ENVIRONMENTAL HEALTH – HYGIENE

Edited by
ĽUDMILA ŠEVČÍKOVÁ

First edition

Comenius University in Bratislava
Slovakia 2015

Moderné vzdelávanie pre vedomostnú spoločnosť/Projekt je spolufinancovaný zo zdrojov EÚ

ŠEVČÍKOVÁ, Ľ. (ED.)

ENVIRONMENTAL HEALTH - HYGIENE

First edition

*Comenius University in Bratislava, Slovakia, 2015, **253** pages.*

Reviewers
Prof. Vladimír Bencko, MD, DSc
Assoc. Prof. Eleonóra Fabiánová, MD, PhD
Assoc. Prof. Kvetoslava Rimárová, MD, PhD

Proofreading
Ing. Janka Bábelová, PhD.
Ing. Anna Cibulková

ISBN 978-80-223-3930-8

Printed by KO& KA in Bratislava

This textbook was prepared and published within the project "MPH curriculum development at Comenius University in Bratislava in English language", ITMS code: 26140230009, funded by European Social Fund -Operational Programme Education (ESF – OPV). Recipient of the ESF: Comenius University in Bratislava, Faculty of Medicine. Head of the project: Prof. Ľudmila Ševčíková, MD, PhD

This textbook is from the series of textbooks listed below. The aim of the textbooks, funded by ESF-OPE, is to provide students of the study program Master of Public Health (MPH) at Comenius University in Bratislava with information and knowledge of public health issues.

Biology and Genetics for Public Health, Pharmacology in Public Health
Basics of Clinical Microbiology and Immunology for MPH Students
Occupational Health, Toxicology
Nutrition and Food Safety in Public Health
Epidemiology for Study of Public Health Vol.1.
Epidemiology for Study of Public Health Vol.2.
Introductory Biostatistics
Social Medicine
Health Promotion and Health Communication
Public Health Ethics – Selected Issues
An Introduction to Public Health Law
Healthcare Management
Information Technologies in Medicine, Medical Information Systems and eHealth
Management of Information Systems Projects in Transition to Knowledge Management

Authors

Prof. Ľudmila Ševčíková, MD, PhD
Institute of Hygiene,
Faculty of Medicine, Comenius University in Bratislava

Assoc. Prof. Ľubica Argalášová, MD, PhD, MPH
Institute of Hygiene,
Faculty of Medicine, Comenius University in Bratislava

Prof. Vladimír Bencko, MD, DSc
Institute of Hygiene and Epidemiology,
1st Faculty of Medicine, Charles University in Prague

Shelby Davies
Departments of Pediatrics and Environmental Medicine,
New York University Langone Medical Center

Assoc. Prof. Jana Jurkovičová, MD, PhD
Institute of Hygiene,
Faculty of Medicine, Comenius University in Bratislava

Prof. Cyril Klement, MD, PhD
Regional Authority of Public Health, Banska Bystrica

Helena Rapantová, MD, PhD
Institute of Hygiene,
Faculty of Medicine, Comenius University in Bratislava

Prof. Michael Weitzman, MD
Departments of Pediatrics and Environmental Medicine,
New York University Langone Medical Center

CONTENTS

PREFACE

Environmental Health – Hygiene is the basic biomedical science of Public health and Preventive medicine. The main goal of the field of environmental health / hygiene is the protection and promotion of health in relationship to living and working conditions. Tasks of this basic preventive branch 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 behavioral factors in order to improve the health of all population groups.

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 behavior, intensifying health education, and regulating health policy and management at all levels.

This textbook has been prepared with the aim of providing students of the study program Master of Public Health (MPH) with information and knowledge of public health issues.

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.

Ľudmila Ševčíková

1 ENVIRONMENTAL HEALTH / HYGIENE BASIC TERMINOLOGY

Ľudmila Ševčíková

1.1 EnviroNmental health - inTroduction

Environmental health (Hygiene) is the basic **biomedical preventive** branch aimed to promote and protect health, taking into account the interactions between the environmental biological, physical, chemical, and social factors and the human organism and the impacts of the environment on human health. 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. It covers the quality of air, water, soil, climate, food and nutrition, working conditions and physical and mental strains, life style, habits, abuses, housing, waste disposal, knowledge of disease incidence and prevention.

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 bears the name of the Goddess of Health – the Greek Hygieia who is presented as a beautiful woman, whose symbol is a snake drinking water from a bowl the goddess holds in her hand.

The founder of modern hygiene as the branch of medicine is considered Max von Pettenkofer (1818–1901).

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.

Environmental health (Environmental hygiene) 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 harmful effects of chemicals, and biological agents, and the effects (often indirect) on health and well-being 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. Each year, hundreds of new synthetic chemical compounds are developed by the chemical industry. 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 a man in his previous history was exposed only to 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 exposure to environmental agents may produce varying degrees of change in the functional status of the human body, which is related to body's adaptive potential. 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 a minor, discrete impairment of health to illness and disability. The nature of adaptation relates 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 primarily due 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 health disorders.

The **specific nature of biological response** depends on the chemical nature of the toxic substance and its harmful effect in organism.

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.

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 (e.g. destruction of the ozone layer, global warming, and sick buildings). 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 health / hygiene. 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 8 and 9.

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

Norm is the most general term encompassing expressions of desiderata such as goals, objectives, policies, and 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 as measurements of pH, chlorine content, etc.).

Standard is either 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, xenobiotics 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, and xenobiotics 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, is rare, and may be associated quantitatively with a specific effect on man. 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 burning of fossil fuels. It will be also associated with sulfuric 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 another 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 they can afford considering health, social, economic, and technological aspects.

From this point of view, a pollutant release and transfer register (PRTR) which is an inventory of toxic chemical released from industrial sources, 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 there are distinguished the environmental, personal, 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 (LE);
- Quality Adjusted Life Expectancy Years (QALYs)
- Health Adjusted Life Expectancy (HALE)
- Disability Free Life Expectancy (DFLE)

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 indicators to measure and monitor the health disorders are:

- Potential Years of Life Lost (PYLL);
- Disability Adjusted Life Years (DALYs)
- crude / age-specific / age-adjusted mortality rate;
- infant mortality ratio / neonatal mortality ratio;
- maternal mortality ratio;

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

Most of these indicators are available from civil registration data or hospital data. Further research has identified new indicators, such as child abuse, childhood behavior disorders, learning disorders, educational development, 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.

ENHIS (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 non-communicable 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 to the 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 wrong 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, 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 and injuries or risk behavior and to reduce the risk for acquiring a pathogen.

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

Screening is the process of identifying a subgroup of people in whom there is a high probability of finding asymptomatic health disorders or a risk factor for developing a disease or becoming injured.

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.

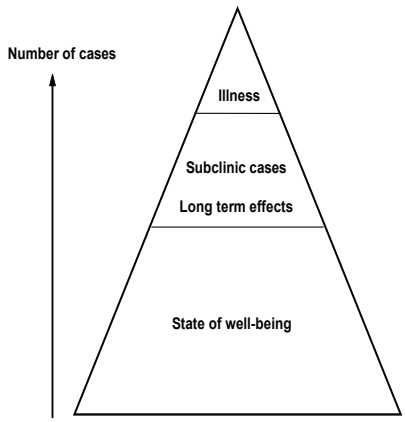


Figure 1.1 The health pyramid

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 desig-

nated time: old and new) by shortening the duration, and tertiary prevention is aimed at reducing the number or impact of complications.

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.

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

A 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 and 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 disease, and chronic obstructive pulmonary disease) and about 20% to cancer, it is evidently reflected in 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.

It is difficult to assess the real significance of the environment for morbidity. However, if 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 major groups of disorders such 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 the 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, and 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 towards 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 to 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 di-

rected toward action on the determinants or causes of health. Public health plays in this an important role.

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. **Vaccinations** have 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 fulfill 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 non-communicable diseases (2020);
9. Reducing injury from violence and accidents (2020);
10. **A healthy and safe physical environment (2015);**
11. Healthier living such as healthier behavior 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. The process involved ministerial conferences held every five years.

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 at the last Fifth Ministerial Conference 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 the 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 European Environment and Health Process will continue towards the Sixth Ministerial Conference on Environment and Health in 2016.

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

Community-focused interventions are essential in reducing most of infections and noncommunicable diseases.

1.4 The Millennium Development Goals

The United Nations Millennium Development Goals (MDGs) is a program that should lead to the elimination of the biggest problems of the developing world. They are eight goals that all 191 UN member states have agreed to try to achieve by the year 2015. The United Nations Millennium Declaration, signed in September 2000 commits world leaders to combat poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women. The MDGs are derived from this Declaration, and all have specific targets and indicators.

The Eight Millennium Development Goals are:

1. To eradicate extreme poverty and hunger
2. To achieve universal primary education
3. To promote gender equality
4. To reduce child mortality
5. To improve maternal health
6. To combat HIV/AIDS, malaria, and other diseases
7. To ensure environmental sustainability
8. To develop a global partnership for development.

The MDGs are inter-dependent; all the MDG influence health, and health influences all the MDGs. For example, better health enables children to learn and adults to earn. Gender equality is essential to the achievement of better health. Reducing poverty, hunger and environmental degradation positively influences, but also depends on, better health.

There has been important progress across all goals, with some targets already having been met well ahead of the 2015 deadline. All stakeholders will have to intensify and focus their efforts on the areas where advancement has been too slow and has not reached all.

The world has reduced extreme poverty by half. Efforts in the fight against malaria and tuberculosis have shown results. Access to an improved drinking water source became a reality for 2.3 billion people. The target of halving the proportion of people without access to an improved drinking water source was achieved in 2010. Disparities in primary school enrolment between boys and girls are being eliminated in all developing regions. By 2012, all developing regions have achieved, or were close to achieving, gender parity in primary education.

The political participation of women has continued to increase. Development assistance rebounded, the trading system stayed favourable for developing countries and their debt burden remained low. Substantial progress has been made in most areas, but much more effort is needed to reach the set targets. Major trends that threaten environmental sustainability continue, but examples of successful global action exist. Global emissions of carbon dioxide (CO_2) continued their upward trend and those in 2011 were almost 50 per cent above their 1990 level. Millions of hectares of forest are lost every year, many species are being driven closer to extinction and renewable water resources are becoming scarcer. At the same time, international action is on the verge of eliminating ozone-depleting substances and the proportion of terrestrial and coastal marine areas under protection has been increasing. Hunger continues to de-

cline, but immediate additional efforts are needed to reach the MDG target The proportion of undernourished people in developing regions has decreased from 24 per cent in 1990–1992 to 14 per cent in 2011–2013. However, progress has slowed down in the past decade. Meeting the target of halving the percentage of people suffering from hunger by 2015 will require immediate additional effort, especially in countries which have made little headway. Chronic undernutrition among young children declined, but one in four children is still affected In 2012, a quarter of all children under the age of five years were estimated to be stunted—having inadequate height for their age. This represents a significant decline since 1990 when 40 per cent of young children were stunted. However, it is unacceptable that 162 million young children are still suffering from chronic undernutrition. Child mortality has been almost halved, but more progress is needed Worldwide, the mortality rate for children under age five dropped almost 50 per cent, from 90 deaths per 1,000 live births in 1990 to 48 in 2012. Preventable diseases are the main causes of under-five deaths and appropriate actions need to be taken to address them. Much more needs to be done to reduce maternal mortality. Globally, the maternal mortality ratio dropped by 45 percent between 1990 and 2013, from 380 to 210 deaths per 100,000 live births. Worldwide, almost 300,000 women died in 2013 from causes related to pregnancy and childbirth. Maternal death is mostly preventable and much more needs to be done to provide care to pregnant women. Antiretroviral therapy is saving lives and must be expanded further Access to antiretroviral therapy (ART) for HIV-infected people has been increasing dramatically, with a total of 9.5 million people in developing regions receiving treatment in 2012. ART has saved 6.6 million lives since 1995. Expanding its coverage can save many more. In addition, knowledge about HIV among youth needs to be improved to stop the spread of the disease. Over a quarter of the world's population has gained access to improved sanitation since 1990, yet a billion people still resorted to open defecation. Between 1990 and 2012, almost 2 billion people gained access to an improved sanitation facility. However, in 2012, 2.5 billion people did not use an improved sanitation facility and 1 billion people still resorted to open defecation, which poses a huge risk to communities that are often poor and vulnerable already. Much greater effort and investment will be needed to redress inadequate sanitation in the coming years. 90 per cent of children in developing regions are attending primary school. The school enrolment rate in primary education in developing regions increased from 83 per cent to 90 percent between 2000 and 2012. Most of the gains were achieved by 2007, after which progress stagnated. In 2012, 58 million children were out of school. High dropout rates remain a major impediment to universal primary education. An estimated 50 per cent of out-of-school children of primary school age live in conflict-affected areas. The MDGs show that progress is possible, providing the platform for further action.

The post-2015 development agenda is slated to carry on the work of the MDGs and integrate the social, economic and environmental dimensions of sustainable development. Continued progress towards the MDGs in the remaining year is essential to provide a solid foundation for the post-2015 development agenda.

References

Ághová L et al. Hygiene. Environmental Medicine. Bratislava: Comenius University, 1997: 200. ISBN: 80-223-1122-7

Bencko V et al. Hygiene & Epidemiology. Selected Chapters. Prague: Charles University The Karolinum Press, 2011: 270. ISBN: 978-80-246-0793-1

Bonita R, Beaglehole R, Kjellström T. Basic epidemiology. 2nd ed. Geneva: WHO, 2006: 213. ISBN: 9241547073

Brennan NJ. Respiratory Diseases: Overview. In: International Encyclopedia of Public Health. HK Heggenhougen, S Quah (Eds.). Bergen: Elsevier, 2008. ISBN: 978-0-12-373960-5

Brooks SM et al. Environmental Medicine. Mosby-Year-Book 1995: 780.

Buxton JA, Mathias RG. Controlling Illegal Stimulants: A Regulated Market Model. In: International Encyclopedia of Public Health. HK Heggenhougen, S Quah (Eds.). Bergen: Elsevier, 2008. ISBN: 978-0-12-373960-5

Detels R. et all. Oxford Textbook of Public Health. Great Britain: Oxford University Press, fourth ed., 2002, 1955 pp, ISBN 0 19 263041 5.

Faggiano F, Vigna-Taglianti F. Drugs, Illicit – Primary Prevention Strategies. In: International Encyclopedia of Public Health. HK Heggenhougen, S Quah (Eds.). Bergen: Elsevier, 2008. ISBN: 978-0-12-373960-5

Health21: The health for all policy framework for the WHO European Region. Regional Office for Europe. Copenhagen, European Health for All Series No. 6: 230. Available at: http://www.euro.who.int/document/health21/wa540ga199heeng.pdf

Jekel JF, Katz DL, Elmore JG. Epidemiology, Biostatistics, and Preventive Medicine. Second ed. W.B. Saunders Company, 2001: 417. ISBN 0 7216-9079 3.

Kirch W (Ed.) et al. Encyclopedia of Public Health. Springer Science+Business Media, LLC. 2008:1599.

Kistemann T, Engelhardt S, Exner M. Standortbestimmung: Umweltmedizin, Hygiene und öffentliche Gesundheit. In: Dott W, Merk HF, Neuser J, Osieka R (Eds). Lehrbuch der Umweltmedizin. Stuttgart: Wissenschaftliche Verlagsgesellschaft, 2002.

Rimárová K. Environmental Medicine – Hygiene. Košice, UPJŠ v Košiciach, 2006: 150. ISBN 80-7097-646-2

Ševčíková Ľ et al. Hygiene – Environmental Medicine. Bratislava, Comenius University, 2011: 340. ISBN 978-80-223-2900-2

Ševčíková Ľ et al. Hygiena. Bratislava, Comenius University, 2006: 325. ISBN 80-223-2103-6

Šulcová M et al. Verejné zdravotníctvo. Bratislava, VEDA, Vydavateľstvo SAV, 2012 : 654. ISBN 978 80 224 1283 4

Wallace, R. (Ed) et al. Wallace/Maxcy-Rosenau - Last Public Health and Preventive Medicine. 15th Edition. The McGraw-Hill Companies, Inc. 2008: 1361.

WHO. The Ottawa Charter for Health Promotion. Geneva, Switzerland: WHO; 1986 Nov 21 Available from: http://www.who.int/healthpromotion/conferences/previous/ottawa/en/index.html

WHO. Millennium Development Goals (MDGs). Available at: http://www.who.int/topics/millennium_development_goals/about/en/, 15. 7. 2014.

