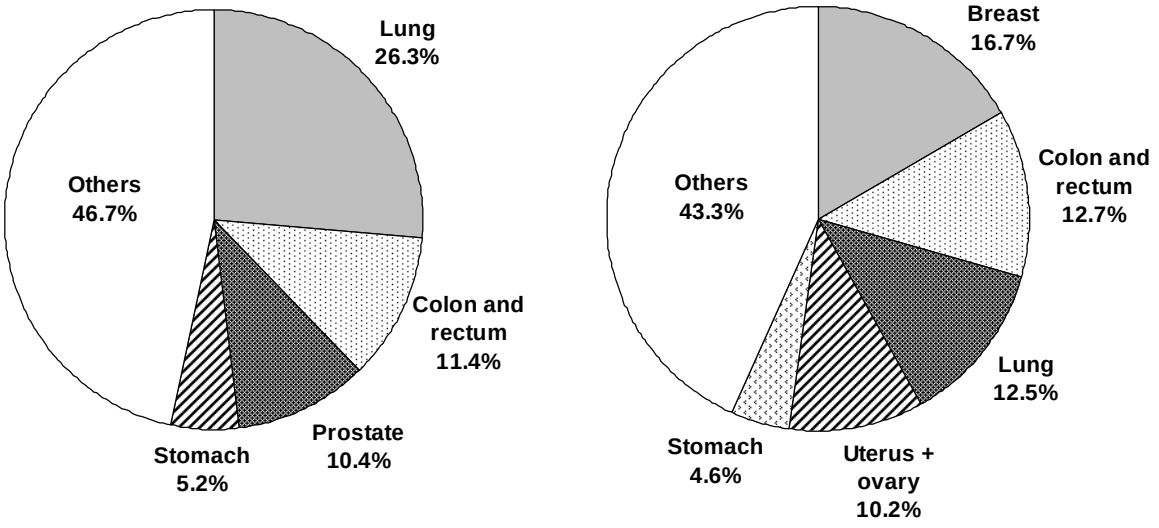

Figure 9.9 Cancer deaths percentage of total cancer deaths in men and women in EU, 2006 (Source: Ferlay et al, 2007)

Not smoking or quitting smoking lowers the risk of getting cancer and dying from cancer. Quitting is important for anyone who uses tobacco – even people who have used it for many years. The risk of cancer for people who quit is lower than the risk for people who continue to use tobacco. (But the risk of cancer is generally lowest among those who never used tobacco.)

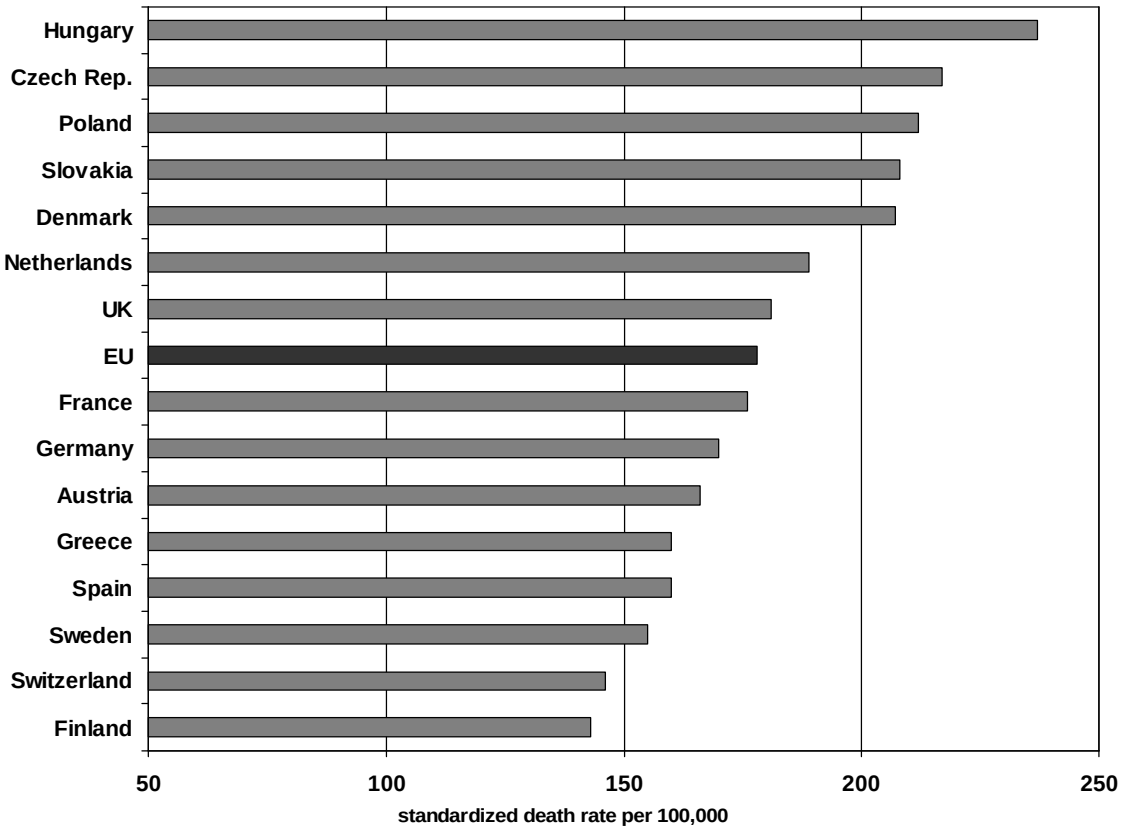

Figure 9.10 Comparison of standardized death rate of all malignant neoplasms per 100,000, all ages, in selected European countries in 2005 (WHO, 2010)

2. Nutrition. Dietary modification is another important approach to cancer control and the diet impact is estimated on 25 – 35 %. There is a link between overweight and obesity to many types of cancer such as oesophagus, colorectum, breast, endometrium and kidney. Regular physical activity and the maintenance of a healthy body weight, along with a healthy diet high in fruits, vegetables and whole grain cereals (as the important sources of vitamins, minerals and some phytochemicals) may have a protective effect against many cancers. Conversely, excess consumption of fat, red and preserved meat may be associated with an increased risk of colorectal cancer. In addition, healthy eating habits that prevent the development of diet-associated cancers will also lower the risk of cardiovascular disease.

3. Alcohol. Studies have shown that drinking alcohol is linked to an increased risk of the several types of cancers. Having more than two drinks each day for many years may increase the chance of developing cancers of the mouth, throat, esophagus, larynx, liver, and breast. The risk increases with the amount of alcohol that a person drinks. For most of these cancers, the risk is higher for a drinker who uses tobacco.

4. Occupational exposure. Approximately 4 – 8 % of malignant tumors are caused by occupational risk factors. People who have certain jobs (such as painters, construction workers, and those in the chemical industry) have an increased risk of cancer. Many studies have shown that exposure to asbestos, benzene, benzidine, cadmium, nickel, polychlorinated biphenyls, vinyl chloride and many others, in the workplace can cause cancer. Asbestos can cause lung cancer; aniline dyes have been linked to bladder cancer; and benzene can lead to leukemia. The prevention of certain occupational and environmental exposure to these and other chemicals is another important element in preventing cancer. The risk of cancer is multiplied by the combination of occupational exposure and smoking.

5. Radiation. Being exposed to radiation is a known cause of cancer. There are two main types of radiation linked with an increased risk for cancer:

- Ultraviolet radiation – comes from the sun, sunlamps, and tanning booths. It causes early aging of the skin and skin damage that can lead to skin cancer. This is the main cause of melanoma and nonmelanoma skin cancers. Avoiding excessive exposure, use of sunscreen and protective clothing are effective preventive measures.
- Ionizing radiation can cause cell damage that leads to cancer. This kind of radiation comes from rays that enter the Earth's atmosphere from outer space, radioactive fallout, radon gas, x-rays, and other sources. Radioactive fallout can come from accidents at nuclear power plants or from the production, testing, or use of atomic weapons. People exposed to fallout may have an increased risk of cancer, especially leukemia and cancers of the thyroid, breast, lung, and stomach.

Radon is a radioactive gas; it forms in soil and rocks. People who work in mines may be exposed to radon. In some regions, radon is found in houses. People exposed to radon are at increased risk of lung cancer.

6. Infections. Certain viruses and bacteria are able to cause cancer. Infectious agents are responsible for almost 22 % of cancer deaths in the developing world and 6 % in industrialized countries. Examples of cancer-causing viruses and bacteria include:

- Human papillomavirus (HPV) increases the risk for cancers of the cervix, penis, vagina, anus, and oropharynx.
- Hepatitis B and hepatitis C viruses increase the risk for liver cancer.
- Epstein-Barr virus increases the risk for Burkitt lymphoma.
- Helicobacter pylori increases the risk for gastric cancer.
- Human T-cell leukemia/lymphoma virus (HTLV-1) increases a person's risk of lymphoma and leukemia.
- Human immunodeficiency virus (HIV) – people with HIV infection are at greater risk of cancer, such as lymphoma and a rare cancer called Kaposi's sarcoma.
- In some countries the parasitic infection schistosomiasis increases the risk of bladder cancer.

Preventive measures include vaccination and prevention of infection and infestation. Two vaccines to prevent infection by cancer-causing agents have already been developed and approved. One is a vaccine to prevent infection with hepatitis B virus, the other protects against infection with strains of human papillomavirus (HPV).

7. The effect of **environmental contamination** in cancer etiology is not positively explicit yet. They could be air pollutants, food additives, drinking water quality, some carcinogens in cosmetics and in building materials, agrochemicals and detergents using etc.

9.2.2 The most frequent types of cancers

Lung cancer is the most frequent malignant disease and the most common death cause in men of all cancer deaths. Tobacco smoking is responsible for nearly 90 % of all lung cancers. Other contributing risk factors are smoking cigars or pipes, environmental tobacco smoke (second-hand smoke), and occupational exposures of physical and chemical factors. High doses of ionizing radiation, residential radon exposure and occupational exposure to mustard gas, chloromethyl ethers, inorganic arsenic, chromium, nickel, vinyl chloride, radon, asbestos or byproducts of fossil fuel are also thought to increase risk. Possible risk factors are air pollution and insufficient consumption of fruits and vegetables, and the diet rich on animal fat and alcohol. The most important preventive approach is lifelong abstinence of all tobacco products.

Colorectal cancer incidence increases both in men and women. Risk factors are personal or family history of colorectal polyps or inflammatory bowel disease, certain rare hereditary conditions, and a diet high in fat and/or low in fiber, fruits and vegetables. Possible risk factors are physical inactivity, alcohol consumption, obesity, and smoking. Risk may be reduced by estrogen replacement therapy, non-steroidal anti-inflammatory drugs (e.g. aspirin,

ibuprofen), dietary calcium and vitamin D. In secondary prevention regular screening examinations can be carried out in high risk individuals (bowel examination for bleeding symptoms).

Stomach cancer incidence and mortality have gradually decreased in past decades in the developed countries. Risk factors are dietary nitrites (in pickled, salted, and smoked foods), pernicious anemia, and diet low in fruits, vegetables and whole grain cereals. Possible risk factors are infection with Helicobacter pylori, high doses of ionizing radiation, cigarette smoking, and genetic factors.

Brest cancer is the most frequent death cause of all cancer death in women in Slovakia with increased incidence. The highest prevalence is in 50 – 70 yeas old women. For women, risk factors are family history (especially mother or sister) of breast cancer, personal history of breast, ovarian, or endometrial cancer, some forms of benign breast disease (atypical hyperplasia), higher education and socioeconomic status, menstruation at an early age, late menopause, never bearing children, first child born after age 30, high doses of ionizing radiation, long term use of post-menopause estrogens and progestins, obesity after menopause, excessive alcohol consumption and diet rich in saturated fat and low in fruit, vegetables and fish. Possible risk factors are dietary fat and physical inactivity. For men, risk factors include increasing age, family history, radiation exposure, and having high levels of estrogen due to inherited gene mutations or treatments. Possible risk factors include gynecomastia and obesity.

In women, breast cancer remains the most important cause of cancer mortality throughout the European region, and in western European countries up to one in twelve women will be affected, with incidence rates rising. There are limited opportunities for prevention; however, age-specific screening strategies using X-ray mammography have been successfully introduced in some countries, with a reduction in observed mortality.

Cervix cancer is likely to be related to sexual behaviour. The highest prevalence is in 40 – 55 years old women. Infection with human papilloma viruses (HPV) is considered as causation; other risk factors are early age at first sexual intercourse, many sexual partners or partners who have had many sexual partners, multiple births, long-term oral contraceptive use, and cigarette smoking. Possible risk factors are certain vitamin deficiencies and hormonal factors. Secondary preventive method – cervical swab examination – has been considered as a very important approach in early cancer detection.

Prostate cancer. Risk factors are some types of prostatic hyperplasia and a family history, especially a father or brother. Possible risk factors are a diet high in animal fat, obesity, hormonal factors, a sexually transmitted agent, smoking, alcohol, and physical inactivity. Black males have much higher prostate cancer rates than white males. Specific prostatic antigen detection (PSA) has some importance in early detection of asymptomatic men.

Skin cancer has an increased incidence in last decades. Risk factors are excessive exposure to ultraviolet radiation (sunlight), fair skin, history of severe sunburns, personal or family history of melanoma, multiple moles or atypical moles (colored skin spots), giant

congenital moles, xeroderma pigmentosum (a rare hereditary disease), personal history of melanoma, and reduced immune function due to organ transplants or HIV infection. Melanoma occurs almost exclusively among whites.

9.2.3 General recommendations in cancer prevention

There is no way to prevent most cancers, but the best plan is to avoid risk factors and to make healthy lifestyle choices.

Having a healthy diet, being physically active, and maintaining a healthy weight may help reduce cancer risk.

- Non smoking or smoking cessation and avoiding of second-hand-smoking.
- A healthy diet includes plenty of foods that are high in fiber, vitamins, and minerals. This includes whole-grain breads and cereals and 5 to 9 servings of fruits and vegetables every day. Also, a healthy diet means limiting foods high in fat (such as butter, whole milk, fried foods, and red meat), and smoked, salted and processed foods.
- Cut down on alcohol consumption.
- Physical activity can help control weight and reduce body fat. It is a good idea for adults to have moderate physical activity (such as brisk walking) for at least 30 minutes on 5 or more days each week. Studies show a strong link between physical activity and a lower risk of colorectal cancer. Some studies show that physical activity protects against postmenopausal breast cancer and endometrial cancer.
- Safe sexual behaviour.
- Avoiding physical an chemical carcinogens exposure.
- Vaccination (hepatitis B, HPV).

9.3 DIABETES AND DIABETIC COMPLICATIONS PREVENTION

Diabetes mellitus is a disease defined by abnormalities of fasting or postprandial blood glucose level and frequently is associated with disorders of the eyes, kidneys, nerves, and circulatory system. Diabetes generally results in early death from cardiovascular diseases. Patients with diabetes have twice the risk of incident myocardial infarction and stroke as that of the general population. Circulatory disorders associated with diabetes include coronary heart disease (CHD), stroke, peripheral arterial disease, cardiomyopathy, and congestive heart failure. Furthermore, large numbers of people with diabetes do not survive their first event, and if they do survive, their mortality rate over the subsequent months to years is generally greater than that of the general population. As many as 80 % of patients with type 2 diabetes mellitus will develop and possibly die of macrovascular disease. This represents a great societal cost, with major loss of life expectancy and quality of life. Diabetes prevalence in selected European countries is in Figure 9.11.

There are two types of diabetes: type 1, with beginning in children, and type 2, which represents up to 90 % of all diabetic patients which affects mainly persons over 50 years with bad life style and obesity. With ongoing ageing of the population further increase of diabetes morbidity is expected. The growing trend of its morbidity is in progress for several years in Slovakia (Figure 9.12). The share of diabetic females (56 %) overrides the number of diabetic males. This is in connection with the length of women life, i. e. their numerous presences in senior age groups.

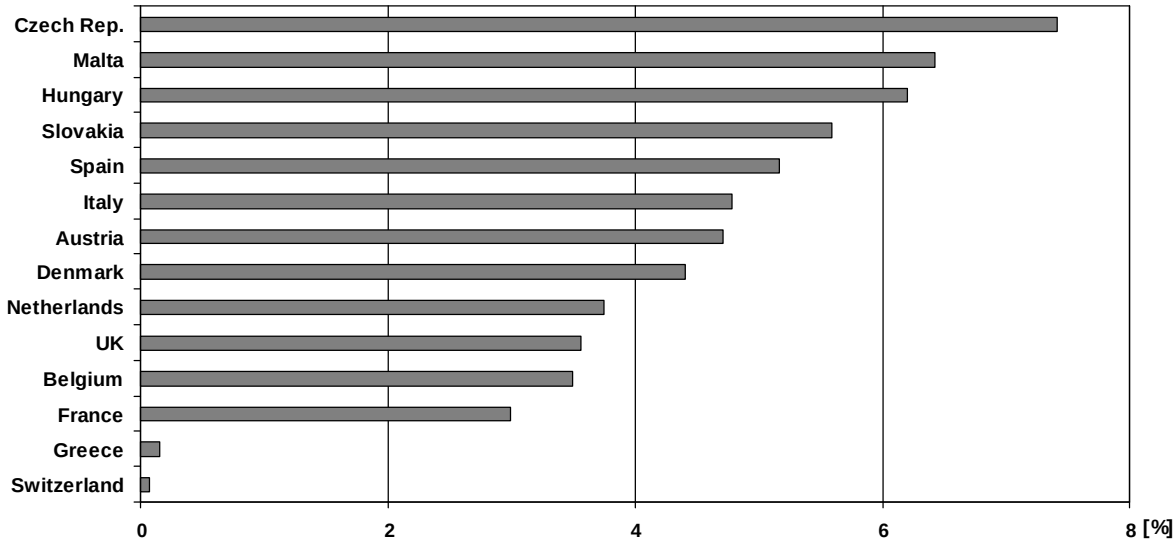

Figure 9.11 Diabetes prevalence (%) in selected European countries (WHO, 2010)

People with either type 1 or type 2 diabetes mellitus are at increased risk for CVD and have worse outcomes after surviving a CVD event. The absolute CVD risk in patients with type 1 diabetes mellitus is lower than in patients with type 2 diabetes mellitus, in part because of their younger age and the lower prevalence of CVD risk factors. However, the relative risk of CVD in people with type 1 diabetes mellitus compared with that of nondiabetics of similar age is dramatically increased in men and women and is associated with classic cardiovascular risk factors and nephropathy.