WHO. Global health risks: mortality and burden of disease attributable to selected major risks. 2009. ISBN 978 92 4 156387 1

WHO. 10 Facts on Neglected Tropical Diseases. Available at: http://www.who.int/features/factfiles/neglected_tropical_diseases/ntd_facts/en/index.html 10. 3. 2010.

WHO. Environmental health indicators for Europe: a pilot indicator-based report. Copenhagen: WHO Regional office for Europe, 2004, 58 p.

WHO. Ministerial Conference on Environment and Health. Parma, Italy, 10–12 March 2010 EUR/55934/5.2 Rev 2, 11 March 2010.

WHO. Health topics. Copenhagen: WHO Regional office for Europe, 2011, Available at: http:/www.euro.who.int/en/what-we-do/health topics, 10.12.2013.

Yassi A, Kjellström T, de Kok T, Guidotti TL. Basic Environmental Health. Oxford: Oxford University Press, 2001: 456.

United Nations. The Millennium Development Goals Report 2014. New York, 2014. 56 p. Available at: http://www.un.org/millenniumgoals/2014%20MDG%20report/MDG%202014%20English%20web.pdf, 30.8.2014.

2 BASIC ENVIRONMENTAL HEALTH FACTORS

Ľubica Argalášová

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.

Current environmental health according to WHO addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviors. It encompasses the assessment and control of those environmental factors that can potentially affect health. It is targeted towards preventing disease and creating health-supportive environments. 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 as the preventive medicine branch is 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. Water-borne 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. Food-borne contaminants contribute less to the other media, although microbial degradation of foods, potential foods, or food wastes can contribute to soil and water pollution. As an effect of the physical environment, noise as a health hazard is now driving change. Environmental noise has often been referred to as the 'forgotten pollutant' but is now recognized as an environmental and public health issue, which needs to be addressed in modern society.

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. Alternatively, it can be studied by sub-type within these

categories. Biological hazards can be divided into viruses, bacteria, parasites, etc. The study of environmental health hazards may also be organized by the 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 the routes of exposure and related factors.

Table 2.1 Biological, Chemical, and Physical Hazards by Routes of Exposure

	Biological	**Chemical**	**Physical**
Air			
Agent/Source	Microorganisms	Fumes, dust, particles	Radiation, noise
Vectorial factors	Coughing, exhalations	Contaminated food and water	Weather, unguarded exposures
Routes	Inhalation, contacts	Inhalation, contacts	Inhalation
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

Source: Yassi et al., 2001

More information about environmental health hazards, characteristics, types, and sources of environmental hazards can be found in Chapter Risk assessment and the textbook Occupational Health, Toxicology.

2.2 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.

2.2.1 Chemical properties of the air

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 variations 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 there 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.

2.2.2 Physical properties of the air

The basic physical qualities of the air are: **temperature, moisture, flow, speed and velocity, pressure, atmospheric electricity and radiation**. 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. Absolute **air humidity** is the concentration of water vapors in air (g/m^3) or partial tension. Relative air humidity is the ratio of the actual water vapor pressure to the saturation water vapor pressure at the prevailing temperature. It is usually expressed as a percentage rather than as a fraction. The temperature at which the air has the maximal moisture is called the dew point. It is linked to the formation of precipitations. When the temperature drops below the dew point, the part of the water vapor present in the air is condensed into water. The absolute humidity in the outer atmosphere as well as the temperature fluctuates in time and space. Early in the morning it is lower than in the afternoon, in the winter it is lower than in the summer, urban air is usually drier than the rural air. **Ion concentration** in the atmosphere is the result of a dynamic balance between the forces, which continuously create new ions and the simultaneous destructive processes. They vary according to the actual conditions in the atmosphere. The high concentration of light ions is in the upper atmosphere. Higher concentrations of light ions are also nearby waterfalls and above the level of the oceans. The low amount of light ions and the increased amount of heavy ions are in the industrial areas or in the stale air. Based on numerous studies the positive effect of light negative ions can be expected in the overall feeling of freshness and also some chronic diseases.

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. 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 raising the sturdiness and efficiency of organisms, the gradual acclimatization and technical equipment (oxygen apparatus, pressurized cabins of aircraft etc.). High air pressure is experienced mainly by divers and those working in caissons or in deep mines. Symptoms such as headache, dizziness, pain in the ears accompanied by slowing of the pulse, dyspnea, 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 name of the resulting illness is **bends**. One of the preventive measures is the replacement of nitrogen with helium in the caisson atmosphere, which is soluble in the blood and therefore do not generate dangerous bubbles at sudden decompression. **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).

The more detailed explanations of the physical factors of the air and the health effects are explained in the textbook Occupational Health, Toxicology.

2.2.3 Biological properties of the air

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 pathogenic 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.

2.2.4 Air pollution

Air pollution is the emission into the air of hazardous substances at a rate that exceeds 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 per-

ceived 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 does it 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 sulfur 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.

2.2.4.1 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 sulfur 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 time 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 non-carbonaceous primary parti-

cles. 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 the 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 coarse and fine ranges. The greatest penetration and retention of particles is in the range from 10.0 to 0.1 μm, which is called **respirable** range (Figure 2.1). Nanoparticles (NPs) are particles between 1 and 100 nanometers in size. NPs of natural origin have been present all along the evolution of life. The problems of today are caused mostly by man-made NPs. Pollutant NPs are generated in high-temperature processes and are typically airborne. Nanoparticle research is currently an area of intense scientific interest due to a wide variety of potential applications in biomedical, optical and electronic fields. The human health effects revealed up to now show the role of environmental NPs in human diseases and emphasize the need for further research.

Sulfur dioxide. The traditional urban mix of air pollutants contains sulfur 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 sulfates. While further pollutants may be present, acute and chronic respiratory effects have been linked primarily with the sulfur dioxide particulate acid aerosol content.

Sulfur dioxide (SO_2) is generated mainly from the combustion of fossil fuels containing sulfur. Eighty percent of worldwide emissions come from burning coal and lignite, 20% come from oil. Coal typically contains about 2% of sulfur and heavy fuel oil about 3% by weight.

Sulphur dioxide and nitrogen oxides in water vapor 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 worsening of the condition of people with chronic bronchitis, were directly related to raised levels of smoke and SO_2.

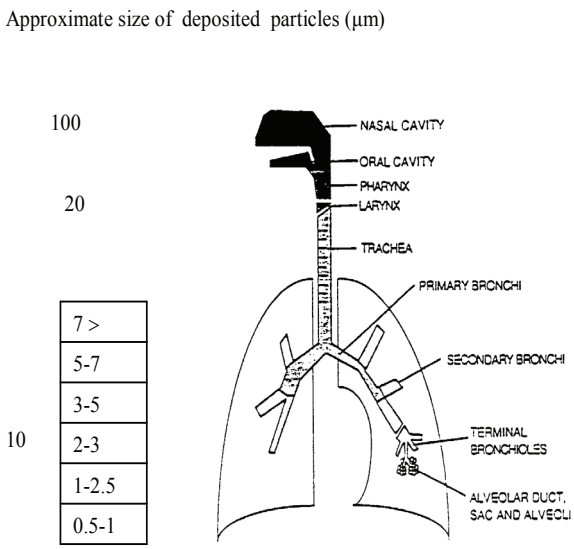


Figure 2.1 Deposition of dust particles by size (Source: Yassi et al., 2001)

Inhalation of SO_2 produces narrowing of the airways (bronchoconstriction), which people suffering from asthma are more sensitive to than other individuals are. 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 Sulfur Dioxide), and 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 Guidelines (in 2000) 24-hour average was 125 μg/m^3 and annual average 50 μg/m^3 (Table 2.2)

Particulate matter (PM). Among air pollutants, particulate matter (PM) is widely present and people are exposed to PM 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).

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 the WHO, hourly concentrations of 200 μg/m^3 can cause eye, nose and throat irritation, chest discomfort, cough and headache; exposure for about six hours to concentrations of 160 μg/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 μg/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 μg/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.

Nitrogen dioxide (NO_2) is produced both as a primary and as a secondary pollutant by combustion processes. In many countries, some 50% of NO2 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. Ozone is created in situ through the photolysis of nitrogen dioxide (NO_2) to nitric oxide (NO) which, in turn, reacts with carbon monoxide (CO) and hydrocarbons to form O_3. Photolysis of O_3 by sunlight (particularly ultraviolet light) is one of the main influential processes in the troposphere (oxidative smog). 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.

The other major air pollution disasters are mentioned in Table 2.3

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

Substance	Time-weighted average	Averaging time
	0.45mg/m³	1 week
Fluoride*	-	-
Formaldehyde*	0.1 mg/m³	30 minutes
Hydrogen sulfide*	150 µg/m³	24 hours
Lead*	0.5µg/m³	annual
Manganese*	0.15µg/m³	annual
Mercury*	1µg/m³	annual
Nitrogen dioxide**	200µg/m³	1-hour mean
	40 µg/m³	annual mean
Ozone**	100 µg/m³	8- hour mean
Particulate matter ($PM_{2.5}$)**	10 µg/m³	annual mean
	25 µg/m³	24-hour mean
Particulate matter (PM_{10})**	20 µg/m³	annual mean
	50 µg/m³	24-hour mean
Platinum*	-	-
PCBs*	-	-
PCDDs/PCDFs*	-	-
Styrene*	0.26 mg/m³	1 week
Sulfur dioxide**	20 µg/m³	24- hour mean
	500 µg/m³	10-minute mean
	50 µg/m³	annual
Tetrachloroethylene*	0.25 mg/m³	annual
Toluene*	0.26 mg/m³	1 week
Vanadium*	1 µg/m³	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*

Carbon monoxide (CO) has an affinity for hemoglobin (Hb) 200 times greater than that of oxygen. It impairs the oxygen-carrying capacity of blood as carboxyhemoglobin (COHb) is formed rather than oxyhemoglobin. When too much oxygen is displaced by CO, it can progressively lead to oxygen starvation. Thus, at levels of only a few per cent of COHb, the 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 the 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/m³ (90 ppm) for 15 minutes;
- 60 mg/m³ (50 ppm) for 30 minutes;
- 30 mg/m³ (25 ppm) for 1 hour;
- 10 mg/m³ (10 ppm) for 8 hours.

2.2.4.2 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 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 a clear effect of exposures to PAHs in coal smoke, diesel smoke, or in other emissions in terms of lung cancer incidence, it 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.

2.2.4.3 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.

Table 2.3 Air pollution disasters

Year	Location	Number		Pollutant	Manifestation of the clinical finding
		Diseased	Dead		
1930	Meuse Valley, Belgium	Majority of the population	63	Sulfur and fluorine compounds	Mucous membranes of respiratory tract and eyes, circulatory system
1948	Donora, USA	6,000	20	Sulfur compounds	Mucous membranes of respiratory tract and eyes, circulatory system
1952	London, UK (several times)	Majority of the population	4,000	Sulfur oxides, smoke	Respiratory system, circulatory system
Several times	Los Angeles, USA	Majority of the population	-	Photochemical smog	Respiratory system, eyes
1950	Posa Rica, Mexico	320	22	Sulfan	Respiratory system
1976	Seveso, Italy	The health status of citizens is being monitored	-	Trichlorphenol, dioxin	Skin, gastrointestinal tract
1984	Bhopal, India	150,000	1,500	Methyl isocyanate, hydrogen cyanide	Eyes, respiratory system, CNS

Year	Location	Number		Pollutant	Manifestation of the clinical finding
		Diseased	Dead		
1984	Chemko, Strážske, Slovakia	The health status of citizens is being monitored	-	PCB, polychlorinated biphenyls	PCB poisoning damage to the skin, decreased immunity, neurological disorders, gastrointestinal disorders, endocrine cycle, menstrual cycle, reproductive anomalies, behavioral abnormalities, impaired intellect, carcinogenesis
1986	Chernobyl, USSR	Late effects (?)	3,500	Radioactive substances	Radiation sickness
1995	U.S. Steel, Košice, Slovakia	300 - 400	11	Carbon monoxide	CO Poisoning
2010	Ajka, Hungary	> 150	10	Red sludge - waste in the production of aluminum, fine dust containing arsenic into the atmosphere	Arsenic poisoning, teratogenic effects, oncological diseases
2011	Fukushima I, II, Okuma, Japan, tsunami	The health status of citizens is being monitored	-	Radioactive substances, ^{131}J, ^{137}Cs	Radiation sickness

Sources: Ševčíková et al., 2006; Bencko et al., 2011; United Nations, 2012

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 as most people spend about 80 – 90 per cent of their time indoors.

2.2.4.4 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 from industrial solvent use, as in automobile coating or dry cleaning operations.

For more information about this topic see textbook Occupational health, toxicology and Chapter Housing and health.

2.2.4.5 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 last 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, CFCs, 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.

2.2.4.6 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 incor-

porate 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 economic 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 smoke plume opacity (often assessed by subjective means).

The best practical approach should reduce pollution while maintaining reasonable costs. 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 plants, 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. 3 ENVIRONMENTAL NOISE

As an effect of the physical environment, noise as a health hazard is now driving change. Environmental noise has often been referred to as the 'forgotten pollutant' but is now recognized as an environmental and public health issue which needs to be addressed in modern society.

Noise has attracted widespread attention as a significant environmental and occupational health concern. Main sources of community noise include road, rail and

air traffic, industries, construction and public work, and the neighborhood. Environmental noise has traditionally been dismissed as an inevitable fact of life and has not been targeted and controlled to the same extent as other health risks. A growing body of research linking noise to adverse health effects coupled with proactive legislation, primarily in the EU, has now intense attention. 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 an equivalent sound pressure level exceeding 55 dB(A) daytime and 20% are exposed to levels exceeding 65 dB (A). More than 30% are exposed at night to equivalent sound pressure levels exceeding 55 dB (A) which is disturbing to sleep.

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 (p0 = 2.10 -5 Pa). This relation is expressed on a decibel scale and defined by the formula:

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

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 workday.

The decibel may be an unfamiliar scale to some but typically, we deal with noise levels between 30 and 100 dB (A) in everyday life. Noise levels below 35–40 dB (A) are usually necessary for a good night's sleep; a busy office may be about 60 dB(A) while the noise level on a footpath beside a busy road might be approximately 75 dB(A) and a departing jumbo jet may result in 120 dB(A) being recorded along the runway. Figure 2.2 displays some typical noise levels and examples of their sources.

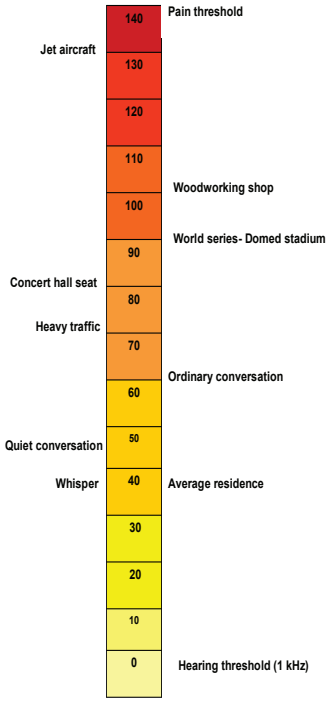


Fig. 2.2 Typical sound pressure levels of noise sources (Source: Murphy and King, 2014)

The World Health Organization ranks reducing noise among 21 goals for the 21st century. The significance of this issue is confirmed by the preparation and issuance of the WHO document "Guidelines for Community Noise" in 2000, whose task was to summarize the current scientific knowledge about the impact of environmental noise on health and provide recommendations to the executive authorities in the field of environmental health. A significant update of this document is currently being prepared. The World Health Organization has released the publication dedicated to noise exposure at night and recommended values of noise levels during eight hours night (Lnight) "Night Noise Guidelines for Europe" in 2009.

Noise during the day in big cities is continuous, without the phenomenon of a traffic peak. Road traffic noise is caused by energy source, i.e. engine, the wheels after backing the roll and airflow around the vehicle and through a cooling and ventilation system of the vehicle, acceding to the next interval occurring noise. Structure and density of traffic flow, population density and the degree of urbanization are important factors affecting noise levels. The resulting noise also depends on other technical parameters of the vehicle, road conditions and driving style. Although more strict noise reduction measures have reduced noise of vehicles in recent years (especially cars), the road traffic has still a significant proportion of the total increase of noise in our cities.