The aggressive use of lifestyle modifications can reduce or delay the need for medical intervention. Appropriate lifestyle and medical interventions will reduce the occurrence of CVD and allow people with diabetes to live healthier and longer lives.

Obesity prevention dominates in primary prevention of diabetes; in secondary prevention of diabetic complications the most important approach is obesity treatment (by means of diet and physical activity). Obesity prevention and/or weight reduction in obese persons will reduce all of the CVD risk factors associated with type 2 diabetes mellitus and will improve hyperglycemia.

To improve glycemic control, assist with weight maintenance, and reduce the risk of CVD, at least 150 minutes of moderate-intensity aerobic **physical activity** per week or at least 90 minutes of vigorous aerobic exercise per week is recommended. Thus, patients with

diabetes should be encouraged to perform 30 to 60 minutes of moderate-intensity aerobic activity such as brisk walking on most (preferably all) days of the week, supplemented by an increase in daily lifestyle activities (e.g. walking breaks during the workday, gardening, and household work). For long-term maintenance of major weight loss, a larger amount of exercise (a minimum of 7 hours of moderate or vigorous aerobic physical activity per week) is helpful.

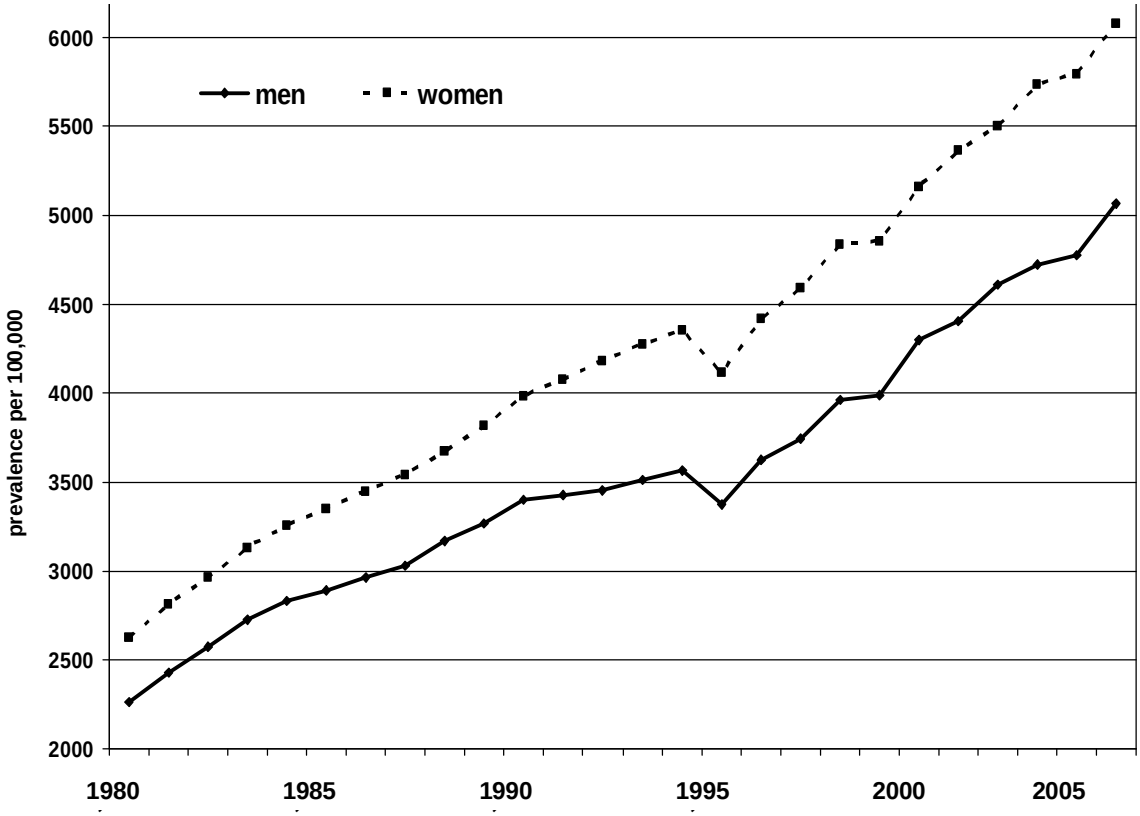

Figure 9.12 Diabetes prevalence increasing in men and women in Slovakia during the year of 1980 – 2008 (NCZI, 2008)

Diabetic diet has to maintain the body weight, glycemia, and to lower the plasma lipids levels. It is recommended as follows:

- Regular food intake with proportional saccharides intake, preferable foods with lower glycemic index (cereals, legumes) and avoiding simple sugars. Ample intake of dietary fiber may be of benefit.
- Total energy intake should be adjusted to achieve body-weight goals.
- Total dietary fat intake should be moderated (25 % to 35 % of total energy intake) and should consist mainly of monounsaturated or polyunsaturated fat (vegetable oils, fish and nuts). Saturated fats should be < 7 % of energy intake; dietary cholesterol intake should be < 200 mg/d.; intake of trans-unsaturated fatty acids should be < 1 % of energy intake.
- Plenty of antioxidants, vitamins (C, E, carotenoids and B) – for vascular and neurological complications prevention.

- Alcohol ingestion increases caloric intake and should be minimized when weight loss is the goal. If individuals choose to drink alcohol, daily intake should be limited to 1 drink for adult women and 2 drinks for adult men. Individuals with elevated plasma triglyceride levels should limit alcohol intake, because intake may exacerbate hypertriglyceridemia.
- In both normotensive and hypertensive individuals, a reduction in sodium intake may lower blood pressure. The goal should be to reduce sodium intake to < 5 g/d.

9.4 OSTEOPOROSIS PREVENTION

Osteoporosis and related fractures represent a major, and growing, public health concern worldwide through its association with fragility fractures. Despite the availability of preventative therapeutic agents, the incidence and its associated costs continue to rise globally. Understanding osteoporosis epidemiology is essential to developing strategies to reduce the burden of osteoporotic fracture in the population.

Osteoporosis can be defined as a systematic skeletal disease characterized by low bone mass, and microarchitectural deterioration of bony tissue, with a consequent increase in bone fragility and susceptibility to fractures.

Osteoporosis occurs when bone resorption exceeds bone formation. The pathogenesis of osteoporosis is complex, requiring attention to the different life phases involved in growth, maintenance, and loss of bone, in addition to non-skeletal factors associated with falls and fractures.

Bone loss is continual with aging in the sedentary individual. Women reach frailty before men because they start with smaller bones at the age of 30 years, and they lose the estrogen-promotion of bone accretion at menopause. The percentage of individuals over 65 years of age having osteopenia (reduced bone density) and osteoporosis (more severely reduced bone density) is very high. Osteoporosis is especially pronounced in women; this disorder does also develop in men, but at a much delayed rate.

The important osteoporotic fractures are hip fracture, vertebral fracture and forearm fracture. The incidence of hip fracture increases exponentially with age in both sexes, but remains higher in women than men throughout life. Broken hips in elderly individuals are associated with increased mortality.

Most vertebral fractures are clinically silent but are associated with much morbidity.

Following risk factors were selected for osteoporosis:

- Physical inactivity. This speeds the onset of osteoporosis with aging;
- Insufficient nutrient and calcium intake;
- Low bone mineral density;
- History of a prior fracture after age 40;
- History of a fracture at the hip, wrist, or vertebra in a first-degree relative (family history);
- Being in the lowest quartile in body weight;

− Reduced female reproductive hormones;
− Current cigarette smoking.

As bone mass peaks around the age of 20, **primary prevention** means that increases in bone mass must be emphasized in childhood and adolescence, i.e., factors detrimental to the addition of bone mass in development should be avoided. After the second decade of life, emphasis needs to be placed on maintaining existing bone mass.

The adequate calcium intake during skeletal growing is essential in a primary prevention of osteoporosis. Daily calcium requirement is higher during grow acceleration: 500 – 700 mg in the first year of life; 900 – 1,000 mg in the age of 6 – 7 years; and 1,200 mg in adolescence. In these age periods, nutrition rich in calcium and D vitamin, together with an adequate physical activity, are the important preventive measures.

However, an appropriate nutrition and adequate physical activity are important in adults and in elderly, too. Appropriate physical activity, such as a chronic loading type, delays osteoporosis and prevents loss of bone mass. The important role plays also an early identification of individuals in high risk of fractures (densitometry) together with the pharmacological treatment.

The main principles in osteoporosis prevention are as follows:

− The sufficient calcium intake – daily calcium intake of 1,000 – 1,500 mg – could significantly lower the fracture risk in elderly people. Daily consumption of milk and dairy products (especially low fat) is highly recommended.

− Lower intake of animal fat and phosphates (meat and meat products), as well as cola beverages and fast-food.

− Non-smoking; alcohol, black coffee and black tea intake reduce.

− Lower salt intake and mineral water with higher content of calcium drinking.

− Avoiding vegan and similar nutrition pattern due to a higher fiber content and higher oxalate content in some kind of vegetables.

9.5 CHRONIC RESPIRATORY DISEASE PREVENTION

Diseases of the respiratory system are an important public health problem in all countries. The respiratory system is exposed to a wide range of potentially injurious agents. Chronic diseases of the respiratory system are frequent causes of morbidity and mortality among adults. Internationally, the rates of occurrence of respiratory tract cancer and of nonmalignant chronic diseases of the respiratory system can be directly related to patterns of cigarette smoking. Despite the limitations of available data, mortality from all tobacco-related diseases is estimated to increase dramatically over the next two decades. Other environmental and occupational respiratory exposures cause potentially preventable chronic respiratory diseases.

9.5.1 Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is a progressive condition characterized by irreversible airflow limitation. Conditions associated with development of this physiologic impairment include **chronic bronchitis**, **emphysema**, and in some instances long-standing **asthma**. In general, this condition results from an abnormal inflammatory response after exposure of the lung to noxious particles and/or gases (Figure 9.13). Since the early nineteenth century, an association between smoke exposure and symptoms of chronic lung disease has been recognized. To date, cigarette smoke remains the most significant risk factor for developing COPD. A worldwide increase in smoking has led to a dramatic rise in the prevalence of this condition. Individuals with COPD typically complain of nonspecific symptoms that include chronic cough, mucus hypersecretion, and shortness of breath. The identification of patients with COPD is often complicated by the fact that symptoms develop late in the course of the disease.

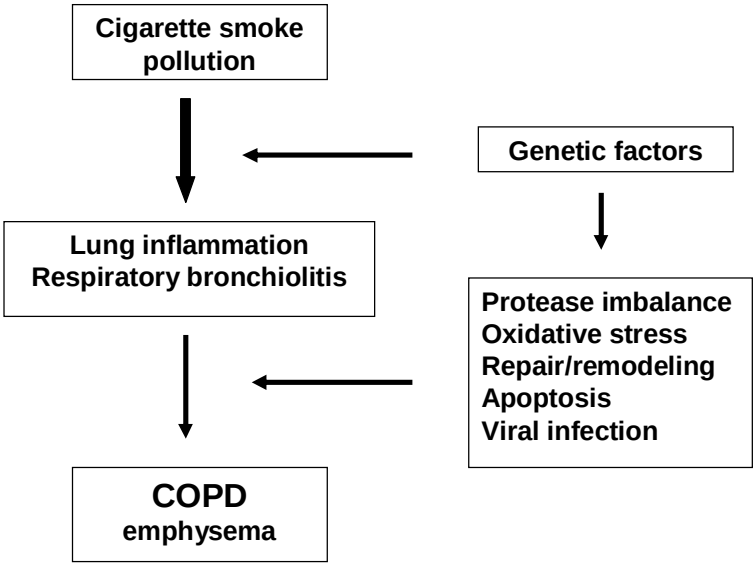

Figure 9.13 Model for disease pathogenesis in COPD (emphysema is the anatomical end-result of the factors that combine to cause COPD (Source: Morgan, Summer, 2008)

Worldwide, mortality rates among countries are highly variable, but overall, mortality from COPD has been increasing. In 1990 COPD was ranked as the sixth leading cause of death in the world and by 2020 it is estimated to be the third leading cause of death. The slow evolution of COPD provides an opportunity to identify and to target for intervention the smokers in whom the disease is developing. With sustained smoking, lung function in smokers, declining at a more rapid rate, tends to drop below normal levels. Lung function testing of chronic smokers can identify individuals whose function has dropped below the range of normal values but not yet reached the degree of impairment associated with frank COPD. These at-risk persons could then be targeted for intensive smoking cessation interventions.

COPD is an underdiagnosed condition, and in part this relates to the fact that patients with mild to moderate alterations in lung function are frequently asymptomatic. Overall, the prevalence of COPD parallels that of cigarette smoking. Indoor and outdoor air pollutants from the combustion of biomass fuels and coal contribute, but play a minor role.

Moreover, incidence cannot be described over short periods because of the slow evolution of impairment in persons developing COPD. Epidemiological data from throughout the world show that COPD is common among adults, with wide variation in prevalence estimates.

The prevalence is greater among men than among women, and increases with age and the extent of smoking.

9.5.1.1 Risk Factors for COPD

The current paradigm is that COPD develops in susceptible individuals who are exposed to noxious gases or particles. Exposure to tobacco smoke is the most significant risk factor. Two main sets of factors determine one's risk of developing COPD:

1. **Individual susceptibility**. The genetic risk factor most closely linked to the development of COPD. Other recognized individual susceptibility factors include low birth weight (or small lungs at birth), intrinsic airway hyperresponsiveness, and possibly gender.

2. **Environmental exposures**. The environmental risk factor most closely linked to the development of COPD is an individual's exposure to cigarette smoke. Importantly, passive exposure to smoke, often referred to as second-hand smoke, is also a risk factor. Indeed, even exposure to cigarette smoke in utero may result in the development of respiratory symptoms and airflow obstruction in later life. Air pollution (both indoor and outdoor) and heavy exposure to occupational dusts and chemicals are other significant environmental risks. Other factors that have been associated with the development of COPD include prior respiratory tract infections and malnutrition.

Chronic bronchitis is defined as a cough productive of sputum for at least 3 consecutive months during a period of 2 consecutive years. Individuals often minimize this symptom referring to it as a simple smokers' cough. Importantly, cough reflects a deeper problem that relates to ongoing airway inflammation, epithelial cell injury, and the progressive narrowing of the airway lumens. Risk factors associated with chronic bronchitis are in Table 9.7.

In contrast to chronic bronchitis, **emphysema** is not a clinical diagnosis, but rather is recognized by identifying dilated air sacs (alveoli) in the distal lung. Emphysema occurs when alveoli become destroyed, and the formation of large dilated air spaces becomes evident in the lung. Patients with this condition develop impaired gas exchange as a result of the gradual loss of surface area of the lung.

Most patients with COPD have features of both conditions – chronic bronchitis and emphysema. Current estimates suggest that approximately 25 % of all smokers will go on to develop COPD.

Table 9.7 Risk factors associated with chronic bronchitis (Source: Colley, 1991)

Categories of risk	Examples of measurement of risk factor
Cigarette smoking	Assessed by questionnaire with confidence
Age	Directly measured
Sex	Directly measured
Air pollution	Urban versus rural, levels of SO_2 and smoke
Atopy, allergy or hypersensitivity	History of asthma, eczema in childhood, wheeze independent of asthma, hay fever, etc., skin reactions to allergens
Occupation	Years of dust exposure
Social class	Occupational classification, education, or income level
Alcohol	Assessed by questionnaire with little confidence
Childhood illness	History of lung trouble before age 16 years, surveillance of illness experience in children
Familiar or household	Household associations
Genetic	Twin studies, measurement of α_1-antithrypsin phenotypes
Respiratory illness history	History of chest illness with phlegm in the previous3 years

9.5.2 Asthma

Classically, **asthma** does not result in irreversible airflow obstruction. In fact, asthma is typically distinguished from COPD by its reversibility. However, for unclear reasons a small fraction of non-smoking asthmatics develop irreversible or fixed airflow obstruction, and are clinically indistinguishable from individuals with smoking-related COPD. It is speculated that irreversible airflow obstruction in these patients results from airway remodeling due to long-standing inflammation.