Transport systems (road traffic in particular) generate both noise and air pollution (e.g. PM, NOx, HC, CO, SO_2). Current knowledge suggests that noise and air pollution may affect the cardiovascular system by different mechanisms. Thus, it is possible that combined exposure to these transport related stressors may interact and increase their single effects on cardiovascular risk synergistically.

Major step forward in the area of non-auditory noise effects of environmental noise has been the adoption of Directive 2002/49/EC of the European Parliament, as implemented in Member States legislation and the development of strategic noise maps and action plans in specific agglomerations. In Slovakia, strategic noise maps have been elaborated in Bratislava agglomeration by now; strategic noise maps and action plans are available to the public (www.hlukovamapa.sk).

The range of issues that may be associated with exposure to excessive noise is really wide. Prolonged exposure to environmental noise in the range between 60 - 90 dB (A) can promote non-specific reactions of the organism, especially in the vegetative, endocrine and regulatory field.

Members of the European network of experts under the auspices of the World Health Organization explore existing opportunities and continue to develop approaches to quantify the effects of noise on health. The results of this collaboration were recently summarized and published in the form of guidelines for the assessment of the risks of noise exposure in the environment. These guidelines are intended to quantify the burden of environmental conditions on health (i.e. environmental burden of disease in Europe (EBoDE) and for the calculation of life years lost due to disability (using disability-adjusted life-years (DALYs)) (Table 2.4). This methodology has been already used by governmental and non-governmental institutions in Germany, the Netherlands, Switzerland, Belgium, Finland, Italy and France. The terms of disability-adjusted life years (DALYs) is the sum of potential years of life lost due to ill-health, disability or early death and the equivalent years of healthy life lost by virtue of being in states of poor health or disability. It is represented by the following equation:

DALYs = YLD + YLL , where YLD is years lived with disability and YLL is years of life lost.

Table 2.4 Burden of Disease from Environmental Noise in Europe

Noise-Induced Exposure	Public Health Impact
Annoyance	587,000 DALYs lost for inhabitants in towns > 50,000 population
Sleep disturbance	90,3000 DALYs for EUR-Ab inhabitants in towns > 50,000 population
Cardiovascular diseases	61,000 years for ischaemic heart disease in high-income European countries
Tinnitus	22,000 DALYs for the EUR-A adult population
Cognitive impairment in children	45,000 DALYs for EUR-A countries for children aged 7–19 years

Legend: DALYs are the sum of the potential years of life lost due to premature death and the equivalent years of 'healthy' life lost by virtue of being in states of poor health or disability.
EUR-A is a WHO epidemiological subregion in Europe comprising Andora, Austria, Belgium, Croatia, Cyprus, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, the Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.
Tinnitus is defined as the sensation of sound in the absence of an external sound source.
Source: Fritschi et al., 2011; Murphy and King, 2014

Annoyance is the most prevalent community response in a population exposed to environmental noise. It is a psychic condition that occurs at involuntary perceptions of the effects or at subordination to circumstances to which the individual has the attitude

of rejection, because they break his/her privacy, hinder the implementation of the activities or affect the quality of rest. The response are the feelings of resistance, irritability and, in some cases, psychosomatic disorders. The level of noise annoyance, together with noise sensitivity are often used as the indicators of noise exposure in relation to extraaural (non-auditory) noise effects (especially in the cardiovascular system). Investigators have proposed standardized questions about residents' long-term annoyance in their home for use in surveys according to different scales (three-to twelve). The uniform five-point scale was proposed as the gold standard. Since the "noise annoyance" is just a subjective indicator the objective measurement of noise exposure in designated areas is desirable.

The impact of road traffic noise on annoyance in urban agglomerations was assessed also by authors from Slovakia. They analyzed the trends of noise burden of citizens in the period 10, 20 and 25 years and elaborated a method of environmental noise exposure risk assessment, which could be used also in the other physical factors. They found objectively the continual increase of a road traffic noise load in selected population groups in ten year interval (1989-1999 – the period of political, social and economic changes in the state with the impact of traffic and its management), in the interval of 20 and 25 years. The authors subjectively observed the increase of road traffic noise annoyance risks in respondents in the interval of 10 and 20 years, and the decreasing trend after 25 years, the result was still significant. The decreasing trend of road traffic noise annoyance could be explained by habituation and the presence of the other confounding factors in the given sample (reconstruction of transport infrastructure and construction work on buildings) or the other annoying noise sources (entertainment facilities, neighborhood and the internal constructions of the building.

Noise sources in the indoor environment are heating and ventilation systems (i.e. HVAC noise-heating, ventilation, air-conditioning), office machines, home appliances and surroundings. This includes for example the noise from catering facilities and restaurants, the entertainment facilities and nightclubs, form live and recorded music, from domestic animals (e.g. barking dogs) and noise from parks and playgrounds. Sources of technical equipment in buildings with insufficient vibroisolation generate relatively strong low-frequency tonal noise that is annoying to humans. Low frequency wave (LFW) is more annoying as expected from the values obtained using A-weighted of SPL, which currently represents perception of sound by human beings. The studies show that acoustical LFW has a specific effect on health of human health. In general, the standing waves, or partial standing waves are generated in closed rooms, which increases the annoyance level.

From environmental factors, noise could be qualified according to recent knowledge and epidemiological studies as a risk factor of cardiovascular diseases (CVD). Noise, as a stressor, is responsible for blood pressure and blood lipids increase that can later manifest in chronic diseases (hypertension, coronary heart disease). As a result of meta analysis, a common risk curve is derived for the relationship between road traffic noise and the incidence of myocardial infarction (MI).

Below 60 dB (A) for the road traffic noise level during the day no notifiable increase in MI risk could be detected. For noise levels greater than 60 dB(A), the MI risk increases continuously, with relative risks (odds ratios) ranging from 1.1 to 1.5. The last meta-analysis showed 8% increase of the risk (the relative risk of 1.08) (95% CI: 1.04, 1.13) per increase of the weighted day-night noise level LDN of 10 dB (A) within the range of approximately 52-77 dB (A) (5 dB-category midpoints). Authors from Slovakia in the year 2010 used the cardiovascular risk score quantification to express non-auditory effects of noise with the complex approach. Determination of the total cardiovascular risk allows the more comprehensive assessment of the risk in relation

to environmental noise, due to the association, interconnection, combination, and multiplication of individual risk factors, which allows grading of particular preventive measures and interventions.

The adverse effects on sleep belong to the other adverse effects of noise. Noise alters not only the sleep quality but also the physiological response of the organism in the form of changes in blood pressure, heart rate, or respiratory rate. With insufficient sleep, the other symptoms are subsequently joined: difficulties to concentrate, fatigue, mood swings, headaches, etc. As several studies show, even when the man seems to get used to noisy surroundings, the actual adaptation of the organism to noise is not even after many years.

In adolescents and young adults, the voluntary or social exposure to noise is very topical. Various leisure time activities may be responsible for hearing impairment (temporary or permanent hearing threshold shift, hearing loss). Exposure to these noise sources is being compared to the lower action values of noise at work. The limit under the Directive 2003/10/EC - noise level A - 80 db for 40 hours is reached after less than 30 minutes per week. There are also personal music players (PMP), which at high volume (above 89 dB) reach the noise exposure equivalent to the lower action value after 5 hours per week. We can therefore conclude that personal music players represent a risk to hearing at high sound pressure levels during long-term exposure. At around 2.5 and 10 million citizens use the PMP so often and so loudly that they risk hearing loss after five years of use. Current data on the usage of PMP among adolescents in Europe are missing and empirical evidence on its association with hearing loss is lacking.

Ohrkan study is an epidemiological study from Bavaria (Regensburg), which follows subjects longitudinally with the purpose of detecting any hearing disorders. Untill now, they have examined 2,240 9thgrade students of elementary school in Regensburg by a validated questionnaire of the study Ohrkan, elaborated by the Bavarian Health and Food Safety Authority, with particular reference to the quantification of social noise exposure in the youth. They objectified hearing examination by tympanometry and audiometry. In the group of examined pupils, 85% of them reported frequent listening to personal music players, 32% of them exceed the lower action levels by its volume setting and 22% exceeded the upper action levels for noise in the workplace. Listening of PMP was more common in boys than girls, in pupils from professionally oriented schools and pupils from single-parent families. In a group of pupils with complete audiometry and tympanometry (1,843), the prevalence of audiometric notches (may indicate hearing loss) was only 2.4% (95% confidence interval 1.7 to 3.1%), suggesting the need to follow subjects longitudinally or also focus on the older age groups, such as college students.

Studies on hearing loss of the youth and the identification of causes of hearing loss in adolescents are very important in order to develop additional precautions. It is also important to determine which groups of those young and healthy individuals are particularly vulnerable to effectively target the preventive measures.

While there has been a dramatic increase in the volume of research undertaken investigating the relationship between noise pollution exposure and its impacts on human health over the last two decades, there remains much work to do to improve our understanding in this area. Over the last half decade, the major improvements that have been seen in noise reduction emissions from transport vehicles, in particular cars and airplanes, have come primarily from improvements in engine and tire technology. Looking to the future, there is little doubt that technology will remain pivotal to creating quieter urban and rural environments. We can only hope that these, together with other improvements, will provide for a much quieter future and that quite soon we can truly refer to environmental noise as the forgotten pollutant.

2.4 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 the following:

- 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 man 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.

2.4.1 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 used more in the past few dec-

ades, because groundwater sources are very limited and water consumption in developed countries is now 4 – 12 times higher than before the 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. Surfacewater 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 of a 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 affect the distribution of mercury in the ecosystem. The mercury concentration in lake water, as well as the pH of the water, are 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 per cent of concentration giving rise to acute symptoms) persist over longer time, 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 aluminum (Al) concentrations in acidic waters are well documented. Aluminum 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.

Concerning 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 discharge 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 practised. 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.

2.4.2 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, color, 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 mills, 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.

2.4.2.1 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 helminths 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 their examples are listed in Table 2.5.

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, typhoid, hepatitis A 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 of 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. Surface waters in subtropical and tropical countries are contaminated with cercariae of human and other schistosomes, which are shed from their snail intermediate hosts in shallow waters. Their cercariae penetrate the human skin and complete their life cycle in man causing schistosomiasis. Animal and bird schistosomes are widespread also in mild climate including Europe. Their cercariae can penetrate the human skin but cannot develop to maturity in man. This causes cercarial dermatitis known as Swimmer's itch, a short-term immune reaction occurring in the skin of humans that have been infected by schistosomatidae. Symptoms, which include itchy, raised papules, commonly occur within hours of infection and do not generally last more than a week. Humans usually become infected with avian schistosomes after swimming in lakes or other bodies of slow-moving fresh water. Snails shed cercariae most intensely in the morning and on sunny days and exposure to water in these conditions may therefore increase risk. Duration of swimming is positively correlated with increased risk of infection and shallow inshore waters — snail habitat — undoubtedly harbor higher densities of cercariae than open waters offshore.

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 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 immunodeficiency syndrome (AIDS) or to chemotherapy facilitating organ or tissue transplants.

2.4.2.2 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 to 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 organic chemicals , chlorinated microorganic chemicals, pesticides and arsenic chemicals) 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 mandatory 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 2.6 and 2.7):

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 in blood rises above 20% of total hemoglobin concentration. 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 contaminated water is used for mixing the 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. 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 not confirmed it so far.

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.

Table 2.5 Diseases related to water and sanitation

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.
	Swimmer's itch, cercarial dermatitis - inflammatory immune reaction	*Trichobilharzia, Gigantobilharzia* (Schistosomatidae)	Lakes or other bodies of slow-moving fresh water
	Dracunculiasis (Guinea-worm disease)	*Dracunculus medinensis*	Humans, contaminated water, cutaneous
Group	**Disease**	**Pathogen**	**Source**

Group	Disease	Pathogen	Source
Water-related diseases	Malaria	*Plasmodium species*	Mosquitoes breeding in water, water sources development
	Onchocerciasis	*Onchocerca volvulus*	Blackflies breeding 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

Source: Compiled from WHO, 2008, 2011

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 animal excreta treatment and disposal.

Table 2.6 Selected chemical water pollutants, their guideline values, common sources and major adverse health outcomes

Contaminant	WHO guideline value [mg/liter]	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 aluminum 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, behavioral 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	Methemoglobinemia in young infants
Selenium	0.04	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

Contaminant	WHO guideline value [mg/liter]	Common sources	Major adverse health effects
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	0.03	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)

Source: Compiled from WHO, 2008, 2011

Calcium and magnesium substances are very important for water mineralization. The salts (carbonate, sulfate) 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 sulfates of calcium and magnesium). Temporary hardness may be diminished by boiling water, when the carbon dioxide is driven off and carbonates deposit. Permanent hardness is not affected by boiling. Both types of hardness are expressed as mg/L $CaCO_3$ (milligrams per liter 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, 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 and 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.

Fluoride in drinking water can have toxic effects in both excess and deficiency, although the WHO only sets 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.

Iodine. Its shortage in drinking water causes the endemic goiter and in serious cases mental retardation, with growth disturbances, called cretinism. 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.

Table 2.7 Selected chemical water pollutants, their guideline values, common sources and major adverse health outcomes

Contaminant	WHO guideline value [μg/liter]	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		

Source: Compiled from WHO, 2008, 2011

While concentrations in natural water are generally less than 0.005 mg/liter, 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/liter. 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 hemoglobin 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/liter) 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 treatments 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 effects. Pesticides based on organophosphates can cause acute poisoning in farmers and agricultural workers.

Heavy metals – cadmium, mercury, lead, chromium, nickel – are toxic substances 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.

Chloroform 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. In all circumstances, disinfection efficiency should not be compromised in trying to meet guidelines for disinfection by-products (DBPs), including chlorination by-products, or in trying to reduce concentrations of these substances. The use of ozone can lead to elevated bromate concentrations through oxidation of bromide present in the water.

Asbestos fibers, In the case of asbestos fibers in drinking water 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 Brazil.

Radiologic contamination of public water supplies may be naturally occurring or resulting 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 most 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.

The percentage of radon present in drinking-water that is released into indoor air will depend on local conditions, such as the total consumption of water in the house, the volume of the house and its ventilation rate, and is likely to be highly variable. It has been estimated that a radon concentration of 1000 Bq/L in drinking water discharged from a tap or shower will, on average, increase the radon concentration by 100 Bq/m3 in indoor. Screening levels for radon in water should be set on the basis of the national reference level for radon in air and the distribution of radon in the national housing stock. Where high radon concentrations are identified in indoor air, this is nearly always due to ingress of radon from the soil rather than degassing from the drinking-water supply. Nevertheless, in circumstances where high radon concentrations might be expected in drinking water, it is prudent to measure for radon and, if high concentrations are identified, consider whether measures to reduce the concentrations present are justified.

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. Although finding the levels of activity above screening values does not indicate any immediate risk to health, it should trigger further investigation to determine the radionuclides responsible and the possible risks, taking local circumstances into account. Screening levels for drinking water, below which no further action is required, are 0.5 Bq/L for gross alpha activity and 1 Bq/L for gross beta activity.

2.4.3 Drinking water quality guidelines, criteria and standards

The 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 worldwide. 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 the WHO is the protection of public health.

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 fourth edition of the Guidelines for Drinking-water Quality develops concepts, approaches and information introduced in previous editions, including the comprehensive preventive risk management approach.

It considers the following:

- drinking-water safety, including minimum procedures and specific guideline values;
- microbial hazards, which continue to be the primary concern in both developing and developed countries;
- climate change, which results in changing water temperature and rainfall patterns;
- severe and prolonged drought or increased flooding, and its implications for water quality and water scarcity, recognizing the importance of managing these impacts as part of water management strategies;
- chemical contaminants in drinking water, including information on chemicals not considered previously, such as pesticides used for vector control in drinking water;
- revisions of existing chemical fact sheets, taking account of new scientific information;
- those key chemicals responsible for large-scale health effects through drinking water exposure, including arsenic, fluoride, lead, nitrate, selenium and uranium, providing guidance on identifying local priorities and on management;
- the important roles of many different stakeholders in ensuring drinking-water safety;
- guidance in situations other than traditional community supplies or managed utilities, such as rainwater harvesting and other non-piped supplies or dual-piped systems.

The safe drinking-water guidelines outline a preventive management that comprises three key components:

- health-based targets based on an evaluation of health risks,
- water safety plans (WSPs) comprising:
  - a system assessment to determine whether the drinking-water supply (from source through treatment to the point of consumption) as a whole can deliver water of a quality that meets the health-based targets);
  - operational monitoring of the control measures in the drinking-water supply that are of particular importance in securing drinking-water safety;
  - management plans documenting the system assessment and monitoring plans and describing actions to be taken in normal operation and incident conditions, including upgrade and improvement, documentation and communication;

- 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.

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 Escherichia coli, which has traditionally been used to monitor drinking-water quality, and it remains an important parameter in monitoring undertaken as part of verification or surveillance. Thermotolerant coliforms can be used as an alternative to the test for E. coli in many circumstances. Water intended for human consumption should contain no fecal indicator organisms. In the majority of cases, monitoring for E. coli or thermotolerant coliforms provides a high degree of assurance because of their large numbers in polluted waters. Total coliform bacteria are not acceptable as an indicator of the sanitary quality of water supplies, particularly in tropical areas. 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 2.8).

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 a 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, odor 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 2.8 *Bacteriological quality of drinking water*

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
Treated water in the distribution system	
E. coli or thermotolerant coliform bacteria	Must not be detectable in any 100 ml sample

Source: WHO, 2011

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 are shown in Tables 2.6 and 2.7.

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.

Water should be free of tastes and odors that would be **acceptable** to the majority of consumers. Microbial, chemical, and physical water constituents may affect the appearance, **odor** 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 colored or has an objectionable taste or odor, 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 favor of more pleasant but potentially unsafe sources. Changes in the normal appearance, odor 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 **color**. Color in drinking water is usually due to the presence of colored organic matter (primarily humic and fulvic acids) associated with the humus fraction of soil. Color 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 color below 15 true color 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. Turbidity is measured by nephelometric turbidity units (NTU) and can be initially noticed by the naked eye above approximately 4.0 NTU. However, to ensure effectiveness of disinfection, turbidity should be no more than 1 NTU and preferably much lower. Large, well-run municipal supplies should be able to achieve less than 0.5 NTU before disinfection at all times and should be able to average 0.2 NTU or less. Small water supplies where resources are very limited and where there is limited or no treatment may not be able to achieve such low levels of turbidity. In these cases, the aim should be to produce water that has turbidity of at least less than 5 NTU and, if at all possible, below 1 NTU. For many of these small and usually rural supplies, measuring turbidity below 5 NTU may present a significant cost challenge, and thus providing low-cost measuring systems that can measure lower turbidities is an important requirement.

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, odor, color 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 a 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 effects on health have been produced yet.

2.4.4 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 the 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.

2.4.5 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 higher risk from chemical poisoning also might result because the large number 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.

2.4.6 Hygienic protection of water sources

The protection of water sources is part of an overall approach advocated by the 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 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.

2.4.6.1 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 ranging 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.

2.4.6.2 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.

2.4.7 Water conditioning

Water, 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 follows:

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 aluminum sulfate is added to the water, forming with it a gelatinous flocculent clot of aluminum 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 a 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 is 20%, we must dose 5 mg of the lime per liter of water. The exposition time is 30 minutes. Only after this time the disinfection is effec-

tive. 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 thiosulfate, which changes chlorine to inodorous 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 eliminated 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, and 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 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 the past few decades there has been an ongoing research on potential chronic and carcinogenic effects 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).

2.4.8 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 fecal 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;
- health 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.

2.4.9 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.**

2.4.9.1 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 dis-

eases. 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 behavior to the public.

2.4.9.2 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 fecal contamination of the water. This may be due to feces 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 fecally-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 a 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.

2.5 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, decomposer organisms, worms and insect larvae that form the ecosystem. Within the **subsoil,** there 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 alumi-

num, 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).

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.

2.5.1 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.

2.5.1.1 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 excreted 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 nightsoil 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-helminths) and their eggs become infective after incubation and life cycle in the soil. The most important soil transmitted helminths are ***Ascaris lumbricoides*** (roundworm), ***Trichuris trichiura*** (whipworm) and ***Ancylostoma duodenale*** (hookworm).

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. Clostridium perfringens, a gram-positive spore-forming

anaerobe with toxin production in the digestive tract associated with sporulation, is commonly present in the normal intestinal flora, feces, and soil. Individual isolates of this bacterium are classified into five types (A to E), based upon their production of four (alpha, beta, epsilon, and iota) typing toxins. Each C. perfringens type is associated with certain human or veterinary diseases.

The most common soil-borne illnesses and soil-associated pathogens are summarized in Table 2.9.

Tab. 2.9 Soil-associated pathogens

Pathogen	Disease
Parasites	
Ascaris	Pneumonitis; intestinal, pancreatic, and biliary obstruction; appendicitis, intussusception, 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
Clostridium perfringens	Watery diarrhea, gas gangrene, necrotizing fascitis
Fungi	
Dermatophytes	Ringworm (*Tinea corporis, pedis, cruris*)

Source: Brooks et al., 1995

2.5.1.2 Contamination of the soil by toxic chemicals

Soil pollution by chemical agents causes poisoning or long-term chronic effects of a 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 rising 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.

A number of pesticides and other soil pollutants such as **heavy metals** e.g. **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 a higher incidence of kidney damage, and **PCBs** and cycl-

odienes 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.

2.5.1.3 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 salinization** 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 successfully developed 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).

2.6 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% of 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% of suspended solids. Such wastes may contain high concentrations (greater than 1%) of dissolved species, such as salts and metals. More details on wastewaters are described in this chapter.

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, such as ignitability, corrosivity, 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 tons of waste are generated in Europe every year. This equals 3.8 tons/capita in Western Europe (WE), 4.4 tons in Central and Eastern Europe (CEE) and 6.3 tons in the countries of Eastern Europe, the Caucasus and Central Asia (EECCA).

In 2010, the total generation of waste from economic activities and households in the EU-28 amounted to 2, 506 million tons; this was slightly higher than in 2008 but lower than in 2004 and 2006; the relatively low figures for 2008 and 2010 may, at least in part, reflect the downturn in economic activity as a result of the financial and economic crisis. Among the waste generated in the EU-28 in 2010, some 101.4 million tons (4.0 % of the total) were classified as hazardous waste. This was equivalent to an average of about 5.0 tons of waste for each inhabitant in the EU-28, of which 201 kg were hazardous waste.

In 2012, in Slovakia there were generated 8,668,104.18 tons of waste introduced on the market. When compared with the year 2011, waste introduced on the market decreased approximately by 20% in 2012. There were generated 1,748 million tons of total municipal waste in Slovakia in 2012. This volume represents 323 kg of municipal waste per capita. Compared to 2011, this is a decrease by 1.2%. When compared with the EU countries, generation of the municipal waste per capita is low, still below the average EU 27 value. In 2012, 4.2 kg per capita of waste from electrical and economic equipment was collected and Slovakia reached the limit of 4 kg/per capita set by EC.

Of total volumes of generated packaging waste in 2012, 59.8% of waste was recycled, and 62.4 % was recovered.

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, and 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, poses a substantial threat or potential hazard to human health.

2.6.1 Health effects of solid wastes

The risk resulting from solid wastes is the possibility to contaminate air, soil, and 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 (dichlorodiphenyl-trichloroethane), 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.

Polychlorinated biphenyls (PCB) are synthetically prepared oily liquids. These compounds showing excellent technological properties were used in technology as fillings for transformers and as hydraulic liquids in condensers, hot-air media, additives to paints and plastic material, printing colors, glues, cements, as lubricants, burning inhibitors, etc.

Effects on humans: PCBs have acute and chronic toxic effects. They enter the organism through the digestive system form the transport, by lungs from the air and by penetration through the skin. In view of their lipophilicity, they accumulate particularly in the food and in the fat part of the body; they are stored mainly in the fatty tissue. The most significant changes caused by the toxic effects of PCBs include weight loss, skin damage, liver, gallbladder, bile ducts, gastrointestinal and urinary tract, lymphatic and endocrine system impairment. Its estrogenic effects cause disturbances in the immune and nervous system. They are included in a group of probable carcinogens. At high exposure doses, the typical sign in humans is chloracne. Overall, in Slovakia in the enterprise Chemko Strážske, during the years 1959-1984 21,481 tons of PCBs were produced. The problem was how to burn them; the imperfect combustion produces dioxins, and dangerous carcinogens. Currently, there are two facilities operating for the disposal of PCB-sodium-combustion technology and combustion of toxic waste incinerator in Slovakia.

Environment and the health status of the population are threatened by unorganized (wild) landfill wastes arising spontaneously and the dump hazardous wastes. Health damage of populations living near hazardous landfill was described - it was mainly about particular reproductive disorders and birth defects, cancer of the selected anatomical locations, immune disorders, kidney disease, impaired liver function, lung disease and respiratory system, and neurotoxic manifestations. Significant associations between congenital disorders of the musculoskeletal system and pesticides, metals and the defects of the nervous system, plastics and chromosomal abnormalities (20% to 46%) were found.

2.6.2 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 3 and 8.

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.

Knowledge about the health risks of hazardous wastes is 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.

2.6.3 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 2.3 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.

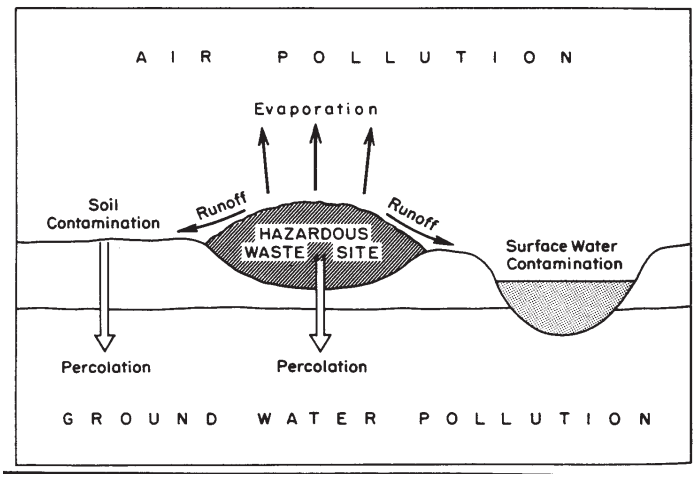


Figure 2.3 Environmental contamination from hazardous waste sites
Source: Tarcher et al., 1992

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** are the most economic methods.

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 uses incinerators of conventional design, the 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 sulfur 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 **reused** as such. Sophisticated technologies now allow recycling of solvents, which become suitable for equipment cleaning, ferric chloride waste from titanium dioxide manufacture, which finds 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.

Special arrangements apply to the disposal of PCBs, waste from the titanium dioxide industry, the used batteries and accumulators containing hazardous substances, construction waste and waste containing asbestos, waste oils, tires, vehicles and so on. There are a number of defined procedures for handling metal waste regarding the limitations in buying of metal waste. The used batteries and accumulators must not be disposed or energy recovered, except those, which have undergone treatment and recycling. The integrity of batteries and accumulators must not be impaired, including the used batteries and accumulators.

Producers of electrical and electronic equipment have the obligation to comply with the limits of collection, recovery, recycling and reuse of the waste of electrical and electronic equipment (WEEE) for 10 categories, respectively:

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer Electronics
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large stationary industrial tools)
7. Toys, tools for leisure, sports, and recreational purposes
8. Medical devices (with the exception of all implanted and infected products)
9. Devices for monitoring and control
10. Vending machines.

The limit of WEEE per capita in the EU is 4 kg.

The EU's approach to waste management is based on three principles: waste prevention, recycling and reuse, and improving final disposal and monitoring. Waste prevention can be achieved through cleaner technologies, eco-design, or more eco-efficient production and consumption patterns. Waste prevention and recycling, focused on materials technology, can also reduce the environmental impact of resources that are used through limiting raw materials extraction and transformation during production processes. Where possible, waste that cannot be recycled or reused should be safely incinerated with landfills only used as a last resort. Both these methods need close monitoring because of their potential for causing severe environmental damage.

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.

References

Act No. 355/2007 Coll. on protection, support, and development of public health (including amendments to certain acts).

Ághová L et al. Hygiene. Environmental Medicine. Bratislava: Comenius University, 1997: 200.

Air quality guidelines for Europe, 2nd Ed. Copenhagen: WHO Regional Office for Europe, 2000. (European Series, No. 91): 273.

Air quality guidelines. Global update 2005. Particulate matter, ozone, nitrogen dioxide, and sulfur dioxide. Copenhagen: WHO Regional Office for Europe, 2006 (European Series, No. 91): 483.

Argalášová - Sobotová L, Mihalčík L, Jajcaj M, Jurkovičová J, Ševčíková L. Noise as a public health problem in Slovakia. In: Needs assessment of capacity building on health risk assessment of environmental noise: Case studies. Eds. Belojevič G et al. Copenhagen: WHO Regional Office for Europe 2012. 38 pp (p. 17-26)

Argalášová Ľ, Jurkovičová J, Ševčíková Ľ, Štefániková Z, Hirošová K, Babjaková J, Kánovicsová A, Filová A. Environmental Noise and Annoyance in the Urban Area at Different Time Intervals. Applied Mechanics and Materials 2014: 617: 110-115.

Babisch W. Updated exposure-response relationship between road traffic noise and coronary heart diseases: a meta-analysis. Noise Health 2014; 16(68):1–9.

Backovic D. Soil pollution. In: Backovic et al. Eds. Lectures in Hygiene, Naucna, Beograd 2001, 179 -187.

Basner M, Babisch W, Davis A, Brink M, Clark C, Janssen S, Stansfeld S. Auditory and non-auditory effects of noise on health. Lancet. 2014; 383(9925):1325-1332.

Bencko V. a kol. Hygiene & Epidemiology. Selected chapters. Charles University in Prague – The Karolinum Press. Prague 2011. 270 pp. ISBN 978-80-246-0793-1

Berglund B, Lindvall T, Schwela DH (eds): Guidelines for Community Noise. Geneva: WHO 2000: 159.

Brooks SM et al. Environmental Medicine. Mosby-Year-Book 1995: 780.

Brooks SM, Benson L, Gochfeld M. Types and sources of environmental hazards. In: Brooks SM (Ed); Environmental Medicine. Mosby-Year Book, Inc, 1995: 9-29.

European Commission, Eurostat, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Waste_statistics (accessed on 27.11.2014)

Fields J M, De Jong R G, Gjestland T. a kol. Standardized general-purpose noise reaction questions for community noise surveys: Research and recommendation. J Sound Vib, 2001; 242 (4): 641–679.

Friis RH. Essentials of Environmental Health. Jones and Bartlett Publishers, Inc. 2009: 390.