Asthma is a common disease, whose prevalence has been increasing worldwide. Asthma is a chronic inflammatory disease of the airways, with airway eosinophils being the most prominent inflammatory cell. A number of initiating factors have been identified, including environmental allergens, viral infections, and volatile molecules and allergens in the workplace. Variable airflow obstruction and airway hyperresponsiveness are the physiological hallmarks of asthma and a variety of stimuli, such as exercise, atmospheric pollutants, and strong smells, can induce airflow obstruction and symptoms in asthmatic patients.

9.5.2.1 Asthma risk factors

- Familiar and genetic factors. I has been suspected that there may be a genetic basis for asthma (parents with a history of asthma are more likely to have children who develop the condition).
- Sex. In childhood there is a higher prevalence of asthma in boys (boys show a greater susceptibility to lower respiratory tract infection than girls); asthma during adult life appears to be more common in women (asthma in men may be labeled as chronic bronchitis, thus underestimating the true prevalence of asthma in men).
- Age. Asthma prevalence shows an apparent trend with age.

- Atopy. The association, particularly in children, has pointed to a possible astopic basis for asthma.
- Respiratory tract infections.
- Air pollutants.
- Smoking (current as well as second hand smoking).
- Other – psychological factors, vigorous exercise, meteorological factors (low ambient temperatures).

Overall, strategies for **asthma management and prevention** in adults differ little from those in children and incorporate pharmacological and other interventions. However, many asthmatics do not receive optimal medical management. Control of exposure to house dust mite allergen has not been effective in adult asthmatics. Early recognition of the relationship between an occupational exposure and asthma is important since prompt removal from exposure correlates best with full resolution of asthma. Certain occupations may be associated with an increased risk of death from asthma.

Other chronic lung conditions that result in irreversible airflow obstruction include bronchiectasis, cystic fibrosis, sarcoidosis, and tuberculosis. (Importantly, these latter conditions should not be confused with COPD as their pathogenesis, treatment, and prognosis are quite different).

9.5.3 Diffuse parenchymal lung diseases

The diffuse parenchymal lung diseases, also referred to as interstitial lung diseases, are a heterogeneous group of disorders comprising more than 200 entities, many of which are rare with no known cause, and result from injury to the pulmonary interstitium (Table 9.8). However, in the general population only five major diagnostic categories of these diseases are usually seen, including occupational and environmental, drug- and radiation-induced, connective tissue diseases, idiopathic interstitial pneumonias, and granulomatous disorders.

In a population-based investigation of the occurrence of interstitial lung diseases the overall prevalence was higher in men compared with that in women. Idiopathic pulmonary fibrosis is the single-largest category, accounting for 51 % of all incident cases. Interstitial lung diseases of known cause (e.g., asbestosis, coal workers' pneumoconiosis, silicosis, hypersensitivity pneumonitis, drug induced) compose only about 15 % of incident cases in the general population. Exposure to environmental agents may also alter risk of development of interstitial lung diseases of known or unknown cause.

Because most interstitial lung diseases are of unknown cause, little can be offered for **prevention** now. However, growing evidence suggests that exposure to environmental agents is associated with idiopathic pulmonary fibrosis, the most common interstitial lung disease. As evidence accumulates to fulfill the criteria for causation for specific exposures and determinants of individual susceptibility are identified, specific recommendations for prevention may be possible.

Table 9.8 Diffuse parenchymal lung diseases (Source: Demedts et al, 2001)

Known causes	Unknown causes
Inhaled agents	Idiopathic Interstitial Pneumonias (IPF, NSIP, DIP, RBILD, COP, AIP)
Inorganic dusts, gases or fumes	Sarcoidosis
Organic dusts	Collagen-vascular disorders
Drugs	Angiitis and granulomatosis
Poisons	Eosinophilic pneumonias
Radiation	Histiocytosis X
Infectious agents	Hereditary and familial disorders (e.g., tuberous sclerosis)
Medical Conditions	Storage disorders (e.g., amyloidosis, alveolar proteinosis)
Chronic pulmonary edema	
Chronic uremia	
Hepatitis, cirrhosis	
Transplantation rejection	
Metastatic cancer	

IPF – idiopathic pulmonary fibrosis
NSIP – nonspecific interstitial pneumonia
DIP – desquamative interstitial pneumonia
RBILD – respiratory bronchiolitis
COP – cryrptogenic organizing pneumonia
AIP – acute interstitial pneumonia

Respiratory diseases are common causes of morbidity and mortality worldwide, and many of these diseases can be prevented. Because the occurrence of the various respiratory diseases may vary widely in different geographic locations, epidemiological data are important for development of prevention strategies. Of particular public health concern is tobacco smoking, a major cause of avoidable respiratory disease from the prenatal period through adulthood. Efforts to reduce its overall burden include smoking cessation and limiting exposure to noxious gases. Importantly, only a subset of at-risk individuals will go on to develop this condition. Family clusters provide strong support for a genetic basis to the disease.

9.6 DRUG ADDICTION PREVENTION

Drug addiction is commonly described both medically and socially as a chronic, relapsing disease, characterized by the effects of the prolonged use of the drug itself and by the behavioral disorder caused by its compulsive seeking. This condition is shared by alcohol and illicit drugs as well as by tobacco. Once established, however, addiction "is often an uncontrollable compulsion to seek and use drugs".

Abuse – excessive or problematic use.

Drug – any substance that changes behavior and/or consciousness when ingested.

Dependence – the diagnosis of dependence requires three or more of the listed criteria to be present at any time in a 12-month period: tolerance; withdrawal; often takes in larger amounts or over longer period of time than intended; has persistent desire or unsuccessful efforts to cut down or control use; spends great deal of time in activities necessary to obtain the substance, use the substance, or recover from its effects; given up important social, occupational, or recreational activities or reduced due to substance use; continues to use despite knowledge of persistent physical or psychological problems caused by or exacerbated by the substance.

Tobacco and alcohol are currently legal drugs in most countries and have been branded and advertised. The long history of the commercialism of these two legal drugs has intentionally increased consumption of these drugs, both of which have significant potential for harm. Their widespread use results in greater morbidity, mortality, and overall economic costs than illegal drugs.

9.6.1 Alcohol

Alcohol is probably the most widely used drug in the world. It is cheap, readily available, and sold in many different formulations in industrialized regions. People generally do not experience the long-term adverse health consequences. However, young people who drink are more likely to abuse alcohol and incur alcohol-related injuries as adults, especially those that initiate alcohol use at a younger age.

Alcohol consumption is linked to over 60 health conditions and the related burden of disease is high; it ranks as the fifth most important risk factor for the burden of disease worldwide. Overall consumption is related to all-cause mortality and alcohol-specific mortality and disability; therefore, changes in consumption lead to changes in the overall as well as the alcohol-specific disease burden in a population.

The relationship between alcohol consumption and health and social outcomes is complex and multidimensional. Alcohol consumption is linked to health and social consequences through three intermediate outcomes: direct biochemical effects, intoxication, and dependence. An example of such direct biochemical effects is the promotion of blood clot dissolution or direct toxic effects on acinar cells triggering pancreatic damage.

Alcohol consumption was found to be related to the following categories:

- Conditions arising during the perinatal period: low birth weight;
- Cancers: mouth and oropharynx cancers, esophageal cancer, colon and rectal cancers, liver cancer, breast cancer and other neoplasms;
- Diabetes mellitus;
- Neuropsychiatric conditions: alcohol-use disorders, epilepsy;
- Cardiovascular diseases: hypertensive heart disease, ischemic heart disease;
- Cerebrovascular diseases: hemorrhagic stroke, ischemic stroke;
- Cirrhosis of the liver;
- Unintentional injuries: road traffic accidents, poisonings, falls, drownings, and other unintentional injuries;
- Intentional injuries: self-inflicted injuries, violence, and other intentional injuries.

A large part of alcohol-attributable burden is avoidable, however, and some of it in the short term. The absence of effective national policies renders untenable the current situation. The public is largely uninformed about how alcohol consumption is related to harms, and

what works to reduce public health problems from such consumption. There is a need to continue to improve the knowledge base about alcohol consumption and patterns of drinking, using standardized indicators and collecting systematic information by age and gender, and both developed and developing countries.

9.6.2 Smoking

The large number of deaths attributable to smoking illustrate that smoking is one of the most important avoidable risk factors for mortality worldwide, and responsible for more than 4 % of the global burden of disease.

Smoking causes or exacerbates acute respiratory diseases, tuberculosis and asthma, and noncommunicable diseases such as chronic lung disease, cardiovascular diseases, and cancer; it is estimated to kill around 5 million people per annum. Tobacco consumption involves a set of learned, patterned social behaviors. While the number of people smoking in highly industrialized countries has decreased in response to the evidence of the relationship between smoking and noncommunicable diseases, tobacco companies have aggressively promoted smoking in developing countries.

Smoking is a global epidemic. Approximately half of all smokers will die of a smoking-related disease and 50 % of these will die in middle age losing, on average, 22 years of life. Furthermore, smoking cessation is one of the most cost-effective interventions available to health-care systems. Despite knowing some of the many health risks of smoking, many people are unable to stop. This is primarily because of the highly addictive nature of nicotine in tobacco.

To understand how people become addicted to nicotine, it is necessary to understand how nicotine affects humans. Nicotine is inhaled with tobacco smoking into the lungs where it is rapidly absorbed into the circulation. It reaches the brain within seconds where it binds to and subsequently activates nicotinic acetylcholine receptors (nAChRs). Activation of nAChRs leads to an increase in dopamine in the nucleus accumbens that in turn ‘rewards’ behavior. It is this speed of nicotine delivery and action and the quick and frequent repetition of the behavior that allows smoking and the psychoactive ‘hit’ to become undeniably associated. An increase in dopamine is associated with most dependency-causing drugs and behaviors (e.g. gambling). For many smokers, it is the withdrawal symptoms that make quitting one of the hardest behavioral changes they will ever attempt to make. Nicotine withdrawal symptoms vary in severity and in how long they will go on for, and may be in part responsible (urges to smoke and depressed mood in particular) for the majority of relapses, which occur within the first month after a quit attempt.

Effective interventions and policies that reduce smoking among males, and prevent increases among females in the developing world (e.g., enforcing the Framework Convention for Tobacco Control) can curb and eventually reverse this increase. The estimates of regional and global mortality presented here provide a baseline for evaluating the implementation of tobacco control interventions and policies. Such an evaluation would however be helped with periodic monitoring of smoking using valid, consistent, and comparable instruments in different countries, including data by age and sex.

Public Health Programs Smoking cessation has an important place in any tobacco control strategy. Smoking cessation is likely to be more effective if delivered as an integral

component of a multifaceted country or population-level tobacco control program. While focused on reducing uptake of smoking and reducing consumption and smoking prevalence, many tobacco control program strategies can prompt smokers to think about quitting. Health-care professionals have a crucial role to play in triggering their patients who smoke to quit and in assisting them to select effective treatments. There are a number of memory aids to assist health-care professionals in helping their clients who smoke; the most widely known is the "5 As":

1. **A**sk – The smoking status of every adult should be identified and prominently documented in their medical record.

2. **A**ssess – Determine nicotine dependency and motivation to quit.

3. **A**dvise – At nearly every encounter, provide brief cessation messages that are clear, strong, and personalized; supportive; and non-confrontational.

4. **A**ssist – Provide assistance to quit by offering self-help materials, assisting with setting a quit date and developing a quit plan; providing practical counseling and support; exploring barriers to successful cessation and strategizing solutions; referring to organized cessation support (e.g., free phone quitlines); and encouraging use of an effective pharmacotherapy.

5. **A**rrange – Arrange follow-up (in person or by phone).

The benefits of quitting smoking are numerous. Smokers who stop reduce their risk of premature death as well as risk of morbidity from a wide range of smoking-related diseases. Other reasons include the cost of smoking, concern about exposing others, particularly children, to secondary smoke, wanting to set a good example for others, fitness, and longevity.

Evidence-based smoking cessation treatments are very cost-effective and have the potential to improve the quality of life and increase longevity of many smokers. Smoking cessation that combines multisession counseling with pharmacotherapy typically produces the best outcomes. If the global public health community is to make inroads into lowering smoking prevalence then tobacco control, which must include tobacco dependence and its treatment, need to be seen as important components of both undergraduate and postgraduate education.

9.6.3 Caffeine

Caffeine is reported to be the most commonly consumed psychoactive substance on earth. While coffee drinking accounts for the majority of caffeine intake, caffeine is found in many other foodstuffs (tea, chocolate, cola and other beverages) as well as over the counter medications. Coffee and/or caffeine consumption has been linked to many human diseases in epidemiologic studies. Causal relationships have been difficult to substantiate. Initial investigations, showing an association between coffee and coronary heart disease, suffer from confounding variables and have been difficult to replicate. Contrary to common belief, the published literature provides little evidence that coffee and/or caffeine in typical dosages increases the risk of infarction, sudden death or arrhythmia.

9.6.4 Psychoactive drugs

Psychoactive drugs are used by many species and have been used by humans for as long as history has been recorded. Psychoactive drugs alter brain function, resulting in temporary changes in mood, perception, and behavior. Harms from drugs come from a variety of causes, which include toxicity, overdose, addiction, and behavioral issues. Some drugs have minimal adverse behavior changes and few toxic effects, such as marijuana. Other drugs are highly toxic or are associated with undesirable behaviors such as crystal methamfetamine.

Experimentation with substances such as alcohol, tobacco, and drugs is common during adolescence. Some teenagers may try these substances infrequently or in small amounts, other more vulnerable adolescents become dependent or addicted, which can have devastating effects on their health and how they function in society. The younger a person uses drugs, the more likely he or she is to abuse the substance as an adult. Substance use is associated with other risk behaviors, and contributes to suicides, motor vehicle crashes, pregnancy, violence, and homicides in young people.

Marijuana is probably the most commonly used illicit drug worldwide. Marijuana does not contain nicotine, and physical addiction has never been demonstrated. However, people who smoke marijuana may be more likely to try other more dangerous substances, hence its controversial role as a 'gateway drug,' causing many law enforcement agencies to enforce regulations against its sale. People who are addicted to other illicit drugs are at risk for overdose, dependency, suicide, and death.

The abuse of **intravenous drugs** is contributed to the spread of HIV in many countries. Intravenous drug abusers are also at risk for other infections including hepatitis C, which causes liver failure. Cocaine, including crack cocaine, has had a devastating effect on adolescents in every socioeconomic class. Methamfetamine ("crystal meth") has reached near-epidemic proportions in some countries because it is highly addictive and easy to make from cheap household products. Younger teenagers may experiment also with inhalants that are cheap and readily available, yet dissolve brain cells and can cause sudden death. Phencyclidine (PCP) use causes men to become a dangerous combination of physically violent, psychotic, and numb to pain. Numerous "club drugs" in the industrialized world such as Ecstasy make men euphoric and augments their sexual drive while lowering inhibitions.

Gambling addiction – also called compulsive gambling or pathological gambling. Problem gambling is an urge to gamble despite harmful negative consequences or a desire to stop. Extreme cases of problem gambling may cross over into the realm of mental disorders. Pathological gambling was recognized as a psychiatric disorder; pathological gambling is an impulse control disorder that is a chronic and progressive mental illness.

9.6.5 General prevention principles

Two main policy fields are addressed to tackle the drugs problem at the international and national level: supply reduction and demand reduction. Although the strategy is aimed at the control of illegal drugs, it serves as an example of a global strategy – including transnational

law enforcement cooperation, treatment service supply, and prevention programs – that is relevant also to tobacco and alcohol. Primary prevention of substance use may be classified as:

- Universal prevention, targeted to the general population as well as to specific unselected populations (school, family, community);
- Selective prevention, targeted to subsets of the population identified as having a higher risk of drug use than average;
- Indicated prevention, which targets those who have already taken drugs and are considered to be at risk of becoming addicted.

Prevention programs should:

- Enhance protective factors and reverse or reduce risk factors.
- Address all forms of drug abuse, alone or in combination, including the underage use of legal drugs (e.g., tobacco or alcohol); the use of illegal drugs (e.g., marijuana or heroin); and the inappropriate use of legally obtained substances (e.g., inhalants), prescription medications, or over-the-counter drugs.
- Address the type of drug abuse problem in the local community, target modifiable risk factors, and strengthen identified protective factors.
- Be tailored to address risks specific to population or audience characteristics, such as age, gender, and ethnicity, to improve program effectiveness.

Evidence suggests that drug prohibition is ineffective, as the amount of drug use in societies fluctuates independently of the severity of enforcement measures. A public health approach to the individual and societal problems associated with substance use stresses the need to shift resources into research, education, prevention, and treatment as an alternative to the continued use of criminal sanctions.

10. RISK ASSESSMENT APPLIED TO ENVIRONMENTAL MEDICINE

Estimation of health risks associated with environmental pollutants is composed of two primary activities: exposure assessment and effects assessment. During exposure assessment, the initial part of the event chain is evaluated, i.e. sources of pollutants, media concentrations, exposures and dose. A major goal is to estimate exposure levels and the number of persons exposed. As part of exposure assessment, the relative contributions of all important sources and exposure pathways to the associated target dose are determined.