Fritschi L, Brown Lex A, Kim R, Schwela D, Kephalopoulos S. Burden of disease from environmental noise. Quantification of healthy life years lost in Europe. Geneva: World Health Organization, 2011. 106 pp. http://www.who.int/quantifying_ehimpacts/publications/e94888.pdf

Guidelines for safe recreational water environments. Volume I. Coastal and fresh waters. Geneva: WHO, 2003: 219.
Guidelines for safe recreational water environments. Volume II. Swimming pools and similar environments. Geneva: WHO, 2006:118.
Guidelines for the safe use of wastewater, excreta and greywater. Volume II. Wastewater use in agriculture. Geneva: WHO, 2006: 196.
Guidelines for drinking-water quality: incorporating 1st and 2nd addenda, Vol. 1, Recommendations – 3rd Ed. Geneva: WHO, 2008: 515.
Guidelines for drinking-water quality - 4th ed. Geneva: WHO, 2011: 564.
Hurtley Ch. (Ed.) Night noise guidelines for Europe. WHO 2009: 184 pp.
Kawecki JM, Lee SD. Governmental regulation of exposure to environmental chemicals and physical agents. In: Tarcher AB et al. Principles and practice of environmental medicine. New York: Plenum Publishing Corporation, 1992: 569-579.
Kirch W (Ed.) et al. Encyclopedia of Public Health. Springer Science+Business Media, LLC. 2008: 1599. ISBN 978-1-4020-5613-0
Klinda J, Lieskovská Z. Správa o stave životného prostredia Slovenskej republiky v roku 2012. Bratislava, Banská Bystrica: MŽP SR a SAŽP 2013: 204 ISBN 978-80-88833-63-5
Maxcy-Rosenau-Last, Wallace RB (Ed.). Public Health & Preventive Medicine. 15th Edition.New York: The McGraw-Hill Companies, Inc. 2008: 1367. DOI: 10.1036/ 0071441980
Murphy E and King E A. Environmental Noise Pollution. Noise Mapping, Public Health, and Policy. Elsevier 2014: 268.
Papp A. Environmental nanoparticles and human health risk. Proceeding of the First International Congress on Hygiene and Preventive Medicine. Serbian Medical Society: Belgrade, 22-24 May 2013: 305-311. ISBN 987-86-6061-034-0
Paunovič K, Jakovljevič B, Belojevič G. Predictors of noise annoyance in noisy and quiet urban streets. Sci Total Environ, 2009; 1 (12): 3707–3711.
Pawlaczyk - Luszczynska M, Dudarewicz A, Szymczak W, Sliwinska - Kowalska M. Evaluation of annoyance from low frequency noise under laboratory conditions. Noise Health 2010;12:166-81.
Rimárová K. Environmental Medicine. Košice: Pavol Jozef Šafárik University, 2006: 150.
Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. General Assembly
Official Records Sixty-seventh session Supplement No. 46. United Nations, New York, 2012:15.
SCENIHR, Potential health risks of exposure to noise from personal music players and mobile phones including a music playing function: Scientific Committee on Emerging and Newly Identified Health Risks, European Commission; 2008.
Sobotová Ľ, Jurkovičová J, Štefániková Z, Ševčíková Ľ, Ághová Ľ. Community response to environmental noise and the impact on cardiovascular risk score. Sci Total Environ., 2010; 408 (6):1264-1270.
Stansfeld SA, Matheson MP. Noise pollution: non-auditory effects on health. British Medical Bulletin, 2003; 68:243-257.
Stephens R. Hazardous wastes. In: Tarcher AB et al. Principles and practice of environmental medicine. New York: Plenum Publishing Corporation, 1992: 77-91.
Ševčíková Ľ et al. Hygiena. Bratislava, Comenius University, 2006: 325. ISBN 80-223-2103-6
Šulcová M., Čižnár I, Fabiánová E. a kol. Verejné zdravotníctvo. Bratislava VEDA 2012. 654. ISBN 978-80-224-1283-4
Tarcher AB et al. Principles and practice of environmental medicine. New York: Plenum Publishing Corporation, 1992: 632.
Twardella D, Perez-Alvarez C, Steffens T, Bolte G, Fromme H, Verdugo-Raab U. The prevalence of audiometric notches in adolescents in Germany: The Ohrkan-study. Noise Health 2013; 15(67):412–419.
WHO. Global health risks: mortality and burden of disease attributable to selected major risks. 2009. ISBN 978 92 4 156387 1
WHO Regional Office for Europe. Protection of water sources, Local authorities health and environment briefing pamphlet series 4, Copenhagen: WHO Regional Office for Europe, 1995.

WHO Regional Office for Europe. Drinking-water disinfection, Local authorities health and environment briefing pamphlet series 3, Kopenhagen: WHO Regional Office for Europe, 1996.
WHO Regional Office for Europe. Air and health, Local authorities health and environment briefing pamphlet series 19, Copenhagen: WHO Regional Office for Europe, 1997.
WHO Regional Office for Europe. Hazardous waste, Local authorities health and environment briefing pamphlet series 29, Copenhagen: WHO Regional Office for Europe, 1998.
WHO Regional Office for Europe. Water in emergency situations. Local authorities health and environment briefing pamphlet series 30, Copenhagen: WHO, Regional Office for Europe, 1998.
WHO Regional Office for Europe. Indoor Air Quality, Health and environment briefing pamphlet series 23, Copenhagen: WHO Regional Office for Europe 2000.
WHO Health topics Environmental health http://www.who.int/topics/environmental_health/en/ (accessed 20.11. 2014).
Žiaran S. Potential health effects of standing waves generated by low frequency noise. Noise Health 2013; 15 (65): 237-245.
Yassi A, Kjellström T, de Kok T, Guidotti TL. Basic Environmental Health. Oxford: Oxford University Press, 2001: 456.

3 RADIATION AND HEALTH HAZARDS

Ľubica Argalášová

3.1 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.

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.

3.1.1 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 of 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.

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 matter 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 shown in Table 3.1.

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 of 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.

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). One Bq equals the quantity of radioactivity in which there is one atomic disintegration per second. It replaced the older cgs system unit of curie.

Table 3.1 Quantities and dose units of ionizing radiation

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).*
Source: Upton, 2008

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 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 3.2). It is expressed in a unit called the sievert, symbol Sv.

Effective dose is the equivalent dose weighted for the sensitivity of the exposed organ(s). It is measured in sievert (Sv). Table 3.3 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 the 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.

Effective half-life. Radioisotopes have a "physical" half-life, which is the period of time it takes for one half of the atoms to disintegrate. Physical half-lives for various radioisotopes can range from a few microseconds to billions of years. When a radioisotope is present in a living organism, it may be excreted. The rate of this elimination is influenced by biological factors and is referred to as the "biological" half-life. The effective half-life is the actual rate of halving the radioactivity in a living organism as determined by both the physical and biological half-lives. Whereas for certain radionuclides, the biological processes are dominant, for others, physical decay is the dominant influence. The physical half-lives of the different radionuclides vary, from less than a second in some to billions of years in others.

Table 3.2 Radiation weighting factors

Radiation type	Radiation weighting factor, w_R*
Photons	1
Electrons and muons	1
Protons and charged pions	2
Alpha particles, fission fragments, heavy ions	20
Neutrons	A continuous function of neutron energy

** Radiation weighting factor, wR weights the absorbed dose for the relative biological effectiveness of different types of radiation and is independent of the type of tissue.*
Source: ICRP, 2007; Council Directive 2013/59/EURATOM

Table 3.3 Tissue weighting factors used in the calculation of an effective dose

Tissue or organ	**Tissue weighting factor w_T**
Red bone marrow	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Breast	0.12
Remainder tissues (*)	0.12
Gonads	0.08
Bladder	0.04
Esophagus	0.04
Liver	0.04
Thyroid	0.04
Bone surface	0.01
Brain	0.01
Skin	0.01
Salivary glands	0.01
Whole body total	**1.00**

** The wT for the remainder tissues (0.12) applies to the arithmetic mean dose of the 13 organs and tissues for each sex listed below. Remainder tissues: adrenals, extrathoracic (ET) region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate (male), small intestine, spleen, thymus, uterus/cervix (female).*
Source: ICRP, 2007; Council Directive 2013/59/EURATOM

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 to1/2, 1/4, 1/8 of its initial value. As the amount of a radionuclide decreases, the radiation emitted decreases proportionately.

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.

3.1.2 Radiation sources and levels

Radioactivity from several naturally occurring and human-made sources is present throughout the environment. Some chemical elements present in the environment are naturally radioactive. These are found in varying amounts in soils, water, indoor and outdoor air and even within our bodies, and so exposure to them is inevitable. In addition, Earth is constantly bombarded by high-energy particles originating both from the sun and from outside the solar system. Collectively, these particles are referred to as cosmic radiation. Everybody receives a dose from cosmic radiation, which is influenced by latitude, longitude and height above sea level.

The use of radiation in medicine for diagnosis and treatment is the largest human-made source of radiation exposure today. The testing of nuclear weapons, routine discharges from industrial and medical facilities and accidents such as Chernobyl have added human-made radionuclides to our environment.

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2008) has estimated that the global average annual dose per person from all sources of radiation in the environment is approximately 3.0 mSv/year (see Figure 4.1). Of this, 80% (2.4 mSv) is due to naturally occurring sources of radiation, 19.6% (almost 0.6 mSv) is due to the use of radiation for medical diagnosis and the remaining 0.4% (around 0.01 mSv) is due to other sources of human-made radiation (see Figure 3.1).

There can be large variability in the dose received by individual members of the population depending on where they live, their dietary preferences and other lifestyle choices. Individual radiation doses can also differ depending on medical treatments and occupational exposures. Annual average doses and typical ranges of individual doses from naturally occurring sources and artificial sources of exposure are presented in Tables 3.4 and Table 3.5 (UNSCEAR, 2008).

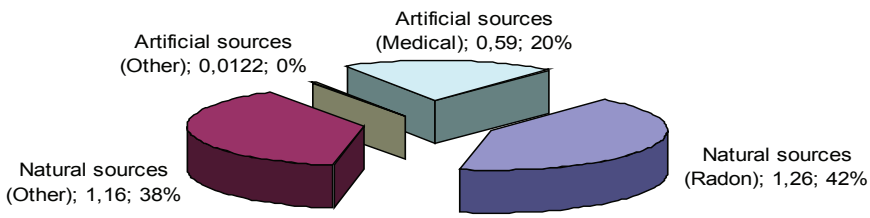


Figure 3.1 Average radiation exposure from all sources (annual effective dose=3.0mSv) (Source: UNSCEAR, 2008)

Table 3.4 Average radiation doses from naturally occurring sources

Source	Worldwide average annual effective dose [mSv]
External exposure	
Cosmic rays	0.39
Terrestrial radiation (outdoors and indoors)	0.48
Internal exposure	
Inhalation (mainly radon)	1.26
Ingestion (food and drinking water)	0.29
Total	**2.4**

Source: UNSCEAR, 2008

Table 3.5 Average radiation doses from artificial sources of exposure

Source	Worldwide average annual effective dose [mSv]
Medical diagnosis (not therapy)	0.60
Atmospheric nuclear testing	0.005
Occupational exposure	0.005
Chernobyl accident	0.002*
Nuclear fuel cycle (public exposure)	0.0002*
Total	**0.6**

** Globally dispersed radionuclides. The value for the nuclear fuel cycle represents the maximum per caput annual dose to the public in the future, assuming the practice continues for 100 years, and derives mainly from globally dispersed, long-lived radionuclides released during reprocessing of nuclear fuel and nuclear power plant operation.*
Source: UNSCEAR, 2008

3.2 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.

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 3.6).

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 3.6).

Tab. 3.6 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.

3.2.1 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 3.7).

Table 3.7 Major forms and features of the acute radiation syndrome

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

Source: Upton, 2008

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 to radiation illness. Acute exposure in excess of 50 Sv can produce cerebral damage leading to confusion, convulsions, coma, and death.

3.2.2 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.

3.2.3 Health effects other than cancer

Somatic effects of radiation on humans are changes that affect the individual, can range from cellular to the 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.

Growth and development. Injurious effects of ionizing radiation on the developing brain have been found in the atomic-bomb survivors who were exposed to radiation 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.

3.2.4 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.

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.

3.3 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 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.

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 the future research on health effects related to the Chernobyl accident.

Fukushima Daiichi Accident 2011

On 11 March 2011, a Richter Scale 9 earthquake triggered a massive (15 m) tsunami east of Sendai in Japan, which disabled electric power in five out of six generating units at Fukushima Daiichi Nuclear Power Plant in Japan. Although Units 1 to 3 of the plant have automatically shut down at the earthquake, the loss of electric power (including back-up supply) for reactor cooling eventually led to the meltdown of the nuclear reactors. Reactors and spent fuel pools lost their cooling capabilities. This, in turn, led to hydrogen explosions. It was the worst civil nuclear disaster since the one at Chernobyl in 1986. Radioactivity was subsequently dispersed into both the atmosphere and the sea. Three workers were killed by non-radiation-related causes. Around 100,000 people up to 40 km were evacuated. The evacuations greatly reduced (by up to a factor of 10) the levels of exposure that would otherwise have been received by those living in those areas. However, the evacuations themselves also had repercussions for the people involved, including a number of evacuation-related deaths and the subsequent impact on mental and social well-being. The information reviewed by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) implies atmospheric releases of iodine-131 and cesium-137 (two of the more significant radionuclides from the perspective of exposures to people and the environment) in the ranges of 100 to 500 petabecquerels (PBq) and 6 to 20 PBq. These estimates are lower, indicatively, by a factor of about 10 and 5, respectively, than corresponding estimates of atmospheric releases resulting from the Chernobyl accident. Winds transported a large portion of the atmospheric releases to the Pacific Ocean. In addition, liquid releases were discharged directly into the surrounding sea. The direct discharges amounted to perhaps 10 and 50 per cent of the corresponding atmospheric discharges for iodine-131 and cesium-137, respectively; low level releases into the ocean were still ongoing.

Adults living in the city of Fukushima were estimated to have received, on average, an effective dose of about 4 mSv in the first year following the accident; estimated doses for 1-year-old infants were about twice as high. Lifetime effective doses (resulting from the accident) that, on average, could be received by those continuing to live in the Fukushima Prefecture have been estimated to be just over 10 mSv; this estimate assumes that no remediation measures will be taken to reduce doses in the future and, therefore, may be

an overestimate. The most important source contributing to these estimated doses was external radiation from deposited radioactive material. Radiation exposures in neighboring countries and the rest of the world resulting from the accident were far below those received in Japan; effective doses were less than 0.01 mSv, and thyroid doses were less than 0.01 mGy; these levels would be of no consequence for the health of individuals.

By the end of October 2012, about 25,000 workers had been involved in mitigation and other activities at the Fukushima Daiichi nuclear power station site. According to their records, the average effective dose of the 25,000 workers over the first 19 months after the accident was about 12 mSv. About 35 per cent of the workforce received total doses of more than 10 mSv over that period, while 0.7 per cent of the workforce received doses of more than 100 mSv.

According to the UNSCEAR no radiation-related deaths or acute diseases have been observed among the workers and general public exposed to radiation from the accident. The doses to the public, both those incurred during the first year and estimated for their lifetimes, are generally low or very low. In June 2011, a health survey of the local population (the Fukushima Health Management Survey) was initiated. The survey, which began in October 2011 and is planned to continue for 30 years, covers all 2.05 million people living in Fukushima Prefecture at the time of the earthquake and reactor accident. It includes a thyroid ultrasound survey of 360,000 children aged up to 18 years at the time of the accident, using modern high-efficiency ultrasonography, which increases the ability to detect small abnormalities. Increased rates of detection of nodules, cysts and cancers have been observed during the first round of screening; however, these are to be expected in view of the high detection efficiency. Data from similar screening protocols in areas not affected by the accident imply that the apparent increased rates of detection among children in Fukushima Prefecture are unrelated to radiation exposure.

After the Fukushima accident, the international community expressed widespread concern about the readiness of nuclear power stations to withstand extreme natural disasters and multiple events. In addition to conducting safety checks for all existing nuclear facilities, various international discussion platforms were held to review and discuss strengthening nuclear safety and enhancing the capabilities of nuclear power stations to handle emergencies. The Chinese Government also ordered a comprehensive safety review of all nuclear facilities operating or under construction within its borders. Focuses of the safety review are the capabilities to withstand severe external impacts and to manage emergency situations with the aim to more clearly identify these severe external hazards and to have measures to counter these hazards and handle the resulting emergency situations.

3.4 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 3.8).

The 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. *Defense-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, the 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. The 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 the first few hours after the beginning of a 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 the first 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 to be made. Countermeasures such as the control of foodstuffs and the relocation of nearby residents may be indicated.

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 the IAEA and are summarized in Table 3.9.

Table 3.8 General description of INES levels

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)* Major damage to the backup power and containment systems caused by the earthquake and tsunami resulted in overheating and leaking from some of the nuclear plant's reactors. Out of the six reactors, three were rated level 5, one was rated at a level 3, and the situation as a whole was rated level 7 *(Fukushima Daiichi nuclear disaster, a series of events beginning on 11 March 2011)*		

INES level	People and environment	Radiological barriers and control	Defense-in-depth
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)			

Source: IAEA, 2009, 2011

Table 3.9 Recommended generic intervention levels for urgent protective measures

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 the WHO recommends 10 mSv*
Source: The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, 1996; IAEA, 2004

The generic optimized intervention levels recommended for temporary relocation and permanent resettlement are given in Table 3.10. The recommended generic action levels for foodstuffs are presented in Table 3.11.

Table 3.10 Recommended generic intervention levels for temporary relocation and permanent resettlement

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

Source: The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, 1996; IAEA, 2004

Table 3.11 Generic action levels for foodstuffs (Bq/kg)

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

Source: The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, 1996; IAEA, 2004

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.

3.5 SYSTEM OF RADIOLOGICAL PROTECTION

In its 1990 recommendations, the 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.

The ICRP now considers that it is 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.

The ICRP also concludes that the slight differences in nominal detriment coefficients between those derived in the new recommendations in 2007 and those given in its 1990 are of no practical significance and therefore has not significantly changed the dose limits. The limits are reproduced in Table 3.12.