Exposure is a key element that leads from release of pollutants into the environment, to a concentration of the pollutant in one or more environmental media, to actual human exposure, to internal and delivered dose, and ultimately to environmentally induced disease and injury.

10.1 CHARACTERISTICS

A **hazard** is defined as a factor or exposure that may adversely affect health. It is basically a source of danger. It is a qualitative term expressing the potential of an environmental agent to harm the health of certain individuals if the exposure level is high enough and/or if other conditions apply.

A risk is defined as the probability that an event will occur (e.g. that an individual will become ill or die within a stated period of time or age, the probability of an unfavorable outcome). It is the quantitative probability that a health effect will occur after an individual has been exposed to a specified “amount” of hazard. **Health risk** is the probability of health impairment, disease or death of a person as a result of exposure to risk factors (chemical, physical, biological) in the environment.

Risk assessment is a formalized process for characterizing and estimating the magnitude of harm resulting from some condition-usually exposure to one or more hazardous substances in the environment. Risk assessment is an evaluation of the health risk of a defined policy, action or ntervention. WHO has produced numerous guidelines and methods for doing risk assessments, particularly in relation to chemical safety.

Environmental risk assessment usually refers to human health risks, while **ecological risk assessment** refers to damage to natural or artificial ecosystems, wildlife species, and endangered species.

Health impact assessment can be considered as risk assessment focused on a specific population or exposure situation, answering such questions as: “What type of health risk can this chemical potentially cause in certain exposure situations?”

The results of risk assessment feed directly into the risk management process carried out by policy makers. The term **risk management** is applied to the planning and implementation of actions to reduce or eliminate health risks. Risk management is the process of weighing policy alternatives and selecting the appropriate regulatory action. It takes into account the results of risk assessment, engineering data and social, economic and political factors. **Risk management decisions** are of four basic types: priority setting, determination of unacceptable risks, selection of the most cost-effective method of preventing or reducing unacceptable risks, and evaluation of the success of risk mitigation efforts. Decision makers also must take into account the economic, engineering, legal, social, and political aspects of the problem (Figure 10.1).

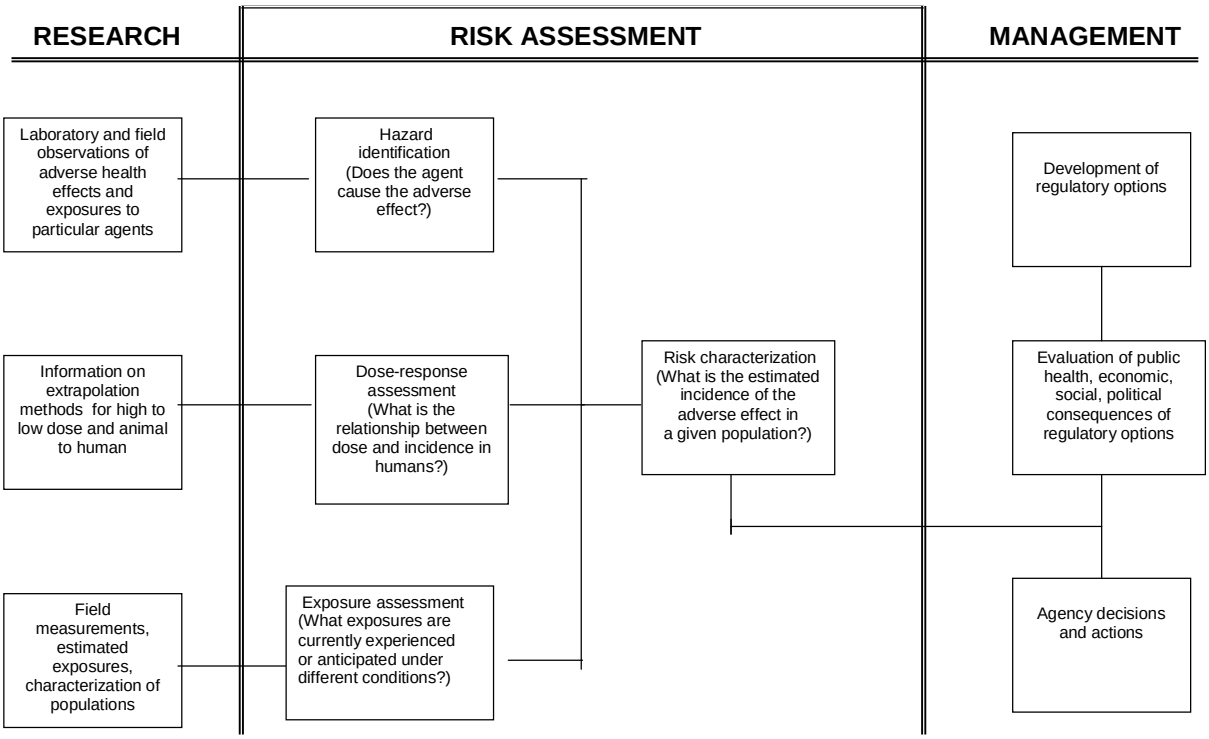

Figure 10.1 Elements of Risk Asssessment and Risk Management
(Source: Kawecki and Lee, 1992)

Risk assessment is primarily a scientific endeavor, while **risk management** refers to those actions taken by society to ameliorate risks. Risk management takes into account human values and fiscal concerns and determines what risk assessments need to be done and how they are to be used.

Risk communication is defined as the purposeful exchange of information about the existence, nature, form, severity or acceptability of risks among individuals, groups and institutions. The **Environmental Protection Agency (EPA)** defines **seven cardinal rules of risk communication:**

1. Accept and involve the public as a legitimate partner.
2. Plan carefully and evaluate your efforts.

3. Listen to the specific concerns of the public.
4. Be honest, frank and open.
5. Coordinate and collaborate with other credible sources.
6. Meet the needs of the media.
7. Speak clearly and with compassion.

Risk perception is also an area of increasing importance. The perception of risks is changing with increased knowledge about the risks, and about ways and means to counteract them. It is the subjective **perception of risk** by individuals or communities facing the risk, and their evaluation of its importance based on personal, moral, economic and political influences.

Health promotion has been defined as the process of enabling people to increase control over and to improve health. Health promotion is a continuum ranging from the treatment of disease to the prevention of disease, including protection against specific risks, to promote optimal health.

10.2 TYPES AND SOURCES OF ENVIRONMENTAL HAZARDS

The term "environmental hazard" refers to a wide array of diverse environmental phenomena that have the potential to cause adverse health effects.

Table 10.1 classifies the major environmental hazards and their relative importance in various environmental settings. **Chemical agents** are responsible for the majority of environmental toxic reactions; physical agents include ionizing and non-ionizing radiation, vibration, temperature, and noise; **biological agents** include infectious and allergic disorders; **psychosocial factors** are an important consideration for environmental medicine, especially at work or in the home; and **trauma** or **mechanical factors** include cumulative or repetitive trauma such as carpal tunnel syndrome which may be more important in the workplace as well as trauma induced by recreational activities or accidents in the home.

The classification of traditional and modern health hazards is presented in Table 10.2. At present, some traditional hazards are gaining popularity due to global changes, disasters and bioterorrism.

Air, earth, water and food are the major environmental media or vectors through which exposure to hazardous environmental agents may occur. Assessment of individual exposures includes an examination of actual and potential exposures to hazardous agents through food; water used for drinking, cooking, or washing; air and soil. There is considerable interaction among environmental contaminants, their media or vectors, and routes of exposure. This interaction reflects the complexity of ecologic processes in the environment.

There are four critical characteristics of exposure assessment:

1. Route (inhalation, ingestion, dermal);
2. Magnitude (concentration or dose);

3. Duration (minutes, hours, days, lifetime);
4. Frequency (daily, weekly, monthly, seasonally).

The assessment of an environmental medical disorder requires an awareness of many other important factors including multifactorial aetiology, lack of specificity, host susceptibility, and latency.

Table 10.1 Environmental hazard classification (prevalence of hazards in individual environments) (Source: Brooks et al, 1995)

Agent Setting	Home	Community	Workplace
Physical			
Ionising radiation	0	++	+++
Non-ionizing radiation	++?	++?	+++
Noise	+	++	++++
Vibration	0	0	+++
Temperature	+	++	+++
Chemical			
Heavy metals	+++	++	++++
Pesticides	++	++	++++
Solvents	++	+	++++
Chlorinated HC	+	+	++++
Polyaromatics	++	+++	+++
Biologic			
Bacteria	+++	++++	+++
Viruses	++	++++	+++
Fungi	+	+++	+
Allergens	++++	++++	+++
Prions			
Trauma			
General	++++	++++	++++
Cumulative	+	0	++++
Psychosocial			
Personal	+++	+	+++
Family	++++	+	+++
Co-workers	+++	+	++++

The intensity of the exposure is designated by plus signs ranging from none or minimal (0/+) to great (+++/++++)

Multifactorial aetiology Environmental disorders should not be considered in isolation (i.e. only looking at the toxic agent in question and pertinent information on the hazardous substance), but rather with other factors that may modify the outcome. Factors that vary from one individual to another and may impact on pathogenesis include age, sex, nutritional status, life-style, preexisting health problems, and exposure to other toxicants. Any or all of these factors may combine with a single exposure to toxic substance to produce unexpected health effects.

Host susceptibility Such important factors as age, race, gender, intercurrent disease, genetics, nutritional status, physiologic capacity, exposure history and emotional state can

influence an individual's susceptibility and response to environmental pollution. The effectiveness of an individual's defense mechanisms plays a critical role in determining the clinical manifestations and outcome of hazardous exposure (Table 10.3).

Table 10.2 Examples of Traditional vs. Modern Health Hazards (Source: Yassi et al, 2001)

Traditional Hazards	Modern Hazards
Disease Vectors	Tobacco Smoking
Infectious Agents	Alcohol
Housing and Shelter	Transport Hazards
Drinking-Water and Sanitation	Environmental Pollution
Indoor Air Pollution From Cooking	Outdoor Air Pollution
Dietary Deficiencies	Use of Chemicals
Reproduction	Workplace Hazards
Injury Hazards in Agriculture	Unbalanced Diet

Table 10.3 Outcomes from Environmental Hazards (Source: Brooks et al, 1995)

Outcome	Example
Human health	Benzene
Carcinogenicity	Ionizing radiation
Heritable genetic and chromosomal mutation	
Developmental toxicity	1,3-Butadiene
Reproductive toxicity	Lead
Acute toxicity	Phosgene or mustard gas
Chronic toxicity	Carbon tetrachloride
Neurotoxicity	Mercury
Ecologic	
Environmental toxicity	Cadmium or aluminum
Persistence	1,1,1-Trichloroethane
Bioaccumulation	Chlordane

10.3 RISK ASSESSMENT AND RISK MANAGEMENT

In 1983, the modern environmental risk assessment approach was codified by the National Research Council's "red book" on Risk Assessment in the Federal Government, which laid out a four-step approach: hazard identification, dose-response assessment, exposure assessment, and risk characterization (Figure 10.1).

Risk assessment is an integral component of risk management, it involves target populations and the question of how much increased risk will occur if a group of people or a natural ecosystem is exposed to a certain amount of hazardous substance or condition over a certain period of time.

Risk assessment can be divided into four major steps:

Hazard identification is based on results from toxicological research and epidemiological studies (epidemiologic data, animal bioassays, in vitro studies, comparison of molecular structure). Data from epidemiological studies may be used directly to identify hazards and dose-response relationships. The types of studies used in epidemiology are in

Table 10.4. This data may be important in answering the ultimate question of whether or not the toxic effects under experimental conditions are also likely to be present in humans under natural conditions. Hazard identification can therefore be considered as a qualitative description of a potential risk.

The types of effects relevant to each chemical (e.g., cancer, or effects other than cancer) are determined as part of the hazard identification.

Table 10.4 Types of epidemiological studies (Source: Bonita et al, 2006)

Type of study	Alternative name	Unit of study
Observational studies		
Descriptive studies		
Analytical studies		
Ecological	Correlational	Populations
Cross-sectional	Prevalence	Individuals
Case-control	Case-reference	Individuals
Cohort	Follow-up	Individuals
Experimental studies	**Intervention studies**	
Randomized controlled trials	Clinical trials	Individuals
Cluster randomized controlled trials		Groups
Field trials		
Community trials	Community intervention studies	Healthy people Communities

Dose-response assessment

This process characterizes the relationship between the dose of pollutant administered or received and the incidence of an adverse health effect in exposed animals and populations.

The incidence of the adverse effect is then estimated as a function of exposure to the agent.

The terms ”dose-response“ and “dose-effect“ are often erroneously interchanged. The relationship between dose and severity of effect in the individual is called the dose-effect relationship, which can be established for an individual or a group (the average dose at which each effect occurs).

At a low carbon monoxide (CO) dose (measured as carboxyhaemoglobin in blood) a slight headache would be the only effect, but as the dose increases, the effects of CO become more severe.

A dose-response relationship describes the relationship between the proportion of individuals in an exposed group that demonstrate a defined effect and the dose. Dose-response relationships are considerably different for noncarcinogens (thought to have a threshold) and carcinogens (thought to be nonthreshold). Theoretically the shape of the dose–response relationship should look like an S or like a cumulative normal distribution (see Chapter Occupational hygiene, Figure 3.5). At low doses almost nobody suffers the effect, and at high levels almost everybody does. The dose–response relationship can in some cases be

approximated to a straight-line relationship, particularly when only a narrow range of low responses is involved. This approach has been used, for instance, in the study of lung cancer risk and asbestos dose or tobacco smoking dose.

Exposure assessment involves measuring or estimating the intensity, frequency and duration of human exposures to an agent present in the environment or estimating the exposures that might arise from the release of new chemicals into the environment. This requires measurements or models of contaminants taken from their sources, the environmental media (including fate and transport), contact with the receptor, bioavailability and absorption, and finally from an estimate of dose to a target organ, tissue or cell. Exposure assessment must take into account the measured or estimated concentration of a substance (air, water, food, soil) and all applicable routes of exposure (inhalation, ingestion, skin absorption). This requires knowing how individuals behave: where they spend their time, what they eat, how much they drink, and many other variables which can be incorporated into increasingly sophisticated models.

The standard human target is the 70 kg adult male. However, if susceptible subpopulations include children, females, or ethnic groups, a more appropriate body mass should be chosen. Exposure is assumed to occur over a 50- or 70-year life span, but in many cases involving childhood exposure, a different critical period is selected.

Definitions for key events in the continuum of risk assessment are as follows:

Emission source: The point or area of origin of an environmental agent is known as source (e.g. stationary versus mobile source).

Exposure pathway: Physical course taken by an agent as it moves from the source to a point of contact with a person.

Exposure concentration: Concentration of an agent in a carrier medium at the point of contact with the outer boundary of the human body.

Intake: Intake is associated with ingestion and inhalation. The agent, which is likely part of a carrier medium (e.g. air, water, food) enters the body, usually through the nose or mouth. The amount of the agent that crosses the boundary per unit time can be referred to as the "intake rate ", which is the product of exposure concentration and the rate of either ingestion or inhalation.

Uptake: Uptake is associated with inhalation, dermal absorption and ingestion after intake has occurred. The amount of the agent that crosses the barrier per unit time can be referred to as the "uptake rate", or "flux".

Dose: Once the agent enters the body by either intake or uptake, it is described as a "dose".

Potential (administered) dose: It is the amount of the agent that is actually ingested, inhaled, or applied to the skin.

Applied dose: Applied dose is the amount of the agent directly in contact with the body’s absorption barriers (such as skin, respiratory and gastrointestinal tract) and therefore available for absorption.

Internal (absorbed) dose: The amount of the agent absorbed and therefore available to undergo metabolism, transport, storage, and elimination is referred to as the "internal" or "absorbed dose". Measurement of the internal dose is crucial for relating exposure to dose (i.e., pharmacokinetics - what the body does to the pollutant) and for relating dose to effects (i.e., pharmacodynamics-what the pollutant does to the body)

Delivered dose (body burden): The portion of the internal (absorbed) dose that reaches a tissue of interest.

Biologically effective (target) dose: The portion of the delivered dose that reaches the site or sites of toxic action. The link, if any, between biologically effective dose and subsequent disease depends on the relationship between dose and response (e.g. shape of the dose-response curve), underlying pharmacodynamic mechanisms (e.g. compensation, damage, repair), and important susceptibility factors (e.g. health status, nutrition, genetic predisposition).

Biologic effect: A measurable response to dose in a molecule, cell or tissue.

Adverse effect: A biologic effect that causes dysfunction, injury, disease, or death.

Biologic markers (biomarkers) of exposure: Biomarkers in the context of environmental health are indicators of events in biological systems or samples. It is important to note the distinctions, though they are not always clear, of three types of biological markers: markers of exposure, markers of effect, and markers of susceptibility.

A marker of exposure is an exogenous substance or its metabolite, or the product of the interaction between a xenobiotic agent and some target molecule or cell that is measured in a compartment within an organism. Markers of exposure tend to integrate all the routes of exposure to some particular chemical. One of the best known markers of exposure is the level of lead in the blood.