Table 3.12 Recommended dose limits in planned exposure situations

Type of limit	Occupational, mSv in a year	Public, mSv in a year
Effective dose	An effective dose of 20 mSv per year averaged over five consecutive years (100 mSv in 5 years) and 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	20 mSv per year averaged over five consecutive years (100 mSv in 5 years) and of 50 mSv in any single year	15
Equivalent dose to skin	500	50
Equivalent dose to hands, forearms and feet and ankles	500	-

Source: ICRP, 2007; Council directive 2013/59/EURATOM; IAEA Safety Standards 2014

Additional restrictions apply to the occupational exposure of pregnant women. If a female worker has declared that she is pregnant, the 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 in order to reflect the annual value of dose that can reasonably be reached in a particular industry or procedure; it may 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.

3.5.1 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 3.12):

- an effective dose of 20 mSv per year averaged over five consecutive years (100 mSv in 5 years) and of 50 mSv in any single year;
- an equivalent dose to the lens of the eye of 20 mSv per year averaged over five consecutive years (100 mSv in 5 years) and of 50 mSv in any single 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 dose limits are not exceeded:

- an effective dose of 6 mSv in a year;
- an equivalent dose to the lens of the eye of 20 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 3.12):

- an effective dose of 1 mSv in a year;
- in special circumstances, a higher value of effective dose in a single year could apply, provided that the average effective 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.

3.5.2 Radiation to occupationally exposed persons

The total number of workers exposed to ionizing radiation is currently estimated to be about 22.8 million, of whom about 13 million are exposed to natural sources of radiation and about 9.8 million to artificial sources. The mining sector accounts for the vast majority of occupationally exposed workers, and radon is the main source of radiation exposure in underground mines of all types.

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 textbook Occupational Health, Toxicology).

3.5.3 Radiation to patients from medical uses of radiation

Medical exposure remains by far the largest artificial source of exposure to ionizing radiation and continues to grow at a remarkable rate. Medical exposures account for 98 per cent of the contribution from all artificial sources and are now the second largest contributor to the population dose worldwide; representing approximately 20 per cent of the total. The total annual collective effective dose due to medical exposures (excluding radiotherapy) stood at approximately 4.2 million man Sv during the period 1997-2007, an increase of 1.7 million man Sv over the previous period.

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 1 mSv.

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 medi-

cal 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 3.13)

Table 3.13 Guidance reference levels for medical exposures. Exposures for diagnostic radiological procedures for a standard size adult patient – radiography

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
Source: IAEA, 1996

The use of computed tomography (CT) has increased considerably in recent years to the point where approximately 5 per cent of all procedures in diagnostic radiology in developed countries are CT scans. With this technique, a fan-shaped beam of X-rays is rotated around the patient and registered on the opposite side by a row of detectors. An image of a slice or section through the patient is then reconstructed by a computer and conveys superior diagnostic information. However, doses in CT can vary by an order of magnitude or can be higher than those from conventional X-ray examinations.

CT examinations are significant contributors to collective dose from medical diagnosis, and in some countries, their contribution is above 40 per cent of the total. Examinations of the lower bowel contribute about 10 per cent of the total collective dose and chest examinations about one per cent. It is clear from these figures that some relatively infrequent procedures can give a far greater dose to the population than the more common examinations. This is why a CT scan is not used where an ordinary X-ray examination would suffice for a sound diagnosis.

For a diagnostic procedure in nuclear medicine, the patient is given a radionuclide in a carrying substance, such as a pharmaceutical, which is preferentially taken up by the tissue or organ under study. Most of the diagnostic procedures make use of the radionuclide technetium-99m. It has a half-life of 6 hours, gives off gamma rays with an energy of 0.14 MeV, can be conveniently prepared in the hospital, and readily labels a variety of carrying substances. Individual doses from technetium scans are comparable to those in diagnostic radiology. The collective dose from nuclear medi-

cine is, however, lower by more than an order of magnitude, because the number of procedures is much lower. When radionuclides are used for treatment rather than diagnosis, much greater activities are given to the patient and much higher doses are given to the target tissues or organs.

Radiotherapy is used to cure cancers or at least to alleviate the most distressing symptoms, by killing the cancerous cells. A beam of high energy X-rays, gamma ray or electrons is directed towards the diseased tissue so as to give it a high dose while sparing the surrounding healthy tissue. Tumors require absorbed doses of tens of gray to kill the cancer cells effectively. Prescribed doses to tissues are typically in the range 20–60 Gy. Considerable care is required to deliver accurate doses: too low or too high doses may lead to incomplete treatment or unacceptable side effects. Rigorous quality assurance procedures are needed to make sure that equipment is properly set up and maintained.

3.6 MONITORING REQUIREMENTS AT NORMAL RADIATION LOAD AND AT RADIATION THREAT

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. Over the last two years, ^{14}C (which is of both artificial and natural origin) has been also monitored.

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 the Act No. 355/2007 Coll. on Protection, Support and Development of Public Health that implements the 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.

3.7 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.

Short lived waste contains mainly radionuclides with relatively short half-lives (less than 30 years), with only very low concentrations of long lived radionuclides.

NORM (naturally occurring radioactive material) waste consists of often very large amounts of waste containing fairly low concentrations of naturally occurring radionuclides (though these concentrations are often higher than those found in nature). This type of waste is generated in the mining and processing of uranium and other minerals, such as phosphates used in fertilizers.

Alpha waste (or transuranic waste) — waste containing alpha emitting radionuclides such as isotopes of plutonium — is treated as a separate category in some countries.

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.

3.8 TRANSPORT OF RADIOACTIVE MATERIALS

Radioactive materials are routinely transported all around the world by air, sea, road, and rail. These materials include those associated with the nuclear fuel cycle — from uranium ores to spent fuel and radioactive waste — but also radionuclides for nuclear medicine and research, and radioactive sources for industry and radiotherapy. Although the safety record of these transports is excellent, they sometimes cause concern in the

areas through which they pass. For example, a number of countries have expressed particular concern about ships carrying radioactive waste passing through or close to their territorial waters.

Regulations are, therefore, needed not just to ensure that the chances of an accident, which could result in radioactive material being dispersed in the environment, are kept to a minimum, but also to ensure that the workers involved in transport — including those loading and unloading shipments as well as drivers/pilots — are protected. Because much of this transport is international, transport safety was one of the first areas in which the IAEA developed safety standards. The IAEA Regulations for the Safe Transport of Radioactive Material were first published in 1961 and have been revised periodically since.

The Regulations govern the necessary packaging, shielding, labeling and other precautions that must be taken when transporting various types of radioactive material, including tests that packages must undergo to prove that they can withstand possible accidents. The requirements are graded according to the level of activity of the materials to be transported. In general, more hazardous radioactive materials need more extensive and more robust packaging and stricter quality and administrative controls.

The IAEA Transport Regulations are widely accepted as the global standard for the transport of radioactive materials. In some cases, the Agency's Regulations are incorporated into national laws or regulations. Other countries write their own regulations governing transport of radioactive materials, but make them consistent with the IAEA Regulations.

3.9 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.

3.9.1 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.

3.9.2 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; the 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 are shown in Table 3.14.

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 the 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.

Table 3.14 Indoor radon concentrations in OECD countries

Indoor radon levels [Bq/m^3]			
OECD Country	**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

Indoor radon levels [Bq/m³]			
OECD Country	**Arithmetic mean**	**Geometric mean**	**Geometric standard deviation**
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
Sources: UNSCEAR, 2000; WHO, 2007, 2009

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.

3.9.3 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 been observed to be elevated as a result of occupational radon exposure. 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.

3.9.4 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.

A national reference level for radon represents the maximum accepted radon concentration in a residential dwelling and is an important component of a national program. 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, the 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.

Member States in the new Council Directive 2013/59/EURATOM established national reference levels for indoor radon concentrations in workplaces. The reference level for the annual average activity concentration in air shall not be higher than 300 Bq m^{-3}, unless it is warranted by national prevailing circumstances.

National action plans are needed for addressing long-term risks from radon exposure. It is recognized that the combination of smoking and high radon exposure presents a substantially higher individual lung cancer risk than either factor individually and that smoking amplifies the risk from radon exposure at the population level.

The list of items to be considered in preparing the national action plan to address long-term risks from radon includes:

(1) Strategy for conducting surveys of indoor radon concentrations or soil gas concentrations for the purpose of estimating the distribution of indoor radon concentrations, for the management of measurement data and for the establishment of other relevant parameters (such as soil and rock types, permeability and radium-226 content of rock or soil).

(2) Approach, data and criteria used for the delineation of areas or for the definition of other parameters that can be used as specific indicators of situations with potentially high exposure to radon.

(3) Identification of types of workplaces and buildings with public access, such as schools, underground workplaces, and those in certain areas, where measurements are required, on the basis of a risk assessment, considering for instance occupancy hours.

(4) The basis for the establishment of reference levels for dwellings and workplaces. If applicable, the basis for the establishment of different reference levels for different uses of buildings (dwellings, buildings with public access, workplaces) as well as for existing and for new buildings.

(5) Assignment of responsibilities (governmental and non-governmental), coordination mechanisms, and available resources for implementation of the action plan.

(6) Strategy for reducing radon exposure in dwellings and for giving priority to addressing the situations identified under point 2.

(7) Strategies for facilitating post construction remedial action.

(8) Strategy, including methods and tools, for preventing radon ingress in new buildings, including identification of building materials with significant radon exhalation.

(9) Schedules for reviews of the action plan.

(10) Strategy for communication to increase public awareness and inform local decision makers, employers, and employees of the risks of radon, including in relation to smoking.

(11) Guidance on methods and tools for measurements and remedial measures. Criteria for the accreditation of measurement and remediation services shall also be considered.

(12) Where appropriate, provision of financial support for radon surveys and for remedial measures, in particular for private dwellings with very high radon concentrations.

(13) Long-term goals in terms of reducing lung cancer risk attributable to radon exposure (for smokers and non-smokers).

(14) Where appropriate, consideration of other related issues and corresponding programs such as programs on energy saving and indoor air quality.

References

Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation

Decree of the Ministry of Health of the SR No. 524/2007 Coll. laying down details on radiation monitoring network.

IAEA: Radiation, People and Environment. Vienna: IAEA, 2004: 80.

ICRP 1991. Recommendations of the International Commission on Radiological Protection ICRP Publication 60; Ann. ICRP 21 (1-3) Elmsford, New York: Pergamon Press, 1991.

ICRP 2007. The 2007 Recommendations of the International Commission on Radiological Protection ICRP Publication 103; Ann. ICRP 37 (2-4), Elsevier Ltd. 2007

INES The International Nuclear and Radiological event scale User's Manual (2008). Vienna: IAEA, 2009.

International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No.115, Vienna: International Atomic Energy Agency, 1996.

IAEA Safety Standards for protecting people and the environment. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. IAEA Safety Standards Series No. GSR Part 3, Vienna: International Atomic Energy Agency, 2014.

IAEA Annual Report 2011. Vienna: International Atomic Energy Agency, 2012.

Ordinance of the Government of the Slovak Republic No. 345/2006 Coll. laying down safety requirements for protection of personnel and population health against ionizing radiation.

Report of the UNSCEAR to the General Assembly with Scientific Annexes. UNSCEAR Report Vol. I. Sources and Effects of Ionizing Radiation 2008, New York, United Nations 2010, 20.

Report of the United Nations Scientific Committee on the Effects of Atomic Radiation to the General Assembly with scientific annexes. UNSCEAR report Vol. I. Sources, Effects and Risks of Ionizing Radiation 2013, New York, United Nations 2014, 17.
Upton AC. Ionizing Radiation. In: Wallace R (Ed): Wallace/Maxcy-Rosenau-Last Public Health and Preventive Medicine. 15th Edition. The McGraw-Hill Companies, Inc. 2008: 735-742.
WHO Handbook on Indoor Radon. A Public Health Perspective. France: WHO, 2000: 94.
Wrixon AD. New ICRP recommendations. J Radiol Prot, 2008; 28: 161-168.
Zeeb H (Ed.) WHO International Radon Project. Report of the 3rd Meeting. Geneva: Forum Deutches Museum Munich, 13-15 March, 2007: 39.

4 CHILDREN'S AND YOUTH'S HEALTH PROMOTION AND PROTECTION

Ľudmila Ševčíková

The health promotion and protection of children and adolescents is the basis of public health in the area of preventive care of children and youth.

This preventive scientific discipline named also as Children's and youth's environmental health or Hygiene of children and youth 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 knowledge on anatomical, physiological and psychological peculiarities of the single evolutionary phases are set down:

- 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 planning, construction, reconstruction and service in preschool institutions, schools and in centers for studying and working adolescents;
- Principles of diseases and health disorders prevention in children and adolescents.

The aim of children and youth preventive care 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 these tasks 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, pediatricians, and specialists from the curative and preventive sector and other different technologists, environmentalists, psychologists, pedagogues, etc. for developing and applying intervention and prevention measures.

Social relevance and specification of health protection and promotion of young population, which are especially vulnerable to environmental exposures, have caused to single out this public health branch in theory and in practice.

4.1 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.

The physical development and growth

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-economic 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 the sense to help or to break the realization of genetic developmental assumptions of the individual.

Growth and development do not 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 by about 25 cm, weight multiplies three times. In the preschool age according to body changes, between the 1st and 4th year we talk about the first period of fullness, which is followed by period of the first slimness between the 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 17 - 18 and in boys later, at the age of 20 in the area of the Central Europe.

The 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 the 5th year;
- **School age - younger** - to the end of the 10th year;
  - **older** - to the end of the 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 the 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;
- 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 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. The following 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 a 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 orientational evaluation. They do not 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 5.1). The growth graphs are an aid to enable to estimate the dynamics of the child's development. A regular growth is when a child persists at repeated measurements in his zone. Marked deviations, except puberty period, do not 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:

$$\text{Body mass index} = \frac{\text{weight}\,[\text{kg}]}{\text{height}^2\,[\text{m}]}$$

$$\text{Rohrer's index} = \frac{\text{body weight}\,[\text{kg}] \times 10^{5}}{\text{body height}^{3}\,[\text{cm}]}$$

$$\text{Brugsh's index} = \frac{\text{chest circumference}\,[\text{cm}] \times 100}{\text{body height}\,[\text{cm}]}$$

$$\text{Pignet's index} = \text{body height}\,[\text{cm}] - (\text{chest circumference}\,[\text{cm}] + \text{body weight}\,[\text{kg}])$$

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 a sufficiently reliable characteristic.

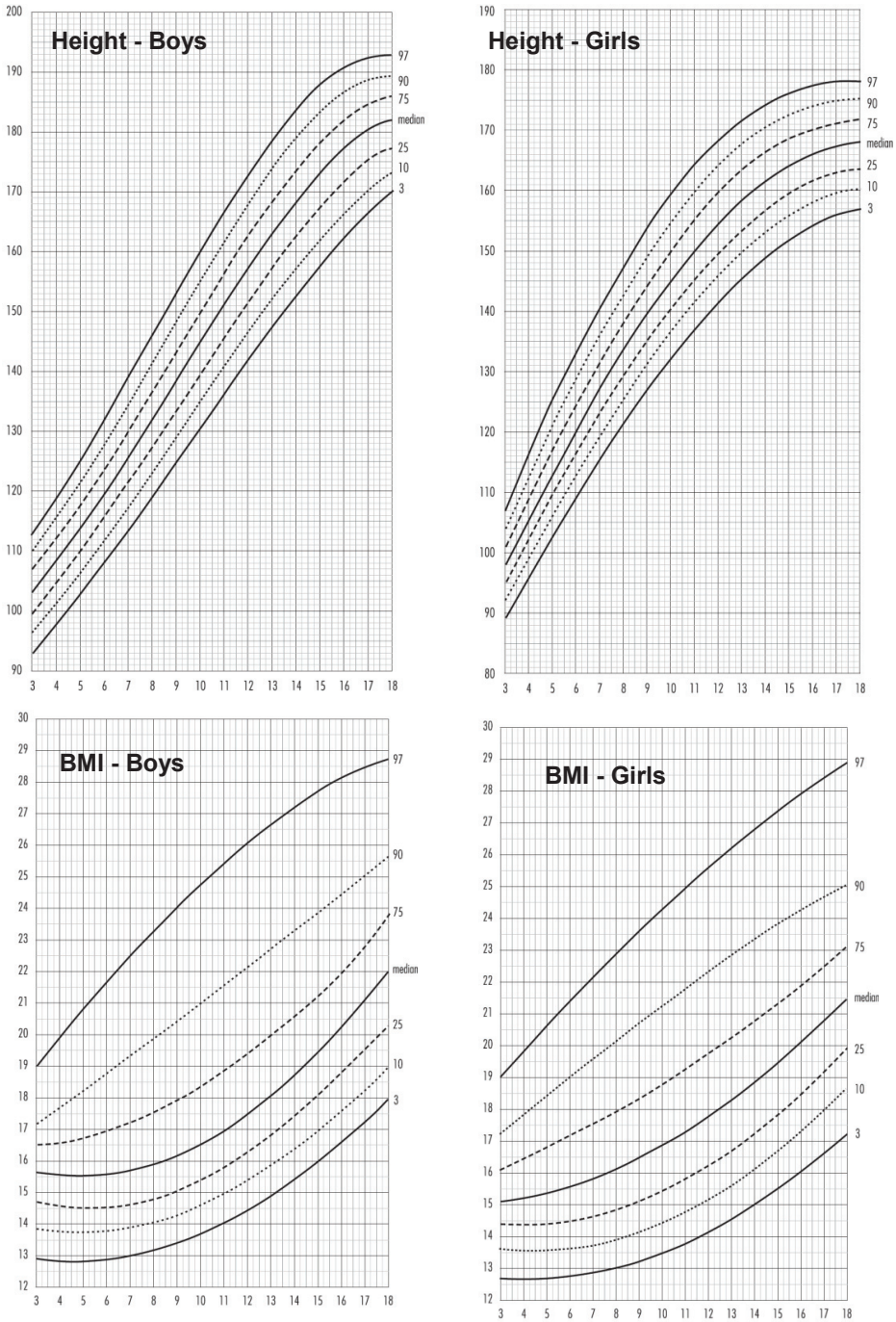
Biological age is a more precise measure of the child's maturity. It is determined according to:

- **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 of 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, psychomotoric 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 good health and nutrition** in children.