A marker of effect is a measurable biochemical, physiological or other alteration within an organism that, depending on magnitude, is recognized as an established or potential health impairment leading to disease. Markers of effect can under certain circumstances be useful for exposure assessment but only if the marker can be related to the exposure responsible for the effect. Some markers of effect signal preclinical or presymptomatic stages in disease development which are specific to a chemical (i.e. CO and presence of COHb in blood signals that CO exposure is occurring), but the source could be the inhalation of CO or the metabolism of methylene chloride. Another reason for increased COHb levels may be hemolytic anemia with an increased breakdown of hemoglobin.

A marker of susceptibility is an indicator of an inherent or acquired limitation in an organism's ability to respond to exposure to a specific xenobiotic substance. Some people are susceptible because of inborn differences in metabolism, physiological characteristics, nutritional status or absorption characteristics. For example measurement of airway reactivity to inhaled bronchoconstrictors can be used as a biomarker of susceptibility. Increased non-specific airway reactivity is a characteristic of most asthmatics and can play a role in disease activity. Thus, airway hyperreactivity in this group can be considered as a marker of susceptibility. This marker can also relate to induced variations in absorption, metabolism, and response to environmental agents.

Risk characterization is the final step in the risk assessment process. The results of the exposure and the effects assessment are combined to estimate the human health risks from future exposure. This risk estimate and associated information feed directly into risk management decisions about protection of public health (Figure 10.1). Risk characterization, as well as the other steps of the risk assessment process, are different in carcinogens and non-carcinogens (see the sections below).

10.3.1 Risk assessment for carcinogens

Since the publication of EPA's original cancer guidelines in 1986, considerable new knowledge has been developed regarding the processes of chemical carcinogenesis and the evaluation of human cancer risk.

Cancer data in the observable range is analyzed using a dose-response model similar to the models used for noncancer effects. The method of extrapolation to lower doses from the

point of departure may vary depending on whether the available data indicate a linear or nonlinear mode of action.

Hazard identification. The 1986 guidelines recognized three broad categories of data: (1) human data (primarily epidemiological); (2) results of long-term experimental animal bioassays; and (3) supporting data, including a variety of short-term tests for genotoxicity and other relevant properties, pharmacokinetic and metabolic studies, and structure-activity relationships. In hazard identification of carcinogens under the 1986 guidelines, human data, animal data, and supporting evidence are combined to characterize the weight-of-evidence (WOE) regarding the agent's potential as a human carcinogen into one of several hierarchic categories:

The International Agency for Research in Cancer (IARC) has a five-tier system for classifying chemicals on the basis of human cancer, and the EPA system is analagous:

Group 1. Known human carcinogen: adequate evidence in humans.

Group 2A. Probable human carcinogen: limited evidence in humans but sufficient evidence in animals.

Group 2B. Possible human carcinogen: limited evidence in humans and less than sufficient in animals.

Group 3. Not classifiable: this category is used most commonly for agents, mixtures, and exposure circumstances for which the evidence of carcinogenicity is inadequate in humans and inadequate or limited in experimental animals.

Group 4. Probably not carcinogenic in humans. Evidence suggests that there is no carcinogenicity in either humans or animals.

The EPA uses similar categories but they are labeled A, B1, B2, C, D, E.

Dose-response assessment for carcinogens Linear extrapolation of risk in the low dose region was proposed as a reasonable estimate on risk. This linear approach has been used to extrapolate the dose-response curve for most chemicals with adequate data. Linear extrapolation remains appropriate when the evidence supports the mode of action of gene mutation due to direct DNA reactivity or another mode of action that is thought to be linear in the low dose region. A linear mode of action will also be the default when available evidence is not sufficient to support a nonlinear extrapolation procedure, even in the absence of evidence of DNA reactivity. Nonlinear methods are to be used if there is sufficient evidence to support a nonlinear mode of action.

Exposure assessment In many cases, the actual site-specific or case-specific data are unavailable, and default values are used. Preferably, direct observations or questionnaires can be used to obtain case-specific exposure estimates. For example, the studies of risks from consuming fish contaminated by metals or radionuclides required site-specific estimates of how much fish fishermen actually consume. Increasing attention focuses on estimating probability distributions for all aspects of exposure including behavior influencing hours at home, minutes of showering and water use and food consumption. Exposure assessment must incorporate estimates of bioavailability and increasingly relies on physiologically based pharmacokinetic models to provide estimates of the internal dose, the dose actually delivered

to the target organ. Obtaining empirical distributions relevant to exposures (drinking water, air volumes, market baskets, etc.) for different populations and age groups is important.

Risk characterization This involves a quantitative estimate of the exposure level at which a particular level of excess risk exists. In the case of cancer, one constructs a dose-response curve based on animal studies of cancer and performs a low-dose extrapolation to estimate the dose that would produce a particular excess of cancer (for example, a 10^{-6} increase, resulting in one additional case per million exposed people). A variety of biological models of carcinogenesis have been advocated, each leading to selection of different mathematical extrapolations. The one hit model assumes a linear relationship between dose and outcome, starting at the smallest dose above zero (i.e., no threshold), with the slope of the line determined from the available studies. It assumes no threshold and is basically drawn from our understanding of radiation and cancer. Multistage models take into account our understanding of chemical carcinogenesis as a process involving initiation and promotion.

For linear carcinogens, EPA's current process of estimating cancer risk is based on the unit risk estimate (URE) for inhalation, and the carcinogenic potency slope (CPS) for ingestion. The URE represents the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air. The interpretation of the URE would be as follows: if the URE = 1.5×10^{-6} $\mu g/m^3$, no more than 1.5 excess tumors are expected to develop per 1,000,000 people if exposed daily for a lifetime to a concentration of 1 µg of the chemical per cubic meter of air. The CPS is an upper bound, usually approximating a 95 % confidence limit, on the increased cancer risk from lifetime oral exposure to an agent. This estimate, usually expressed in units of proportion (of a population) affected per mg/kg/day, is generally reserved for use in the low-dose region of the dose-response relationship, that is, for exposures corresponding to risks less than 1 in 100.

10.3.2 Risk assessment for noncancer effects

Risk analyses for noncancer endpoints use a variety of approaches usually based on the highest dose known to produce no effect (no observed adverse effect level [NOAEL]) or if only the control dose had no effect, the lowest dose known to produce an adverse effect (lowest observed adverse effect level [LOAEL]) can be used. Ideally, one would use data from epidemiologic studies including the most sensitive human subpopulations, where there has been a lifetime of adequate exposure by appropriate routes as well as a lifetime of follow-up (to ensure that events with long latency are not missed). In such a study, the exposure would be documented for all subjects for all years.

Hazard identification Due to the wide variety of endpoints, hazard identification procedures for noncancer effects have not been described as completely in EPA guidance as procedures for the identification of carcinogens. However, EPA has published guidelines for assessing several specific types of chronic noncancer effects including mutagenicity (1), developmental toxicity (2), neurotoxicity (3), and reproductive toxicity (4), as well as a framework for using studies of these and other effects in inhalation risk.

Dose-response assessment Several terms need to be understood.

Benchmark dose An alternative to relying on a NOAEL, the benchmark dose is the lower confidence limit on a dose which produces an effect in some percent of test animals (usually

set at 1, 5 or 10 %). It is derived from modeling. It is usually less conservative (less protective), and is linked to an assumption that a certain percent of illness (up to 10 % of the population) is tolerable. Estimates of benchmark doses need to account for exposure uncertainty.

NOEL and NOAEL In toxicological studies, these are the "no observable effect" level and "no observed adverse effect" level, respectively. The NOAEL is the dose at which there is no biological or statistically significant adverse effect. Often there may be measurable effects that are not known to have adverse consequences (hence the term NOEL).

LOAEL Lowest observed adverse effect level. In some studies, even the lowest dose induced a significant adverse effect. Rather than throw out such studies, use this data, but treat the LOAEL differently from a NOAEL, incorporating a 10x uncertainty factor.

Reference Dose (RfD), or Acceptable Daily Intake (ADI), or Tolerable Daily Intake (TDI). The **RfD** is established by the Environmental Protection Agency based on risk assessments for noncancer and nongenetic endpoints. This is a daily dose expressed usually in μg/kg/day that one could be exposed to every day (usually for a 50-year lifetime) without experiencing any adverse effect. **ADI** is the estimate of the amount of a substance in food and/or drinking water, expressed on a body weight basis that can be ingested daily over a lifetime without appreciable health risk to the consumer on the basis of all the known facts at the time of the evaluation.It is usually expressed in milligrams of the chemical per kilogram of body weight. ADIs are used for substances that have a reason to be found in food (as opposed to a contaminant - TDI) and as such, include additives, pesticide residues and veterinary drugs in foods. A **TDI** is an estimate of the amount of a substance in air, food or drinking water that can be taken in daily over a lifetime without appreciable health risk. TDIs are calculated on the basis of laboratory toxicity data to which uncertainty factors are applied.

TDIs are used for substances that do not have a reason to be found in food

Safety factor (SF), or Uncertainty factor (UF). One of several, generally 10-fold factors, used in operationally deriving the Reference Dose (RfD) from experimental data. UFs are intended to account for 1) the variation of sensitivity within the human population, 2) the uncertainty in extrapolating animal data to the case of humans, 3) the uncertainty in extrapolating from data obtained in a study that is of less-than-lifetime exposure, and 4) the uncertainty in using LOAEL data rather than NOAEL data.

Modifying factor (MF) is an additional uncertainty factor that is greater than zero and less than or equal to 10. The magnitude of the MF depends upon the professional assessment of scientific uncertainties of the study; e.g., the completeness of the overall database and the number of species tested. The default value for the MF is 1.

Acceptable daily intake: ADI (TDI) = (NOAEL or LOAEL) / UF
Reference dose: RfD = NOAEL / (UF x MF)

Where:
NOAEL = no-observed-adverse-effect-level
LOAEL = lowest-observed-adverse-effect-level
UF = Uncertainty factor TDI = tolerable daily intake ADI = acceptable daily intake RfD = Reference Dose
MF = Modifying Factor

Exposure assessment

The reference concentration (RfC) for inhalation and the reference dose (RfD) for oral exposure are the primary quantitative toxicity metrics for use in noncancer risk assessments for chronic exposure. The RfC is an estimate of the amount of continuous inhalation exposure

to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL (no observed adverse effect level), LOAEL (lowest observed adverse effect level), or benchmark concentration, with uncertainty factors generally applied to reflect limitations of the data used. The RfD is an estimate of the amount of daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Risk characterization

Unlike linear dose-response assessments for cancer, noncancer risks generally are not expressed as a probability of an individual suffering an adverse effect. Instead, "risk" for noncancer effects typically is quantified by comparing the exposure to the reference level via a ratio known as the "hazard quotient" (HQ; i.e., the exposure divided by the appropriate chronic or acute value). For a given air pathogen toxic exposures at or below the reference level (HQ=1) are not likely to be associated with adverse health effects. As exposures increase above the reference level (i.e., HQs increase above 1), the potential for adverse effects also increases.

10.4 RISK MANAGEMENT (RISK EVALUATION, RISK PERCEPTION, RISK COMMUNICATION, CONTROL OF EXPOSURE, RISK MONITORING)

Risk management brings together the **evaluation** and **perception of risk** to control exposure to hazards. It is partly a scientific, quantitative exercise in which the results of risk assessment are compared to standards, guidelines, or comparable risks. Having made this comparison, and knowing the assumptions, extrapolations and estimates that go into the two numbers in the comparison, an environmental health professional can determine whether a significant risk is present. The perception of risk by individuals and communities must be taken into account. The **risk communication** can affect risk perception.

The goal of risk perception research is to understand how individuals appreciate risks, how they make their risk-taking and risk-avoiding decisions, and how to bring their understanding of specific risks into congruence with the actual levels of risk.

Risk managers have the goal of reducing anxiety and encouraging people to accept exposures, particularly those that would be costly to mitigate.

Comparisons of lay public versus “experts” consistently reveal that the former views technology as more risky than the latter, apparently independent of the technology and risks. Among scientists, those in the life sciences and those in academia tend to perceive greater risks from nuclear waste than do physical scientists or those in industry or government. The latter are also more willing to impose risks on others. Not surprisingly, employees of a nuclear plant perceived a lower risk of accidents than did the general public.

Demographic factors influence perception in complex ways. In some studies more educated people who may have a better understanding of science and technology are more accepting of technological hazards, but the fact that people of lower socioeconomic status and education fear such developments relates in part to their perception that they personally are at greater risk.

Risk management decisions are of four basic types: priority setting, determination of unacceptable risks, selection of the most cost-effective method to prevent or reduce unacceptable risks, and evaluation of the success of risk mitigation efforts.

After the risk is evaluated and the exposure is controlled as appropriate, the risk must be **monitored** to ensure that it remains under **control**. Usually, the process is interactive and the different steps in risk assessment and risk management may be carried out simultaneously.

10.5 LIMITATIONS AND FUTURE PRIORITIES OF RISK ASSESSMENT

Some of the limitations of risk assessment are inherent in the underlying toxicological and epidemiologic databases, the lack of adequate exposure data, or incomplete outcome ascertainment. Specific issues alluded to above include:

- For the most part risk has been and will continue to be based on published animal research. However, until recently, toxicological research on animals was not designed with quantitative risk assessment in mind, hence the choice of doses and number of animals used may have been appropriate for descriptive purposes, but not for the low-dose extrapolations used in risk assessment.
- Many of the endpoints of concern in humans have not been adequately studied in animal models.
- The uncertainties inherent in extrapolating from animals to humans have engendered controversy.
- Human epidemiologic studies of adequate power are usually too sparse to contribute to risk assessment, hence the continued necessity of relying on animal models.
- Human exposure data are often inadequate.
- In cancer-risk assessments, there are dramatic differences depending on which mathematical model is used.
- Risk estimates based on collective exposure are not easily translated into individual risk.
- The temporal aspects of dose, peak exposures, and duration are generally ignored in chemical risk assessment and only superficially considered in radiation risk assessment.
- There is continuing debate over what constitutes an acceptable risk level, which often overrides biomedical estimates of risk.

Although these concerns interfere with performance and application of risk assessments, the process has become increasingly robust so that it is useful functions in ordering priorities,

in comparing the risks of different solutions, and in providing some data for establishment of policy.

Although risk assessment is criticized as being both over- and underconservative, involvement of stakeholders at all stages coupled with enhanced methods, should converge on greater acceptability. New metrics such as quality-adjusted life years may enhance both the estimation and communication of risk. As with toxicology in general, risk assessment for mixtures is an essential development. Accounting for the duration-dose trade-off is beginning to attract more attention, both for research and application to standard-setting policy. The spatial analysis and depiction of risks is a rapidly growing field. Risk assessment has its detractors as well as exploiters.

10.6 CASE STUDY: CONTAMINATION OF HUMAN PLACENTAS WITH ORGANOCHLORINE COMPOUNDS IN SELECTED SLOVAK REGIONS

The content of this case study was compiled from the results of the wide-ranging risk assessment project under Slovak conditions on prenatal exposure to chemical compounds in relation to childhood allergies accomplished by Reichrtova et al, 1999.

The aim of this study was:

a) To compare the contamination of human placentas with selected organochlorine compounds in 5 regions in Slovakia,

b) To investigate the relationship between placental contamination by organochlorine compounds and the cord blood total IgE level in neonates in two selected regions in Slovakia

Hazard identification

Atopy has a strong genetic component, but environmental and social factors (including lifestyle) appear to have an important relationship with allergic diseases. The fact that allergic diseases have increased in prevalence, especially in the industrialized countries, has evoked an interest in the environmental factors encountered in prenatal and early postnatal life. Human placental contamination with organic xenobiotics may act as a biological marker for the exposure of the pregnant woman, or the foetus via transplacental transfer. The placental barrier is more or less permeable to many xenobiotics (e.g. organochlorine insecticides, polychlorinated biphenyls - PCB are xenobiotics with negative effects on reproductive and immune functions), drugs and hormones. The placental barrier is selective, especially for maternal IgG antibodies, but not IgE. Contrary to the transplacental IgG transport only a small amount of IgE antibodies are present in newborns and it seems that these IgE antibodies are of fetal origin. It has been reported that higher IgE levels in cord blood are a good predictive test for atopy.

Dose response assessment

The study was based on 220 pregnant women in five selected Slovak regions chosen with respect to predominant type of environmental pollution. (Region 1 – Bratislava – the capital city of the SR, polluted by organo-chemical industry, Region 2 – Nové Zámky – agricultural region with high usage of fertilizers, Region 3 – Spišská Nová Ves – the region contaminated mostly from mining of iron-ore and mercury and copper, Region 4 – Košice – the city is known for its metallurgic industry and Region 5 – Stará Lubovňa – it is predominantly a rural region, no source of industrial pollution in this area). Mothers were selected according to the following criteria (40 weeks ± 2), no occupational exposure to organochlorine compounds, residence in the region at least 3 years before conception, and informed consent from the mother. At delivery samples of full-term placentas were

uniformely excised and in two selected regions the sample of cord blood was taken and centrifugated. The concentrations of organochlorine compounds in placenta (selected chlorine benzenes, organochlorine insecticides, polychlorinated biphenyls) were determined by capillary gas chromatography method. The technique based on ImmunoCAP technology was used for the in vitro determination of total IgE concentrations in cord sera specimens. The data from the questionnaires focused on mothers was analyzed and evaluated statistically. The statistical analysis of placental organochlorine compound concentrations revealed that the contents of 12 out of 20 organochlorine compounds analyzed were higher in chemical pollutants in Region 1 when compared to the other investigated regions. However, statistically significant differences with respect to Regions 2, 3, 4 and 5 were found for the following substances: 1,3,5-trichlorbenzene, hexachlorbenzene, alfa-hexachlorcyclohexane and delta-hexachlorcyclohexane. The contents of p, p-DDE (dichlordiphenyl-chlorethylene), PCB (polychlorinated biphenyls) congeners 52 and 180 were found to be significantly higher in agricultural Region 2. It is of interest that among the investigated regions, the lowest concentrations of 9 out of 20 organochlorine compounds were found to be in both regions polluted chiefly by iron-ore mining or iron-ore metallurgy (Regions 3 and 4). Furthermore the highest rate of negative placental samples among the regions was found in these two regions.

The highest proportion of pathological microstructural deviations was found in human placentas collected from Region 1 polluted by organic chemistry, in comparison to rural Region 5. Higher average and median lead concentrations in placentas were found in Region 5 compared to Region 1. The average placental lead content from the rural region was high, possibly due to high non-domestic traffic density at the border crossing between Slovakia and Poland.

Data on the total IgE in cord sera samples of neonates was compared between Region 1 and Region 5. The neonates were divided into three groups according to their cord serum IgE concentrations: 1. group: < 0.7 (negative newborns), 2. group – 0.7-3.5 and 3. group > 3.5 kU/l. A higher number of IgE positive neonates in the second and third group were found in Region 1 as compared to Region 5. The statistically signifantly positive correlation was found for p, p`- DDE and cord serum total IgE level. The findings pointed to an association between organochlorine compounds and the higher levels of total IgE in newborns, signaling a higher allergic sensitization in the industrial region.

Exposure assessment

Exposure to organochlorine compounds can be determined in samples from various tissues, including encountered fetal and placental tissues. Laboratory experiments in pregnant minks after exposure to polychlorinated biphenyls have pointed to morphological changes in fetal and placental tissue demonstrated by degenerative changes in maternal endothelium and extensive placental infarctions. Experimental findings revealed that organochlorine compounds may induce oxidative stress in fetal and placental tissue with resulting tissue damage. The production of lipid peroxides was determined in physiological human placenta as well. Lipid peroxides are responsible for endothelial cell impairment and vasoconstriction, leading to preeclampsia and high-risk pregnancy. Oxidative stress might be evoked by drugs, hormones, and various environmental chemicals such as organochlorine pesticides.

Risk characterization

Our findings demonstrated the global exposure of pregnant women to organochlorine compounds with respect to a predominant type of pollutants in their environment. From an analytical point of view, assessments of human placental contamination with organochloride compounds should be done carefully due to low amounts of the compounds in placental tissue (due to a low fat content in the placenta) relative to concentrations in maternal and cow’s milk. The differences in placental contamination found among the selected regions clearly reflected the difference in major regional human activities aimed at production or utilization of organochlorine compounds. The period of intrauterine development of the embryo/foetus is highly susceptible to adverse impacts of organochlorine compounds. Further research focused on the risk of pregnancy, prenatal pathology and immunology is highly needed.

11. DISASTERS

11.1 DEFINITIONS AND TERMINOLOGY

A disaster is a serious disruption of the function of society, causing widespread human, material or environmental losses that exceed the ability of the affected society to cope with, using only its own resources. It can be interpreted as event that causes great destruction or damage and human suffering.

The common denominator calls for a disruption of such magnitude that the organization, infrastructure, and resources of a community are unable to return to normal operations, following the event, without outside assistance.

The World Health Organization defines a disaster as a „sudden ecological phenomenon of sufficient magnitude to require external assistance“.

The American College of Emergency Physicians (ACEP) states that a disaster has occurred „when the destructive effects of natural or man-made forces overwhelm the ability of a given area or community to meet the **demand for health care**“.

In contrast to disasters, Multiple Casualty Incidents (MCI) have as their primary effects morbidity and mortality to individuals, while the **community infrastructure** remains relatively **intact.**

A passenger train accident with 500 injured and dead occupants is considered an **MCI**. However, if this morbidity and mortality were the result of the release of chlorine gas from a hazardous material accident, a much higher potential for additional casualties would exist. Normal operations and activities of daily living would be disrupted for a longer period, which would be considered a **disaster** by most experts.

Thus, according to the extent of consequences of a hazardous factor impact, an MCI (also MCE as an acronym for Mass Casualty Event) is considered to be the first-degree **emergency**, affecting predominantly **people**, with death, mental and physical injuries, and mental and physical diseases, including common epidemics.

Disaster is a higher degree of emergency, accompanied with damage to natural environment and the occurrence of secondary hazards (fire, disease), damage to infrastructure, breakdown in essential services, displacement of people, loss of property, loss of income and livelihood, breakdown in security.

The highest tip is the **complex emergency** in situations with breakdown in social economic and political structures. Complex emergencies are the result of interrelated social, economic and political problems and almost always involve armed confrontation.

To clarify the contrast between normal emergencies and disasters, ACEP states, emergency medical services routinely direct maximal resources to a small number of

individuals, while disaster medical services are designed to direct limited resources to the greatest number of individuals.

11.2 CLASSIFYING DISASTERS

Disasters can be natural or man-made, abrupt or insidious. **Natural disasters** are precipitated by the forces of nature and weather and their destructive elements (volcanic lava, earthquake force, fire, snow, mud, heat, cold, strong wind, abundant water, or lack of water) in vulnerable places with a high damage potential. They have been with us throughout history and since the down of civilization have jeopardized people and their settlements.

The same can be said for **warfare** and its accompanying destruction, disease outbreaks, and famine.

Technological disasters (explosions, fires, crashes and chemical or radiological release) had emerged since the Industrial Revolution and usually are the result of poor engineering, improper safety practices, or simple human error.

Technological disaster, war and **terrorism** belong to the **man-made disasters.**

For planning purposes is this distinction without practical sense, because these two types of disaster (natural and technological) are frequently mixed.

Artificial structures may collapse as the result of hurricanes or earthquakes. During Hurricane Katrina in the United States, August 2005, emergency personnel had to contend with fires while rescuing people from flooded areas. Gasoline fires in Durunka, 1994, Egypt, were the result of flash flooding that ruptured a fuel storage tank and carried burning petroleum into the nearby town. Volcanic ash in the atmosphere has also been known to cause engine shutdowns in commercial aircraft, leading to in-flight emergencies.

Such synergistic disaster has been termed **NATECH** (Natural-Technological). The menace of them increases when chemical plants, nuclear reactors, or other potentially dangerous industries are seated in geological regions that are highly vulnerable to natural disasters.

Disasters are often classified by the resultant anticipated necessary response:

A level I disaster is one in which **local emergency response** personnel and organizations are able to contain and deal effectively with the disaster and its aftermath.

A level II disaster requires regional efforts and mutual aid from **surrounding communities**.

A level III disaster is of such a magnitude that local and regional assets are overwhelmed, requiring **statewide or international** (in the United States federal) **assistance.**

11.3 NATURAL DISASTERS

Increases in population density and accelerating industrial development in areas subject to natural disasters increase the probability of future disasters and the potential for massive

human exposure to hazardous materials released during disasters. Most natural disasters occur suddenly, and often with little or no warning.

There are several generating mechanisms of natural disasters, such as: earthquake, volcano eruption, tsunami, storm, flood, drought, wild fire, landslide, avalanche, extreme heat wave, cold winter weather, blizzard, meteorite fall. The probability of occurrence of a severe disaster in each of these categories depends on the **geographical location.**

Material damage, caused by natural disasters, has been increasing over time, for a number of reasons, but mainly due to an **increase in exposure**. For instance, humans have massively encroached flood-endangered areas by developing floodplains and coasts, increasing damage potential by the build-up of populations and wealth in flood-prone areas. Urban squatting accompanies high vulnerability to flooding. A similar harm potential represents building up of settlements, in geological areas designed as seismic zones, which are prone to earthquakes, without any respect to special seismic building codes.

Hundreds of thousands of fatalities were caused by **cyclones, tsunamis, and earthquakes.**

The most devastating natural phenomena, with regard to numbers of fatalities, were thought to be earthquakes, till the December 2004**, tsunami**, triggered by an earthquake (Richter magnitude 9.0 to 9.3) in the seabed off the Indonesian island of Sumatra. This tsunami disaster was unique in encompassing a very large area from Indonesia to Africa, including numerous resorts packed with foreign Christmas holiday tourists. The height of tsunami waves reached 30 meters. The number of dead and missing has been evaluated at about 230,000 and the number of displaced at nearly 1.7 million.

About 500,000 people drowned (and 100,000 were missing) during a coastal **storm surge** caused by the Bhola **cyclone** in East Pakistan and Bangladesh in November 1970, while another tropical cyclone killed nearly 140,000 in Bangladesh in April 1991. The Great Kant **earthquake** devastated Tokyo, 1923, Japan, killing 100,000–150,000 people. A more recent, Tang-Shan earthquake, 1976, China, caused the death toll of over 240,000 persons. An earthquake *cum* resultant fires devastated Lisbon, 1755, causing 15,000–40,000 fatalities.

Many people have died of hunger caused by **drought and flood-related famines.**

Heat wave events are associated with marked short-term increases in mortality. In August 2003, a heat wave in Western and Central Europe caused between 27,000 and 40,000 excess deaths, while the death toll of a heat wave in the United States, summer 1980, was between 1,250 and 10,000.

Tens of thousands of people were killed by single **volcanic eruptions**, such as the Nevada del Ruiz volcano in Armero, November 1985, Colombia, with the death toll of 23 – 25,000.

A large number of fatalities have been caused by **landslides** (20,000 were killed in Peru, in 1970), **avalanches (**10,000 fatalities in Tirol, 1916, Austria, and **blizzards,** killing over 300 people in one day in November 1950 in the Eastern United States.

Disaster events, which cause highest economic losses are not necessarily the main killers. The ratio of material losses to number of fatalities grows with the wealth level measured by the GNP per capita of a country. That is, more wealthy countries are more successful in saving life, while material damages cannot be avoided.

According to some definitions, **epidemics** also belong in the category of natural disasters. It is estimated that in the 14th century, pest and famine killed 75 million people in Europe. In

1918 – 1919, the (pandemic) epidemic of Spanish flu killed 25 – 30 million. More recently, the widely-spread infectious disease HIV/AIDS considerably challenged the public health care systems, worldwide.

11.3.1 Floods

Urbanization of many watersheds has adversely influenced flood hazard. Increase in the portion of impervious area (roofs, yards, roads, pavements, parking lots, etc.), leading away of precipitation by channels with a few time for evaporation, reduction of water storage by the loss of natural inundation areas (lakes, wetlands, flood plains), **deforestation** and regulation of watercourses result in faster and higher maximum river flow (water level) generated by intensive precipitation.

Public health issues associated with floods extend beyond concerns for mortality due to drowning. In Bangladesh, the flooding which followed a 1991 tropical cyclone reduced the portability of water from wells and caused wide spread outbreaks of **diarrheal disease**. Flooding may also result in increased numbers of breeding sites for mosquitoes and consequently an increased risk of exposure to their associated diseases, such as **malaria** or **dengue.** Immediate public health actions required following a flood usually include **vector control**, the provision of potable water and food, and the restitution of vital environmental health services.

Most natural disasters occur suddenly and often with little or no warning. Overall, however, early **warning systems**, improved **evacuation plans,** and the **discouragement of settlement** in flood-prone areas may have much greater potential to save lives than activities associated with external emergency response to flood disasters. The recent Indian Ocean tsunami illustrated the limitations of response activities in curtailing mortality during rapid flooding; most victims in this disaster were carried out to sea and drowned.

The basic cause of river flooding is heavy rainfall in upstream catchments areas, sometimes in combination with snow melt. Obstruction downstream exacerbates the problem. **Flash floods** occur within hours (or minutes) of excessive rainfall, a dam or levee failure. These floods can roll boulders, tear out trees, destroy buildings and bridges and scour out river beds. They are the biggest cause of weather-related disasters. **Slow flooding** occurs mainly in the lower-lying flat lands and deltas, during seasonal weather variation, when contributory rivers exceed their banks.

Some experts in hydrology think that the substantial reason of torrents, floods, windstorms and storms is the **disturbance of the natural water cycle** and an unequal evaporation of precipitation, limited in towns and cities, as mentioned above, but also in lands with diminished soil penetration and its capability to absorb and retain water (deforestation, balks abolishment etc.)

Among mitigation strategies considering flood and its consequences an important place takes the process of building the **flood preparedness system** that may include some of the following components:

- Rigorous implementation of zoning – land use management to limit the use of floodplains for the site of vulnerable elements (including human settlements, industrial infrastructure, etc.).
- Relocation of riparian inhabitants and structures out of the floodplain.
- Raising awareness of the floodplain communities.
- Building an effective and reliable flood forecasting and **warning system**.
- Engineering of structures in the floodplain to withstand flood forces (dikes, flood walls with opening barriers, dams, storm water drainage systems).
- Adaptation of building codes, e. g. building design to elevate floor levels, use of flood-resistant building materials (water resistant materials, waterproof seals, strong foundations), placement of storage and sleeping areas high off the ground.
- Development of system of flood insurance.
- Development of preparedness system for the case when the existing structural defenses (dikes) will not be able to restrain the flood waters, flood evacuation preparedness including identifying shelters, preparing boats and rescue equipment; emergency plans with clear division of competencies and responsibilities of agencies.

11.3.2 Fires

Unlike windstorms, floods and earthquake, which are impossible to restrain, fires often arise owing to the **negligence and carelessness** of human (dysfunction of chimney, defective rods, short circuits, burning of the grass and coppice, play with safety matches, butts thrown away), if they are not set **intentionally.**

Fires may flame up by the influence of nature forces too, as the lightning strike or the self-ignition, resulting from exothermic chemical reaction of organic compounds and the activity of thermophilous bacteria by smolder (in forests, hay ricks, refuse damps).

Forest fires are common in countries with hot and dry climate, and arid zones. At high air temperatures and a long-term absence of rain, it is very difficult to cope with them. They cause immense economic and ecological damages. **The majority of fire products is toxic** causing, together with heat generating, a considerable number of deaths.

Also a system for **wild fire mitigation** includes measures to constrain the wild fire (planting of fire-resistant vegetation and wild fire breaks) and to improve the system resistance. The latter category includes zoning (land use management to limit development in high wild fire risk areas); appropriate sitting of structures (away from the top of slopes or ridges); **building codes for fire hazards**; fire resistant building-materials; removing wild fire "fuel" (rubbish, branches, leaf litter) from around house and gutters; **secure storage of flammable materials** (fuel, wood, paint).

Development of a fire weather warning systems and improvement of community awareness of wild-fire risk is necessary. A **fire evacuation plan** should be in place, and **sufficient water supply, hoses and protective clothing** should be available.

11.3.3 Cyclones and tornados

Severe storms arising over warm tropical waters in the Atlantic region during the summer months are known as **hurricanes** (from the indigenous term „Hura Kan", or „winds of the gods"), while those, developing in the Pacific Ocean and the China seas are called **typhoons.** The common name is cyclone.

Cyclones are large-scale storms characterized by low pressure in the center (the eye – with quiet weather conditions and the blue sky), surrounded by circular wind motion with strong winds, and rain.

A hurricane covers a **circular area** 300 to 700 km in diameter whereas the calm eye is about 20 – 30 km across. The wind speed can sometimes reach 300 km per hour. Owing to the rotating movement, winds from hurricanes can hit a location from any direction. Many casualties are caused after the eye passes over an area, and people have emerged from their homes and shelters, thinking the storm is over. Then the winds suddenly strike from the opposite direction, surprising the exposed population.

Injuries or deaths can result from drowning, electrocution, blunt trauma from falling trees, lacerations from flying debris. People, after leaving their shelters, should be advised against wading in water, as there may be downed power lines, broken glass, metal fragments, or other debris beneath the surface.

Wind and debris will cause **damage to structures** (roofs, doors, windows). Mains are often ruptured by uprooted trees, telegraph poles and pylons. River intakes and mains may become clogged with debris and silt. Heavy rains cause floods. However, the greatest damage to life and property is not from the wind but from tidal surges and **flash flooding**, since a distinctive characteristic of hurricanes is the increase in sea level often referred to as the **storm surge.**

Hurricanes are tracked by satellites from the moment they begin to form, so **warnings** can be issued three to four days before a storm strikes. They are categorized from one to five on the Simpson-Saffir scale, indicating wind speeds from 120 km/h upwards.

Tornados are rapidly whirling, funnel-shaped air spirals that emerge from a violent thunderstorm and reach the ground. They can have a wind velocity of up to 300 km per hour and generate sufficient force to destroy massive buildings or to raise and move away trucks and cars.

While hurricanes tend to last longer, tornados are generally short-lived. The average circumference of a tornado is a few hundred meters, and it is usually exhausted before it has traveled as far as 20 kilometers.