Figure 4.1 Growth charts of boys and girls 3 – 18 year-old – Body height, Body mass index (Source: Sevcikova L, Novakova J, Hamade J et al, 2004)



A 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.

The psychical development in each period of childhood and adolescence has typical characteristics.

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.

Newborns sleep daily more than 20 hours. Their other activities include food intake, being wakeful and undifferentiated reactions to strong stimuli from surroundings. From the close biological relationship between mother and child, the basis of the emotional and social components of adaptation is created. The beginning of impulsive uncoordinated movement is gradually changing to systematic movements. Their development have cephalocaudal procedure – the infant begins actively to take control of the head, then the movements of hands, trunk and at the end legs.

At 3 months of age, 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 make the first speech sounds, which are part of speaking later. At 4 months, a baby responds to people who they are in contact with. Between 6 – 8 months a baby recognizes familiar faces, 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 conditioned reflexes are more and more gentle, complicated, and constant. The speed of their formation 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.

At **6 months of age, the child begins sitting up** 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 (grabbing with the thumb in opposition to the other fingers).

Between 6 – 9 months, the child gets on his/her hands and knees, he/she starts to crawl and tries to stand up. There are the first **attempts to walk from 9 to 10 months** of age. At the turn of the 1st and 2nd year of age, the independent walking is the great locomotor and psychic developmental milestone.

Toddler period

After the 1st year of age there are prevailing word's impulses in conditioned 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 environments.

At the end of toddler's age, the speech is the main means of learning and expressively influences behavior of the child. Child's basic vocabulary 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 a very important moment. Rough and gentle movements are developing. The walk is not perfect, yet. This level of physical and mental development gives a possibility for advancing in social area.

The relation of the child to the surroundings is formed on the basis of experiences. During the 2nd year of age, he/she is learning to keep the body clean.

For this age, there is typical the **emotional instability** – changing of mood, weeping and laughing. The child is copying activity of adults, practises 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 can be 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, abstract thinking , 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 are reached. The coordination of movements and fine motor movements of the hands are improved. An assumption to draw his/her 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/she needs direction and help. The child of this age takes dominant male or female behavior. The base form of their 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 there are distinguished **younger school age** (up to the end of 10 years of the age) and **older school age** (up to the age of 15). It is characterized by further improvement of the rough and gentle movements, and sensory perception. Moves of the hands are speeded up (at the age of 8 – 10). Each child creates its own characteristic mimics and gesticulation. The movements are systematic based on balance between automatic and volitional mechanism.

Among children there have been found **differences in biological maturity,** particularly not in favor of boys. In older school age during puberty, the inequable skeletal and muscular development has impact on 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 at school age (its composition, articulation, and vocabulary building). 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 at younger school age can be characterized as relationship to friends and to work. These children have lower dependence on the family, create **society of peers**, and play collective games. Leaders from them do well.

At older school age**, period of maturation**, the social adaptation is worsened, relationship to the opposite sex is changed, and sexuality wakes up. In the emotional area this is a 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 stages of adolescence are defined in pediatrics by sub-categories of chronological age: early adolescence is characterized as ages 11 – 14; middle adolescence as 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, and stabilizing of personality.

Objective information on the course of psychosomatic and functional development in children and adolescents is the basic assumption to create optimal conditions of living, educational, working and curative environment, and all children's activities.

The normative items in preventive care on children and youth are based on estimating of the developmental peculiarities.

References

Blair M, Stewart-Brown S, Waterston T, Crowther R. Child Public Health, 1st ed. Oxford: Oxford University Press, 2003: 262. ISBN: 0-19-263192-6.

Halfon N, Regalado M, Sareen H, Inkelas M, Peck Reuland CH, Glascoe FP, Olson LM. Assessing Development in the Pediatric Office. Pediatrics, 2004; (6)13: 1926-1933.

Musacchio NS, Forcier M. Adolescent Health. In: International Encyclopedia of Public Health. HK Heggenhougen, S Quah (Eds.). Bergen: Elsevier, 2008. ISBN: 978-0-12-373960-5

National Research Council and Institute of Medicine. Children's Health, the Nation's Wealth, 1st ed. Washington DC: National Academies Press, 2004: 336. ISBN-13: 978-0-309-09118-3

Pirasteh A, Hidarnia A, Asghari A, Faghihzadeh S, Ghofranipour F. Development and validation of psychosocial determinants measures of physical activity among Iranian adolescent girls. BMC Public Health, 2008, 8: 150.

Ševčíková Ľ, Nováková J, Hamade J et al. Percentile Charts and Anthropometric Data: Growth and Development of Children and Youth in Slovakia. Bratislava: Public Health Authority SR, 2004.

Ševčíková Ľ et al. Hygiene – Environmental Medicine. Bratislava, Comenius University, 2011: 340. ISBN 978-80-223-2900-2

The state of the world's children 2008. Child survival. New York: United Nations Children's Fund, 2007. Available at: http://www.unicef.org/sowc08 [accessed 23 April 2010].

Wagner N, Meusel D, Kirch W. Nutrition education for children - results and perspectives. J Publ Health, 2005; 13: 102-110.

WHO. Health Behaviour in School-aged Children. WHO International report from the 2005/2006 survey. Edinburg, HBSC International Coordinating Centre, 2008. Available at: http://www.euro.who.int/__data/assets/pdf_file/0005/53852/E91416.pdf [accessed 20 June 2009].

4.2 CHILDREN'S AND YOUTH HEALTH AND ENVIRONMENT

Ľudmila Ševčíková

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 there live approximately 85 per cent 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, due to 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 per cent of deaths in developing countries are attributable to vaccine-preventable infectious diseases.

According to 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). There has been dramatic and accelerating progress in reducing mortality among children, and the data prove that success is possible even for poorly resourced countries. The report Levels and Trends in Child Mortality 2014 has shown that in 2013 6.3 million children under the age of five died from mostly preventable causes, around 200,000 fewer than in 2012, but still equal to nearly 17,000 child deaths each day. In 2013, 2.8 million babies died within the first month of life, which represents about 44% of all under-five deaths. About 45% of all child deaths are linked to malnutrition.

Data from 2005 have shown that more than half a million women 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. In 2013 about 289,000 women died of complications during pregnancy or childbirth.

From the eight "Millennium Development Goals" (MDGs) of the 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). New data released by the United

Nations show that under-five mortality rates have dropped by 49% between 1990 and 2013. The average annual reduction has accelerated – in some countries it has even tripled – but overall progress is still short of meeting the global target of a two-thirds decrease in under-five mortality by 2015. Since 1990, maternal deaths worldwide have dropped by 45%.

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 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 (see Chapter 4.3).

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 the 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.

4.2.1 Children's Environmental Health Indicators

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 the European region on the basis of identified policy needs, the WHO group developed a core set of indicators for implementation and an extended set of 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 envi-

ronmental health indicators. CEHAPE sets **four regional priority goals (RPGs)** that encapsulate key themes for action on children's health in relation to the following environmental factors:

I. **Gastrointestinal health related to safe water and adequate sanitation** (see Table 4.1)**;**
II. **Healthy and safe transport, mobility, and home environment to reduce injuries and enhance physical activity** (see Table 4.2)**;**
III. **Respiratory health and clean air** (see Table 4.3)**;**
IV. **Health through environment free of hazardous chemicals, physical, and biological factors** (see Table 4.4)**.**

CEHAPE recognizes that also social factors are critical in determining a child's possible increased exposure or vulnerability to a number of environmental factors.

Table 4.1 Core and extended indicators related to CEHAPE regional priority goal I (Water safety)

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
Recreational water quality (exposure)	Proportion of identified bathing waters (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 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

Source: Pond K et al. WHO Working Group, 2007

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 the western Europe. Exposure to air pollution, lead, chemicals, and noise has 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.

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.

Table 4.2 Core and extended indicators related to CEHAPE regional priority goal II (Healthy and safe transport, mobility, and home environment to reduce injuries and enhance physical activity).

Indicator title (and type)	Definition of the indicator
Core indicators	
Child mortality from traffic accidents (health)	- by age group and by mode of accident;
Policies for safe transportation for children (policy)	- existence and actual enforcement of legislation and regulations establishing mandatory requirements
Children's mortality due to unintentional injuries not related to traffic accidents (health)	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,
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

Source: Pond K et al. WHO Working Group, 2007

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.

Table 4.3 Core and extended indicators related to CEHAPE regional priority goal III (Respiratory health and clean air)

Indicator title (and type)	Definition of the indicator
Core indicators	
Policies to reduce tobacco smoke exposure in children (policy)	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)	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)	PM_{10}, $PM_{2.5}$(Child population-weighted annual mean PM_{10}, $PM_{2.5}$ concentration), O_3, NO_2, SO_2: exceedance of air quality limit 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 ; 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 aged 0–4, 5–9, or 10–14 years living in proximity to heavily trafficked roads
Extended set of indicators	
Hospital admissions and emergency room visits due to asthma in children (health)	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 centers with a ventilation < 7 L/sec per person

Source: Pond K et al. WHO Working Group, 2007

Indoor air contaminants and symptoms occurring after short and long-term exposure:

- Environmental Tobacco Smoke (ETS): symptoms see in Chapter 4.3.
- 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 the central nervous system, increased risk of leukemia.
- Biologic Agents (bioaerosols: bacteria, viruses, molds; house dust mites, cat, and 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.

Table 4.4 Core and extended indicators related to CEHAPE regional priority goal IV (Health through environment free of hazardous chemicals, physical, and biological factors)

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)	Composite index of national efforts to improve protection of children against UV exposure
Incidence of melanoma (health)	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 aged < 18 years 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 Program (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 in children aged < 6 years . Percentage of children aged < 6 years 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/m$^{3.}$ Specified at the national or regional level
Children with hearing loss and reporting tinnitus (health)	Proportion of children with hearing loss due to noise

Source: Pond K et al. WHO Working Group, 2007

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 is also 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 for a short time, 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.

4.2.2 Health hazards and strategies to improve health in adolescents

Adolescents (aged 10 to 19 years according to the WHO definition) have specific health and development needs, and many of them 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.

Mortality rates are low in adolescents compared with other age groups and have shown a slight decline in the past decade. Globally, the leading causes of death among adolescents are road injury, HIV, suicide, lower respiratory infections and interpersonal violence.

This fact file explores topics of concern to adolescents and strategies to improve their health across the globe.

The health status of adolescent

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 young people.

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.

Early pregnancy and childbirth

About 16 million girls aged 15-19 give birth every year – roughly 11% of all births worldwide. The vast majority of births to adolescents occur in developing countries. The risk for 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.

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.

Mental health

At least 20% of young people will experience some forms 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.

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.

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.

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.

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.

Many adolescent health challenges are closely interrelated and successful interventions in one area can lead to positive outcomes in other areas.

The WHO is helping countries:

- to collect, analyze and use data on adolescent health to support and inform policy-making;
- to develop evidence-based policies and programs 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.

References

Briggs A. Making a Difference: Indicators to Improve Children's Environmental Health. Geneva: World Health Organization, 2003. Available at: http://www.int/ceh/publications/ceh1590599/en/index.html [accessed 8 March 2007].

National Research Council and Institute of Medicine. Children's Health, the Nation's Wealth, 1st ed. Washington DC: National Academies Press, 2004: 336. ISBN-13: 978-0-309-09118-3

Planning to protect children against hazards. WHO, 2007. Available at: http://www.euro.who.int/eehc [accessed 23 April 2010].

Pond K, Kim R, Carroquino M, Pirard P, Gore F, Cucu A, Nemer L, MacKay M, Smedje G, Georgellis A, Dalbokova D, Krzyzanowski M. Workgroup Report: Developing Environmental Health Indicators for European Children: World Health Organization Working Group. Environ Health Perspect, 2007; 115: 1376–1382.

Preventing Drug Use among Children and Adolescents. Bethesda: National Institute on Drug Abuse, U.S. Department of Health and Human Services. Second Edition. October 2003: 49.

Pronczuk de Garbino J et al. Children's health and the environment. A global perspective. Geneva: WHO, 2004: 345.

Rimárová K. Environmental Medicine. Košice: Pavol Jozef Šafárik University, 2006: 150.

Sobotová L, Liu YH, Burakoff A, Sevcikova L, Weitzman M . Household Exposure to Secondhand Smoke is Associated with Decreased Physical and Mental Health of Mothers in the USA. Matern Child Health J, 2009. DOI 10.1007/s10995-009-0549-z

Ministerial Conference on Environment and Health "Protecting children's health in a changing environment" Parma, Italy, 10–12 March 2010 EUR/55934/5.2 Rev 2, 11 March 2010.

UNICEF, WHO, The World Bank, United Nations Population Division. The Inter-agency Group for Child Mortality Estimation (UN IGME). Levels and Trends in Child Mortality. Report 2013. New York, USA, UNICEF, 2013. Available at: http://www.who.int/mediacentre/news/releases/2014/child_mortality_estimates [accessed 20 October 2014].

United Nations Children's Fund. The state of the world's children 2008. Child survival. New York: United Nations Children's Fund, 2007. Available at: http://www.unicef.org/sowc08 [accessed 23 April 2010].

WHO Regional Office for Europe. Children's Environment and Health Action Plan for Europe. World Health Organization, Geneva. Available at: //www.euro.who.int/childhealthenv/policy/20020724_2 [accessed 2 June 2010].

WHO. Children's Environmental Health Indicators (CEHI): Presenting Regional Successes, Learning for the Future – Summary. Geneva: World Health Organization, 2009. Available at: http://www.who.int/ceh/indiconcept/en [accessed 2 June 2010].

WHO Media centre. Children: reducing mortality. Available at: http://www.who.int/mediacentre/factsheets/fs178/en/ [accessed 23 October 2014].

WHO. World Health Statistics 2014. Geneva, World Health Organization; 2014. Available at: http://apps.who.int/iris/bitstream/10665/112738/1/9789240692671_eng.pdf?ua=1 [accessed 10 September 2014].

4.3 IMPORTANT ENVIRONMENTAL RISK FACTORS IN CHILDREN AND ADOLESCENTS IN PREVENTIVE PEDIATRIC HEALTH CARE

Michael Weitzman and Shelby Davies

4.3.1 Recommendations for preventive pediatric health care

Much of well-child preventive pediatric health care is concerned with:

- monitoring child physical, mental and social development as well as nutritional status and exposure to social and environmental toxins;
- screening for specific problems such as iron deficiency and lead and secondhand smoke exposure;
- providing parents anticipatory counseling to enhance child health and decrease risks of adverse health outcomes;
- provide immunizations.