One can considerably improve the **system resistance** by engineering structures to withstand wind forces; sitting of buildings on leeward side of hillsides; adapting wind-load parameter in building codes; good quality construction of wind-resistant buildings; adequate

securing of elements which could be blown away or cause damage; trimming of tree branches and cleaning of gutters. It is necessary to develop severe weather **forecasting and warning** systems, to raise **community risk awareness**, and to provide safety shelters and evacuation plans. In the gale-wind preparedness system, land-use management can improve protection from wind, e. g. by planting of windbreaks.

11.3.4 Earthquakes

Earthquakes typically cause traumatic injuries and deaths, as well as destroying buildings and infrastructure. Earthquake-prone areas are called seismic zones.

It is still not possible to warn of an impending earthquake, consequently, the occurrence may be sudden and unexpected.

The Tang-Shan disaster brought more than 200,000 sudden trauma-related deaths. The relatively moderate (Richter scale 6.6) earthquake in Bam, 2003, resulted in at least 30,000 deaths, largely due to trauma sustained when earth and mud buildings collapsed on inhabitants. The earthquake in Kobe, 1995, Japan caused 5,000 immediate deaths and created the need for an urgent and massive relief effort.

The Richter scale is often used to express the seismic magnitude or energy released. This is an open ended scale, but an earthquake of magnitude two would only be detected by very sensitive instruments, while magnitude eight would result in total destruction of structures, deformation of the ground and objects thrown into the air.

In contrast to most floods (the recent Indian Ocean tsunami excepted), the **morbidity** and mortality of earthquakes is much more **immediate**. Deaths are primarily due to crush injuries and other trauma resulting from unstable, collapsing, or crumbling buildings.

Earthquakes are not usually followed by long-term public health problems such as famine or epidemic diseases, although following the Northridge earthquake of 1994, a wide range of external primary care services were required by the population for up to 4 weeks.

Other **public health issues** associated with earthquakes include concerns for the health of persons in shelters, occupational health protection for rescue workers, and the provision of mental services for survivors.

In terms of **prevention** it is advisable to avoid building installations on fault areas, loosely compacted soils or sandy soils saturated with water. Disaster-resistant building techniques should be applied for new structures, and existing structures reinforced.

In an **earthquake preparedness system**, it is necessary to improve the resistance of the system by seismic zoning. Land-use management should reduce development in geological areas known to amplify ground vibrations, e. g. alluvial soils, reclaimed land. Upgrading structural design is needed, by engineering of structures to withstand vibration forces; compliance with seismic building codes, enforcement of generally higher standards of construction; adequately high design standards for important buildings, and strengthening of existing buildings (retrofitting).

11.3.5 Volcanic eruptions

Worldwide more than 500 volcanoes are active, but eruptions have occurred from volcanoes previously thought to be extinct. Most volcanoes are continually monitored, as the majority of eruptions are preceded by very subtle and complex signs and can, to a certain extent, be predicted. The exact date of an outbreak can not be predicted, but the likelihood and the intensity of it does.

The principal products of volcanic eruption are asphyxiating gases, ashes, lava and stone fragments, lava flow, falling debris, fast flowing avalanches of hot ash and gas, which destroy and kills everything in its path. Lahars (mud flow) are formed by heavy rainfall, release of water from crater lake, or rapid melting of snow and ice on the volcano peak. They can sweep down valleys, far from volcano, covering them with debris, several hundreds of meters thick. Flows of molten lava leave the land completely useless for years to come.

Volcanic eruptions may result in injury or death also due to explosive blast effects. **Volcanic gases** are irritable (eyes, throat), do harm to vegetation and corrode metal. Fluoride and carbon dioxide gases can be deadly in high concentrations.

One of the most unusual gas releases associated with volcanic activity occurred in Cameroon, 1986. In this incident, carbon dioxide was released from an active volcano underneath Lake Nyos. The gas enveloped nearby villages and caused approximately 1,700 deaths by asphyxiation.

11.4 MAN-MADE DISASTERS

Man-made disasters may be caused by accidents, unfortunate, undesirable, unplanned and unforeseen events, which may, or may not, result from carelessness or ignorance. Accidents trigger economic loss, injury, or death, air pollution, water and soil contamination till up to the ecological catastrophe. They can be classified into a number of categories:

Industrial (technological) accidents, related to human **production activities** (especially chemical industry, metallurgy, mining), include explosions, fires, release of chemical substances into the environment, wild fires, nuclear and oil accidents as well as results of an improper treatment of toxic waste and its irresponsible disposal.

The mercury poisoning in Minamata, and the Itai-itai disease, due to cadmium poisoning, both in Japan, have arisen from a long-term consumption of fish and other sea animals, caught in bays, where the chemical factories had discharged toxic waste water.

Among the man-made disasters in the 20th century, with considerable or disastrous health and environmental consequences belong: the toxic gas leak (methyl iso-cyanate) at Bhopal, 1984, India, (7,000 fatalities); explosion in chemical plant in Seveso, 1976, Italy, with release of very toxic dioxin gas; disaster in nuclear power plants – the Three Mile Island, and the nuclear reactor accident at Chernobyl; the extensive chronic environmental pollution in several former Soviet block nations; the acute environmental catastrophe associated with the Exxon Valdez oil spill; the oil spill and oil fires generated by Saddam Hussein in Kuwait, one of the widely known man-made environmental catastrophes.

A large mining disaster in Honkeiko, 1942, China, caused 1,549 fatalities, while explosions in Greece, 1856, killed about 4,000 people. A large fire in Sandoz works in 1986 caused inflow of 30 tons of mercury pesticides

into the Rhine, which devastated life in the river. In 1989, in Asha, Ufa, Bashkiria, USSR, over 500 people were killed by explosion and fire caused by leakage in a long distance pipeline and sparks from passing trains.

Transport accidents in passenger and goods traffic on roads, railway, rivers and the sea; rail, car or bus, and plane crashes; sinking of ships and tankers. Serious consequences may have an accident in haulage, by crashes of trucks and tankers, transporting hazardous substances.

Damage on construction as the buildings and bridges collapse, ruptures of water, gas and petroleum pipelines, destruction of timbering in mines with following mine caving, dam and water reservoirs breaks.

A unique case of dam break, which caused several hundred thousand fatalities, happened in China, when a dam on the River Huang He was blown up in order to halt the Japanese invasion.

Warfare and armed conflict with the use of conventional weapons or the weapons of mass destruction.

Intentional actions as terroristic acts, arson and sabotage.

11.4.1 Technological disasters

Technological accidents are recognized as an important and increasingly common producer of public health problems. They are usually the result of poor engineering, improper safety practices, or simple human error.

The potential for harm from improper management of industrial technologies is a major concern in developed nations where at any given moment there are myriad complex industries in operation and tons of hazardous materials in transit through populated areas.

Accidents and breakdowns in the industry are, in the majority of cases, connected with the **release of chemical substances**, endangering immediately or later the health of citizens, as well as animals, and causing damages on the environment and of properties.

The release of chemical substances in all states of matter (solid, fluid, gaseous) is usually going on in the form of a triad of following processes: **explosion – fire – release.** The gaseous and volatile matters (fluids that easily evaporate) are more hazardous because they spread in the wind direction and can infest large areas.

In fires of chemical substances the smoke is enriched with **toxic fumes** of belonging chemical that are often more toxic than the original raw material. In such cases is better not to extinguish the flames with water (to hinder their penetration into the soil), and to leave the fire burn away, protecting only its neighborhood.

The majority of toxic gases is transported or stored in compressed or liquefied state. In case of release they start immediately evaporate with the following extreme **decrease of temperature** in the proximity of the accident. The affected persons may sustain frostbites and lungs damage. The low temperature increases the fragility of rubber, plastics and metals that can cause the failure of respiratory devices and other means of the individual protection of firemen and other rescue persons.

Dealing with the **consequences** of a technological disaster or a NATECH presents many challenges. Recognizing the nature of the hazardous material, evacuating citizens after an accident, providing appropriate medical care for victims, and protecting emergency responders against hazardous exposures are but a few of the many tasks that emergency responders potentially face.

In addition, because industrial disasters may leave **toxic residues** in the environment that pose ongoing threats to the health of populations, the initiation of chemical exposure and disease **registries** (in order to track adverse health effects of disaster victims over time) may be a fundamental component of emergency response. Clinical investigations following technical disasters may require assistance from laboratory scientists, toxicologists, and environmental epidemiologists.

Public health prevention efforts include sound **plant design and operation**, safe disposal of waste products, thorough safety occupational programs, linkage to local emergency management operations, and proper **site selection** for industrial facilities.

11.4.2 Transport of hazardous substances and hazardous waste

Hazardous chemical substances are constantly transported from places of their production to depositories or on sites of their further application. Much more serious is the transport of **chemical and radioactive waste.**

Developed countries try to get rid of it because of increasing demands on the environmental protection, transferring it to the countries with fewer restrictions and less severe regulations. This is about developing nations or those countries, which prefer to receive the financial compensation for the agreement. Most of these countries are not able to store or to liquidate it properly, and to control the possible penetration of harmful substances into the soil, water and in the air.

Since the year 1989 the cross-frontier moving of harmful waste has been guided by the **Basel Convention.** The most important issue of its six principles is the, in writing confirmed, agreement of the countries with the transit and import of hazardous waste, on the assumption that they exactly know about the contents of transported load.

11.4.3 Warfare and armed conflicts

One special category of man-made disasters are wars, including the two World Wars in the 20th century, with a legacy of hundreds of millions of victims – dead, wounded, long-term affected, and with an immense human suffering, culminating in terrifying Hiroshima and Nagasaki events in August 1945.

Conflict-related disasters are a growing phenomenon, in particular on account of increasing armed conflicts in the world. War has always been destructive, but in recent years the nature of armed conflict has become increasingly more devastating, including in the increase in the ratio of civilian deaths to combatant death.

The insidious cycle of **armed confrontation, famine and population displacement** has been described with the growth of the number of refugees worldwide, as well as the number

of internally displaced persons. The **public health problems** of that are often overwhelming. Crude mortality rates among displaced population rise markedly above baseline levels, principally due to **nutritional shortages, environmental problems, and preventable infectious diseases**. Conflict-related disasters have similar effects on those, who do not flee when infrastructure is destroyed or severely damaged, thereby limiting their access to food, potable water, basic medical services, and the possibility of the appropriate refuse disposal. Nevertheless, a direct and primary cause of morbidity and mortality may be **violence,** disregard for humanitarian law, and abuse of human rights („ethnic cleansing" operations).

The provision of **emergency relief** can be very dangerous. Many relief workers have been killed in recent years. The protection of them is often a major challenge of disaster relief operations. The provision of **humanitarian relief** can be easily perceived as a partisan act, or can be manipulated for the benefit of different warring factions.

Development initiatives, weapons control, conflict resolution and other such measures may be more effective ways of preventing mortality in situations of conflict than the traditional medical and public health interventions; some experts consider them as an exacerbation and prolongation of the conflict.

The **military relief** of wealthier nations, personnel and operational, with their robust capabilities (food, transportation, medical care, and logistics) is invaluable in disaster response. An improvement in relations to the nongovernmental relief organizations (NGOs) and more understanding on both sides would contribute to better results in their activities.

One of the most extensive public health catastrophes today concerns the worldwide dissemination of **landmines**, responsible for more than 15,000 fatalities each year. Many landmines are designed to maim, which means augmented burden to emergency surgical services (the need of limb amputation) and requires prolonged rehabilitation for victims. This has had devastating impact on the individuals, the economies, and the health-care systems of many developing nations.

Landmines impede the resettlement of displaced populations and serve to remove land from cultivation, as well.

11.4.4 Terrorism

Terrorism by its very definition is primarily designed to produce **fear and panic** in population. The formerly held view that terrorists, motivated largely by political aims, avoided large numbers of casualties (as they would turn away potential supporters), has recently been supplanted, in many cases, by the religious or ideologically motivated views of groups such as al-Qaeda. These groups seem to have no hesitation about the production of massive numbers of casualties. Even though the number of victims in particular cases would be small the **cumulative toll of terrorism** worldwide has been immense.

While small-scale terrorist endeavors, such as kidnappings and assassinations have been with us for centuries a recent emphasis on the possible employment of **weapons of mass destruction** (**WMD**s) and the production of large numbers of casualties in a single event has caused terrorism to be considered a potential cause of large-scale disasters. Even if the

number of casualties arising from most individual terrorist attacks is still dwarfed by those, due to natural disasters (earthquakes, tsunamis, and floods), an increasing **sophistication of terrorist methods** and an increasing **destructive capacity of terrorist weapons** (the possibility to develop nuclear devices as small portable units such as „dirty-bombs") has caused terrorism to become **the scourge** of the twenty-first century.

The willingness and capability of the part of terrorists to employ WMDs have been demonstrated by the attack on the Tokyo subway system, perpetrated by the Japanese doomsday cult Aum Shinrikyo (a **chemical weapon**, the nerve agent sarin) and the release of anthrax-contaminated mail (a **biological weapon**) following the terrorist assaults on the Pentagon and World Trade Center on September 11, 2001, resulting in 2,992 deaths. These attacks were an „innovative" unprecedented intentional mass killing. Passenger jets with many people onboard, fully fueled, and were taken over by terrorists who crashed them against most important buildings with very high damage potential.

Many disaster planners employ the acronym CBRNE (chemical, biological, radiological, nuclear, explosive) to encompass all the potential terrorist weapons. The possible use of them has focused considerable attention on public health and disaster preparedness, and has called for **unique disaster response issues**. Such issues include, in addition to conventional disaster response considerations, the need for rapid characterization of the offending agent, mass decontamination, ready access to antidotes and medications, specialized medical training, and proper protective equipment for emergency responders.

While each of these weapons brings with it these unique methods of response, it is the **psychological and psychosocial impact** that is likely to define a disaster associated with terrorism.

11.5 ENVIRONMENTAL AND HUMAN HEALTH ASPECTS OF DISASTERS

Consequences of disasters can be divided into **direct** ones (caused directly by disasters) and **indirect** ones, which may occur over a longer period of time, even years after, such as in case of nuclear accident.

As a rule, after a major disaster, buildings are damaged, or rendered unsafe. Utilities are discontinued. There is no electricity or safe water, food supplies are spoiled, cars are disabled or destroyed. There is significant damage to the infrastructure including roads, railways, and bridges, health clinics and hospitals, schools and public buildings, levees, industrial installations, irrigation channels, affecting large cropland. There is vast damage to personal property. Survivors leave their communities for the relative safety of displacement camps. Since disasters ruin the domiciles of many of those evacuated, **homelessness** becomes a problem. Disasters paralyze social systems. Many businesses are damaged, and all are closed in the immediate aftermath. Hazards may be greater when industrial or agricultural land adjoining residential land is affected.

Heterogeneous substances, having got into the **atmosphere**, may contaminate soil and water, resulting in long-term toxic exposures to the population and exacerbate respiratory illness in persons residing down-wind.

The **flood water** is enriched with all chemical and biological elements that were dissolved or flushed from flooded spaces and surfaces on its destroying route, taking them far away. Therefore foodstuffs of all kind that has come into contact with the flood water have to be considered as contaminated, with the exception of those, in waterproof packing. In the majority of cases they must be liquidated.

Direct health-related impacts of disasters are: deaths, injuries, communicable diseases and mental health problems. Health effects may result from unsafe or unhealthy conditions (lack of safe drinking water, spoiled food supplies) following the disastrous event.

Indirect effects arise through economic disruption, infrastructure damage and population displacement, which leads to an increase in communicable diseases resulting from over-crowding, lack of clean water and shelter and poor nutritional status.

There are **short-term** health effects (injuries, stress associated with disaster) and **long-term** health consequences – psychiatric disorders, depression, anxiety, substance abuse, functional disabilities, and domestic violence.

Malnutrition and famine triggered by disastrous events may be among the most important consequences of a natural disaster, and may outnumber the direct fatalities. In areas hit by a disaster with no evacuation warning, the hardship can be even more intense. The impacts of disasters are particularly severe in less developed areas, featuring environmental degradation, and in communities lacking basic public infrastructure.

There has been vast evidence of disaster impacts on **mental health**. The prolonged impairment from common mental disorders (anxiety and depression) may be considerable. Some survivors suffer from **post-traumatic stress disorder** (PTSD). It is a psychological damage that develops after a traumatic experience and is almost always a **delayed reaction** to the trauma. Among the symptoms of PTSD is vanished sense of security, fear of another calamity, hyper vigilance, fatigue, poor concentration, feeling nervous or tense, depression, anxiety or stress, and psycho-somatic experiences (sleep disturbances, appetite difficulties, etc.). Those, who experience disasters, are prone to severe stress. People get into a state of shock and their rational thinking processes fail to function normally. Their ability to cope with problems of life and their sense of security is undermined.

Health impacts of disasters also fall under the categories of medically unexplained physical symptoms (**MUPS**) and functional somatic syndromes (**FSS**).

11.6 DISASTER PLANNING AND PREPAREDNESS

Human factors play an aggravating role in almost all disasters, even natural ones. The risk to a population to disasters may be enhanced by local vulnerabilities within a community, such as poverty, population density, type of construction, lack of disaster planning.

The low mortality in the developed community with emphasis on **prevention and mitigation activities** was thought to be due to better local emergency medical service,

disaster management services and due to enforcement of local building codes. Two cases of earthquakes of similar force need not have the same consequences in different communities.

Disaster could be understood as a trigger event that exposes and exacerbates societal problems and weaknesses. Food shortages and famine, triggered by drought, have been primarily the result of armed conflict, inadequate economic and social system, failed governments and other man-made factors. Effective dealing with social problems, on which the **complex emergencies** depend, requires close integration of relief efforts with political, social, economic, military, cultural and other activities.

A framework for disaster planning and response provides National Response Plan (NRP), achievable in developed nations. Efforts at disaster planning and response during complex emergencies, in developing nations obviously, must be tempered with the realities (inadequate infrastructure, severe resource constraints and warfare). The institutional response to any disaster, natural or man-made, begins at the **local level**.

Some issues of medical and public health functions, which should be considered in disaster planning and response at the local level, were drafted by authorities at the California Emergency Medical Service.

1. **Medical needs assessment** Reliable information should be obtained regarding the extent of the immediate needs of a disaster-stricken population and the status of their supporting public health infrastructure. Such information should describe a population specific need for various emergency relief services and identify the extent of the needed response.

2. **Health surveillance and epidemiology** Surveillance systems should be established in sentinel sites (such as clinics) in order to monitor the health of the population and gauge the effectiveness of ongoing relief programs. Targets of **public health surveillance** include deaths, the appearance of malnourished children and the occurrence of vaccine-preventable infectious diseases. Rapid assessment of the nutritional status of a population, investigation of outbreaks, surveys of vaccine coverage and surveys for the prevalence of certain diseases are targets of more focused investigation.

3. **Identification of medical and health resources** Personnel, equipment and supplies available locally, should be inventoried in advance and a realistic assessment made, regarding ancillary resources from regional, state or foreign countries sources, in case of necessity. Memoranda of understanding and contracts should be worked out between response agencies and local private sector institutions. It must be remembered that one person might be engaged and registered in more response organizations, and multiple agencies often rely on the same personnel. Such problems should be identified and resolved before a disaster occurs.

4. **Medical and evacuative transportation** During the planning process ground and air ambulance resources should be catalogued and alternative sources of patient transport and jeopardized inhabitants, such as bus companies, owners of bigger (lorries, vans, wagons) and all possible **vehicles,** might also be examined. Primary reliance on such alternative methods

of transport is often a necessity in resource-poor regions and developing nations. During many disasters, patients will arrive at treatment facilities by any means available. Affected or only „worried well" people often prefer the private vehicles, instead of calling and waiting for the ambulances. In contact with organizations and people, possessing **vessels** of any kind (powerboats, boats, canoes, rubber dinghies, rafts), the sufficient number of means to save and evacuate people from flooded areas should be ascertain.

5. **Patient distribution and evacuation** Regional disaster response plans should plan for the rapid establishment of casualty collection and **triage points** and project the number of casualties to be sent to each of the participating hospitals, regarding also the emergency community and ambulance assets for patient transportation. Deployment of **portable military field hospitals** to bring medical assets into close proximity to afflicted population has turned out very useful in cases of the hospitals and communication infrastructure destruction. That obviates a requirement to transport patients over long distances.

6. **Pre-hospital emergency services** The external medical rescue services after earthquakes, hurricanes, and explosions to treat injured persons and to extract survivors trapped in collapsed buildings, or squeezed in mines, led to the development of **specialized emergency services**, designed to extract and treat entombed victims. Extrication has evolved into a **fire services function** in most of the country. They are provided with specialized technical and trench rescue teams and have more experience with building collapse and secondary hazards (floods, fires) than other organizations.

7. **Hospital emergency services** An important triage and treatment role in disaster response play the **emergency departments**. After acute disasters with numerous victims such as earthquakes, fires, explosions, tornados, hurricanes emergency facilities can rapidly become overrun and resources exhausted. In the event of a chemical attack or **toxic exposure** they can quickly become contaminated, and the staff and all persons assisting by the decontamination exposed to the toxic substance.

Local **emergency facilities** must be incorporated into the disaster response planning, although they are mostly unavailable in the developing countries nowadays, and in chronic ongoing disasters, such as famine and war, they play a lesser role.

8. **In-hospital care** All hospitals and health-care institutions should have plans in place in the event of a disaster. They are directed to conduct a hazard vulnerability analysis, to develop an **emergency management plan** and evaluate this plan annually. The planners should also develop reasonable estimates for **bed requirements** (by number and type) as well as the number and specialty of the supporting **health-care providers**, necessary to staff the beds.

Such a plan must include an all-hazards command structure which is linked with local governmental **incident command system** (ICS). Depending on its structure and function, search and rescue may fall under the direction of **fire, emergency medical services (EMS), or police (security) forces**. A cooperative approach is necessary and the very act of search and rescue must be highly organized to ensure adequate and complete coverage of all areas.

9. **Out-of hospital care** Other medical and domiciliary facilities such as nursing homes, home health-care facilities, community and public health clinics should also be prepared to respond in the event of a disaster. However, the planners must remember the fact, that such facilities usually don't have the **backup power generation** capability as the hospitals do, what in case of blackout may cause problems, the worst of them, the failure of respiratory devices and other medical equipment.

10. **Temporary field treatment** The local disaster plans must address the provision of temporary field treatment not only for cases when the medical treatment facilities are overwhelmed or destroyed and the next one is in a great distance away. Prompt and proper treatment in the field may be necessary to save lives.

11. **Food safety** Food distribution plans need to be incorporated into disaster response plans of governmental and non-governmental organizations, because in the aftermath of mass casualty disasters, **food processing and distribution** may be seriously disrupted. There is a need to identify the most vulnerable population (children, lactating women, and the elderly) and to deliver adequate quantities of food, containing essential nutrients – protein, essential lipids, and vitamins. (Food staples delivered by military services to afflicted population during 2004 tsunami consisted of rice and noodles). The use of prepackaged field rations may be a short-term solution. The disruption of **refrigeration and cooking** in the wake of the disaster brings up the necessity of people education, to acquire the **basics of food hygiene**, preparing, in advance, fact sheets on food safety.

The **deliberate contamination** of food, as a means of biological terrorism, is difficult to differentiate from sporadic point-source endemic food-poisoning events. Fortunately this means of biological terrorism would be less effective than a well-executed aerosol attack. An effective response to a food borne biological attack would utilize the same **important steps** used to counter naturally occurring food borne epidemics: recognition of the epidemic, identification of the etiologic agent, limitation of ongoing exposure, treatment of casualties, and prevention of future outbreaks.

12. **Management of hazardous agent exposure** The release of chemical, biological and radiological agents into the environment may be caused intentionally, but more often accompanies natural disasters or industrial accidents (ruptures of gas and petroleum pipes, sewage conduits, chemical storage tanks, washing away agricultural and other chemicals in floods, release of infectious agents from damaged microbiological laboratories). The **time is often critical** in limiting the effects of such contamination; therefore this function becomes a local responsibility. Local responders and governmental functionaries must have a **basic understanding of hazardous agent management and response.**

13. **Mental health** In addition to traditional public health concerns disasters may present medical responders with patients who are suffering from complaints that are predominantly **psychological** in nature. Mental health concerns may include the need for psychological triage and treatment programs not only for victims but also for the emergency response

personnel that are equally subject to stress and its short- and long-term effects, especially those, involved in post-disasters management of decedents.

14. **Medical and public health information** One of the most important means of limiting the psychological trauma associated with a disaster is to provide timely **consistent information** and risk communication.

A disaster can provoke fear, uncertainty and anxiety in the population, resulting in overwhelming numbers of patients seeking medical evaluation for unexplained symptoms and demanding antidotes for feared exposure. This „behavioral contagion" is best prevented by **risk communication** from health and government authorities, which includes a realistic assessment of the risk (or lack thereof) of exposure, information about the resulting disease, and what to do and whom to contact for suspected exposure. Communications with local media to make sure that the public receives appropriate information and recommendations is equally useful and welcome.

Effective risk communication is predicated upon the well-conceived **risk communication plans and tactics**, as well as plans to rapidly deploy local centers for the administration of post exposure prophylaxis, to develop patient and contact tracing, to access and distribute stockpiled vaccines and medications and to prepare local facilities and health-care teams for the care of mass casualties.

15. **Vector control** Certain disasters have been associated with a dramatic increase in the incidence of **vector-born diseases** as was the malaria epidemic among the Haitian population, following Hurricane Flora in 1963 and after the slowly developing El Nino „disaster". Meteorological events such as cyclones, hurricanes, and flooding can affect vector-breeding sites. While initial flooding may wash them away, **standing water** caused by heavy rainfall or overflow of rivers can create new breeding sites. This situation, with typically **some weeks delay**, can result in an increase of the potential disease transmission. **Dengue** transmission is similarly influenced by meteorological conditions (rainfall and humidity). Thus, the **control of mosquitoes** and other insect vectors is an important component of disease prevention following such disasters.

16. **Potable water** The most important relief commodity ensuring the survival of disaster-affected populations is the potable water, for drinking, cooking and the adequate personal hygiene. The human daily requirements (at least 15 – 20 liters pro person and day) increase in heat stress and psychical activity. Additional allotments of water to support clinical facilities, feeding centers and other public health activities must be planned.

17. **Waste management** The principal public health thrust of sanitation measures in emergency conditions is to reduce **fecal contamination** of food and water supplies by the way of the proper management of human waste. Earthquakes and floods frequently cause damage to sewage treatment facilities and the cross-contamination of normally potable water sources. Communicable diseases that can be transmitted through contact with human feces include typhoid fever, cholera, bacillary and amoebic dysentery, hepatitis, polio, schistosomiasis, various helminth infestations, and viral gastroenteritis.

Temporary latrines, including pits, trenches, and other chemical toilet methodologies can be established in a disaster site.

18. **Communicable disease control** The risk of outbreaks after disasters is frequently exaggerated. The fear is likely derived from the association between dead bodies and epidemics. Human remains do not pose a risk for outbreaks when death is directly due to the natural disaster (blunt trauma, crush related injuries, drowning). The **risk factors** for outbreaks after disasters are associated primarily with **population displacement**. Natural disasters (regardless of type) that do not result in population displacement are rarely associated with outbreaks.

Outbreaks are less frequently reported in disaster-affected population than in **conflict-affected population,** in which the **malnutrition** is more common and increases the risk for death from communicable diseases. However, disaster conditions often serve to facilitate disease transmission and increase individual susceptibility to infection. Infectious diseases often occur in a population that moves to a **new location**, where an unfamiliar disease is **endemic** (malaria epidemics among people displaced to a malaria endemic area).

The effective response to the needs of the disaster-affected population requires an accurate **communicable disease risk assessment,** on the basis of which the **priority interventions** are able to be determined.

Such evaluation should identify: endemic and epidemic diseases that are common in the affected area; characteristics and living conditions of the affected population, including number, size, location, and density of settlements; availability of safe water and adequate sanitation facilities; underlying nutritional status of the population; immunization coverage among the population (the level of immunity to vaccine-preventable diseases); the access to healthcare services.

Disease outbreaks during **complex emergencies** are usually the result of many factors, including a breakdown in environmental safeguards, crowding of person in camps, lack of appropriate immunization programs, malnutrition, inadequate case finding, and limited availability of appropriate curative medical services.

The following **types of communicable diseases** have been associated with populations displaced by natural disasters of the last years. (floods, 2004 tsunami, earthquakes and hurricanes).

Flooding was identified as a significant risk factor for **diarrheal illnesses**; the risk for them is higher in developing countries than in industrialized ones (drinking of contaminated water from unprotected wells and water sources by survivors and evacuees). Among the **infectious agents** were confirmed: *Vibrio cholerae,* enterotoxigenic *Escherichia coli, Salmonella enterica Paratyphi A, Cryptosporidium parvum*. Rapid case finding and aggressive treatment (rehydration, antibiotics) can substantially reduce the consequences of diarrhea outbreaks. The outbreaks were controlled after the adequate water and sanitation facilities were provided.

Hepatitis A and E as cases of acute jaundice, occurred more often as clusters, because of developed immunity in peoples living in areas, where the hepatitis is endemic.

Leptospirosis is transmitted through contact of the skin and mucous membranes with water, damp soil, mud and vegetation, contaminated with rodent urine, containing the infectious agents. Leptospirosis was described at many places of the world after flooding, which facilitate spread of the organism because of the proliferation of rodents and their moving to the human's proximity, seeking safety at higher grounds.

Principal representants of diseases associated with **crowding,** that is common in displaced populations by natural and especially conflict related disasters are **measles, acute respiratory infections** (ARI), **meningitis, and malaria.**

Crowded living conditions facilitate measles transmission and necessitate even higher immunization coverage levels to prevent outbreaks. Emergency **measles vaccination programs** along with the administration of vitamin A are critical and highly effective measures. Prompt response with **antimicrobial prophylaxis** can interrupt transmission of *Neisseria meningitidis.*

Acute respiratory infections are a major cause off illness and death among displaced population, particularly in children under 5 years of age. ARI accounted for the highest number of cases and deaths among those, displaced by the tsunami in Aceh in 2004 and by the 2005 earthquake in Pakistan. Incidence of ARI has increased 4-fold in Nicaragua after Hurricane Mitch in 1998.

Lack of access to **health services** and to **antimicrobial agents** for treatment increases the risk for death from ARI. That is, what must be considered in the proactive response and preparedness planning. Similar requirement concerns the well estimated amount of remedies for malaria treatment and antitoxic sera to cope with the *Clostridium tetani* infection of wounded people.

An unusual outbreak of **coccidiomycosis** among emergency responders occurred in the aftermath of the Southern California earthquake in 1994. This outbreak was associated with subsequent landslides and exposure to **airborne dust,** contaminated by the fungus *Coccidiodes immitis* that used to be found in the soil in certain semiarid areas of North and South America.

19. **Animal control** Care of animals, domestic, wild, and "pets", which also have to be rescued, evacuated, and transported is a part of disaster response activities, thus must be considered in disaster preparedness. Involving **veterinary and animal husbandry personnel** in disaster planning efforts at the local level can aim in ameliorating the ecological, economical and psychological (an intimate relation of people to their animals) consequences.

Carcasses can foul water supplies and spread disease. Surviving unsecured animals can serve as reservoirs for zoonotic disease outbreaks and fecal matter.

Animal deaths can represent the **loss of a critical food source** for a stricken population. Moreover, significant losses in the livestock industry can represent a major **economic blow** to the economies of many nations.

20. **Coroner and mortuary service** Although there is a little evidence to suggest that serious epidemics arise from decaying unburied corpses (with the exception of those, deceased of cholera, shigellosis, hemorrhagic fevers or similar communicable diseases) and disease transmission following disaster is fare more likely to be associated with survivors, the manipulation with dead bodies presents some serious concerns (medical, psychological and public relations problems). Local authorities must be prepared to address them.

For the management of dead bodies, following principles and recommendations were summarized: mass management of dead bodies is often based on the false belief that they represent an epidemic hazard if not buried or burned immediately; burial is preferable to cremation in mass casualty situations; every effort should be made to identify the bodies; mass burial should be avoided if at all possible; families should have the opportunity (and access to materials) to conduct culturally appropriate funerals and burials according to social custom; where existing facilities, such as graveyards or crematoria are inadequate, alternative locations or facilities should be provided.

For workers routinely handling bodies should be ensured: universal precautions for blood and body fluids; use and correct disposal of gloves; use of body bags if available; hand-washing with soap and hand disinfection after handling bodies and before eating; disinfection of vehicles and equipment. Bodies do not need disinfection before disposal (except in cases of deaths caused by diseases mentioned above).

Proactive planning (by designating temporary and makeshift morgues in advance, for example) may prevent the hasty and ill conceived burial or cremation of remains before proper victim identification has been made.

21. **Care and shelter** Disaster planning efforts should include provisions for mass care and shelter, including shelter for medically infirm. **Provision of sufficient shelter**, apart from access to water and food, is often the most immediate need of disaster-stricken population, particularly in cold weather. This prevents, depending on weather conditions, hypothermia, malaise, colds, frostbite or heatstroke and dehydration, with the very threat to the ARI development. High mortality rates, particularly among the young and elderly, can occur when displaced populations are suddenly subjected to severe cold stress.

Public buildings (not only schools) disposing of sufficient spaces for the placement of people should be taken into consideration, as well as the preparedness for establishment of **temporary camps** with the all needed equipment (tents, field beds, blankets, sleeping bags, plastic sheeting for keeping rooms and people warm, etc.). This should be planned in **cooperation** with the Red Cross and other nongovernmental agencies. Medical planners should be prepared to support shelters with physician, nursing, and ancillary health support.

Decisions must be also made regarding whether **emergency feeding programs** should focus on widespread distribution of food rations, or on preparing food for consumption on-site in feeding centers and field canteens. Sound program decisions should be based on information from rapid **nutritional surveys** as well as **analyses of economic indicators** that provide more detail on the nutritional status of the population.

Nevertheless, the most rapid reduction in morbidity and mortality during **emergency famine relief** will occur when improvements in environmental health and communicable disease control accompany the **restoration of proper nutritional resources.**

Because, the lack of sufficient food in disasters is usually the result of many factors such as economic collapse, disruption of production, inadequate distribution and other socioeconomic conditions, rather than a true lack of food. The long term solution is in restoring an indigenous food economy, not in maintaining emergency feeding programs.

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