Prenatal period. Prenatal pediatric care has been found to improve birth outcomes. This visit best occurs during the last trimester of pregnancy. Healthcare professionals may use this encounter to educate parents on breastfeeding, appropriate car seats, and care plans for the mother and baby after birth, as well as being educated about the vulnerability of infants to infectious disease, sudden infant death syndrome (SIDS), and shaken baby syndrome. This is also a time to assess for secondhand smoke or lead exposure and for evidence of domestic violence, which has the potential to negatively influence child physical and mental health. Women who experience domestic violence during pregnancy are at higher likelihood of preterm labor, later entrance into prenatal care, lower infant birth weight, and more prenatal substance abuse.

Developmental milestones. Preventive care visits are a time for the pediatrician to make sure that the child is reaching his/her developmental milestones in strength and motor ability, coordination and skills, thinking, perception, and abstraction, language progresses, communicate thoughts of increasing complexity and creativity, learn to read, write, and social and emotional development progresses (see more in Chapter 4.1).

Screening procedures. Screening procedures are an important component of preventive care visits. Newborns should have metabolic screens and assessment for a number of inherited diseases such as hypothyroidism, phenylketonuria, and other metabolic and hematologic problems. Problems tested for vary widely by country. Newborns should also receive an initial vision and hearing screen within the first month of life. Follow up vision and hearing tests are to be performed in children with specific risks. By nine months to one year, children should be screened for lead exposure and anemia. Throughout early and middle childhood, providers should continue to screen for vision, hearing, anemia, and home lead exposure. Tuberculin test (PPD) for tuberculosis should be provided for children who meet the risk criteria. During this period, providers should also start to screen for hyperlipidemia and high blood pressure in children at risk. By adolescence, all menstruating females should be assessed for anemia. All adolescents should be screened for sexually transmitted infections (STIs). Adolescents between the ages of 16 and 18 years should also be screened for HIV at least once per recommendations of the AAP.

Overview of environmental risk factors. Providers should educate parents about the relationship between child health and the home. Lead exposure is a profoundly significant public health concern and currently there are no safe levels of lead exposure

for children. Potential sources of lead in the home include air, bare soil, drinking water, toy jewelry, home remedies, and ingesting lead-contaminated dust and lead-based paint that has chipped, peeled or flaked. Primary prevention screening for increased lead levels is the most effective means of lowering lead exposure in children. The US Centers for Disease Control and Prevention (CDC) recommends that state health officials develop lead screening programs based on the risk profile of their local communities. Providers must educate their families on the potential sources of lead exposure and assessment of lead-based paint hazard in the homes by properly licensed local contactors under supervision of the local health department.

Providers should also counsel on the effect of indoor air quality on child health. Potential sources of air pollutants include carbon monoxide, tobacco smoke, water-damaged building materials, radon, and volatile organic compounds. Over half of the states in the US require that carbon monoxide (CO) detectors be installed in residential buildings (e.g. family homes, child care centers, group child care homes and schools) near bedrooms and on ceilings or walls and replaced every 5-6 years as needed. The home should be a smoke free environment, and parents should be informed of the dangers of firsthand, secondhand, and thirdhand smoke exposure (e.g. Sudden Infant Death Syndrome (SIDS), asthma, otitis media, upper respiratory tract infections, hyperactivity, oppositional defiant disorder, delinquency, and internalizing and externalizing behaviors, impaired school performance and cognitive function, dental caries and food insecurity, etc.) and of the profound effectiveness of tobacco cessation counseling and tobacco cessation medications such as nicotine patches and certain drugs such as buproprion. Per the International Agency for Research on Cancer report, ***Evaluating the Effectiveness of Smoke-free Policies***, smoke-free home policies reduce exposure of the child to secondhand smoke and reduce adult and possibly youth smoking. Radon gas can enter homes through cracks in basement floors or walls, or from diffusing out of building materials, and residential exposure to radon has been associated with lung cancer. Most developed countries have their own guidelines for radon levels in new and existing homes; providers should educate parents on these guidelines and recommend home radon inspection as needed. Likewise, volatile organic compounds (VOCs) negatively affect child health and are found in paint, varnish, wax, cleaning, disinfecting, cosmetic, and degreasing products. Homes should also be maintained at an appropriate temperature and humidity level, as increased humidity is associated with respiratory complications, including asthma exacerbations and respiratory infections. The American Society of Heating Refrigeration and Air Conditioning Engineers has established standards for proper home ventilation.

The quality of water used for drinking, in food production or irrigation, for fish farming, surface water, and recreational water has profoundly important public health implications. Water in homes has the potential to be contaminated with chemicals such as pesticides, bacteria or viruses, and heavy metals. Parents should be educated about water purification systems for the home and Integrated Pest Management (IPM) to reduce pests and pesticide use. IPM assesses the location of pests and encourages proper food storage and cleaning, repair of structural defects through which pests enter homes, and use of low-toxicity pesticides as needed.

There are certain housing structure and design factors that impact childhood health. Children are particularly prone to falls from strollers, walkers, down the stairs, and off the bed or crib. Pediatricians should educate parents on the appropriate distance between crib and playpen slats in order to prevent falls or suffocation. Gates should be installed at the top and bottom of all staircases. Toddlers and preschool children are most at risk for scald burns. Parents should make sure that all hot water heater thermostats are set lower than **49°C (120°F)**, and the water should be tested before bathing

the baby. Electrical burns can occur from the stove, microwave, and/or toasters. Fire may occur secondary to adult smokers, children playing with matches, poor household wiring, defective heating systems, and electric, or kerosene room heaters. Pediatricians should make sure that all families have a working smoke alarms and fire extinguishers in the home. Electrical sockets should be blocked with plastic inserts and frayed or brittle electrical cords should be replaced to prevent injury. Parents should be educated on proper use of rear-facing, forward-facing and belt-positioning booster seats for the car according to age and the importance of helmets when riding bicycles or skating.

Children are also at risk for chemical poisoning by ingestion of prescription or non-prescription medications (acetaminophen, aspirin or diphenhydramine), drain cleaners, herbicides, poisonous plants, personal care items (perfumes, soaps, and hair and nail care products), and low-viscosity hydrocarbons (lighter fluid, pain solvents, and furniture polishes). Parents should be instructed to place safety locks on all cabinets, which the child might be able to access and use child-resistant containers to avoid toxic ingestions.

4.3.2 Two most ubiquitous and dangerous toxic exposures of children in the home - smoke and lead exposure

4.3.3.1 Second and thirdhand smoke exposure in children and adolescents

Tobacco exposure has adverse health implications from the prenatal period through adulthood and has overwhelming medical and economic implications. Many smokers are still unaware of the harmful effects of their tobacco use. Children and adolescents are at particularly high risk for tobacco exposure through prenatal exposure secondary to maternal smoking and/or maternal exposure to secondhand smoke (SHS); exposure to SHS or thirdhand smoke during childhood or adolescence; and active firsthand smoking during adolescence.

SHS is the smoke discharged from the lit end of a burned tobacco product as well as the smoke inhaled by a smoker and then exhaled into the environment during active smoking. There are more than 4000 chemicals in SHS, and more than 250 are known to be toxic. Thirdhand smoke is the residual matter from tobacco smoke that collects on surfaces and in dust. Many components of thirdhand smoke are the same as SHS, but there are additional biologically active chemicals in thirdhand smoke that are formed from the reaction of SHS particles with chemicals such as ozone and gaseous oxide. Children spend the majority of their time lower to the ground where environmental dust with thirdhand smoke particles is present in the highest concentrations. According to the Surgeon General of the U.S. Public Health Service, the most important environmental tobacco smoke exposure for children occurs in the home.

There is no safe level of exposure to tobacco smoke, and tobacco continues to be the leading cause of preventable premature death worldwide. Physical effects of prenatal tobacco exposure involve almost every developing organ system, including the lungs, brain, heart, and ears. Infancy is the postnatal period with the highest risk of respiratory, neurologic, and immunologic morbidity. The rates of complications decrease as children age, partly due to the fact that older children spend less time in the presence of parents, and therefore are exposed to lower levels of SHS.

Prenatal exposure to tobacco and postnatal exposure to SHS are leading preventable causes of sudden infant death syndrome (SIDS), and have been associated with intrauterine growth restriction, low birth weight, and decreased head circumference. They are also associated with health problems during early and middle childhood, including upper respiratory tract infections, lower respiratory tract infections and de-

creased pulmonary function, asthma, otitis media, dental caries, hearing loss, and the metabolic syndrome. Studies have found that children living with smokers are twice as likely to experience food insecurity as children living with non-smokers are. This food insecurity is associated with poor physical health, neuro-psychological development, and poor academic achievement in children. Animal models have shown that nicotine has teratogenic effects on neurodevelopment and marked alterations in neurotransmitters and neuronal pathways. There is also evidence among human studies that exposure to tobacco smoke, both in the prenatal and postnatal periods, increases the risk of poor behavioral and cognitive outcomes in children, including conduct disorder, attention-deficit/hyperactivity disorder, and additional cognitive impairments.

In the United States, the prevalence of current cigarette smoking among adults has declined from 42% in 1965 to 18% in 2012. Cigarette use has dramatically decreased in recent years; however, there has been an increase in adolescent and young adult use of alternative tobacco products (ATPs). The total consumption of cigarettes in the US has decreased 33% between 2000 and 2011; however, the consumption of alternative tobacco products such as hookahs (waterpipes), cigarillos, cigars, bidis, kreteks, smokeless tobacco (snuff, dip, snus and chewing tobacco) has increased an alarming 123% over the same time period. Hookah is perceived as a safer and less addictive alternative to cigarettes, despite multiple studies that show that hookah smoke is potentially more harmful than cigarette smoke. Smokeless tobacco is another alternative tobacco product that is consumed orally, and includes chewing tobacco and oral snuff. The negative health implications of these products include oral leukoplakias, gingival recession, cancer, cardiovascular disease, peripheral vascular disease, hypertension, peptic ulcers, and increased rates of fetal morbidity and mortality.

4.3.3.2 Lead exposure in children and adolescents

The near eradication of acute lead encephalopathy represents one of the great pediatric public health success stories in the United States. Virtually no children in the United States die from this disease any longer. Despite this success, however, a large number of children continue to have levels of lead exposure that affect their health, and severe toxicity and even deaths still occur. Moreover, there are parts of the world where childhood lead remains a major problem and many parts of the world where screening and monitoring are not routinely done so we do not know the prevalence of lead poisoning in these areas. Continued efforts in the areas of primary prevention screening, public education, and removal of sources of lead are needed.

Epidemiologic features of childhood lead poisoning

Blood lead levels of children in the United States have declined dramatically. The mean blood lead level of children 1 to 5 years of age has declined from 15 mcg/dL in 1976 to 1980 to 1.3 mcg/dL in 2007 to 2010. These changes have been accompanied by corresponding declines in the prevalence of 1- to 5-year-old children with blood levels greater than 10 mcg/dL, from 77.8% (1976–1980) to 0.8% (2007-2010). At the same time, however, a consistent and widely accepted research literature has emerged demonstrating adverse neurodevelopmental and behavioral consequences of lead exposure in children at levels previously believed to be safe and it is now clear that there is no known threshold below which adverse effects of lead are absent.

Sources of lead

For most children, lead-contaminated interior and exterior household paint that has chipped, peeled, or chalked in their primary residence or in the homes of relatives, babysitters, or childcare providers remains the most common source of exposure. Most often, lead-contaminated dust, rather than actual paint chips, is the source of the ex-

posure. In the U.S., the older the house, the more likely it is to contain paint; the less affluent the family, the more likely this paint is to be in disrepair. Lead-based paint was not completely banned in the U.S. until the late 1970s while other countries banned it earlier. Numerous other sources of lead exposure exist. Children may be exposed to lead in water, food, soil, toys, or lead glazed ceramics. Parents whose clothing becomes contaminated with lead at work may inadvertently bring lead into the home. Occupations at high risk for take-home exposures include those involving battery production or recycling, the making of pottery, smelting, printing, paint contracting, in brass foundries, or on the demolition or renovation of outdoor structures. In addition, making lead fishing sinkers or bullets, collecting lead figurines, spending time at indoor firing ranges, and making ceramic pottery can place children at risk. Some home remedies can serve as sources of lead poisoning. Lead-glazed ceramic dishes and containers also can cause lead poisoning, especially if acidic foods such as salad dressings or citric acid juices are stored in them. Lead plumbing also remains an important source. In addition, maternal lead stores can be transferred to infants prenatally and in breast milk.

Adverse health effects

Exposure to lead has numerous adverse health consequences. Most concerns, however, focus on the adverse neurocognitive effects of lead toxicity. Adverse neurocognitive effects caused by blood lead levels above 10 mcg/dL have been recognized for some time. Over the past decade, it has become increasing recognized that lead levels well below 10 mcg/dL cause similar negative outcomes. A pooled analysis of findings from 7 prospective studies involving 1,333 children has shown lowered IQ scores that are independently associated with the lowest measurable levels of blood lead: as blood lead levels increase from 2.4 to 10 mcg/dL, there is a 3.9 IQ point decrease; between 10 and 20 mcg/dL, there is an additional 1.9 IQ point decrease; and between 20 and 30 mcg/dL, there is an additional 1.1 IQ point decrease. At this time, it is not possible to ascertain whether a child's peak blood lead level, the average over the child's early years, or a blood lead level taken in proximity, time-wise, to a child's standardized IQ test is most predictive of the magnitude of IQ decrease. An impressive number of studies now show IQ losses and increased rates of adverse outcomes for a substantial number of other aspects of children's functioning, including attention, language development, the transfer of information from short-term to long-term memory, aggression, and antisocial or delinquent behaviors associated with blood lead levels as low as 5 mcg/dL. These findings clearly indicate that blood lead levels well below 10 mcg/dL are associated with subtle but potentially serious alterations of children's neurocognitive functioning. No apparent threshold exists for the toxic effects of lead; that is, negative cognitive effects occur at the lowest measurable levels of blood lead. Prenatal lead exposure has also been studied and has been negatively associated with intellectual development of school-aged children.

Screening for elevated blood lead levels

Primary prevention has proved the most effective means of eliminating lead poisoning in the U.S., and even more intensive large-scale primary preventive measures, such as more aggressive housing rehabilitation, have been advocated. However, to identify children who need individual interventions to reduce their blood lead levels, screening of blood samples remains an essential tool in the prevention of childhood lead poisoning. Although capillary blood samples collected by finger stick are acceptable, the potential for contamination by lead deposits on the skin dictates that capillary specimens with values at or above 5 mcg/dL be confirmed with a venous sample. It is advisable for state health officials to develop universal or targeted screening programs based on the risk characteristics of their local communities. It also is advisable that child health care professionals use blood lead tests to screen 1- and 2-year-olds (and 3- to 6-year-olds who

have not been screened previously but who have risk factors for elevated lead levels, such as those who have siblings with elevated levels or who are recent immigrants or who have the risk factors noted above). Similarly, if parents or health care professionals have suspicion of lead exposure, prompt performance of a blood lead test should be undertaken, regardless of patient age or general health department recommendations.

Effective treatment of children with elevated blood lead levels requires that primary care clinicians collaborate with local health, public housing, and social services to help identify sources of a child's exposure and ways to eliminate them or to provide the children with alternative housing when necessary.

Follow-up of positive screening test

Children with blood lead values > 5mcg/dL

All children with blood lead levels ≥ 5 mcg/dL are encouraged to have ongoing monitoring for continuing lead exposure. If the elevated blood lead level was obtained by a finger-stick blood test, it should be confirmed with a venous blood lead test. The evaluation consists of (1) a detailed medical, nutritional, developmental, and environmental history, and a complete physical examination; (2) a laboratory evaluation of iron status; and (3) an environmental history to identify potential sources of the child's exposure, such as living in or visiting a home built before 1950, or one built between 1950 and 1978 when lead-based paint was still being used in some homes. The physical examination is unlikely to reveal overt signs of neurological damage. Such children should receive a nutritional assessment. Iron deficiency, even in the absence of anemia should be treated with iron supplements as iron deficiency increases the amount of ingested lead that is absorbed from the gastrointestinal tract and has also been found to be independently associated with increased rates of neurobehavioral problems. Increasing meal frequency may decrease lead absorption, but this action should be prescribed in the context of a diet that is not excessive in calorie content.

As elevated lead levels increase the risk for decreased IQ and subtle, or overt neurocognitive and behavioral problems, monitoring of these aspects of child function is particularly important, and referral for formal developmental, neuropsychological, or educational psychology evaluations are indicated if there is any concern about the child's development, educational performance, or behavior, such as inattention or hyperactivity. Families need education about potential sources of lead exposure, means to reduce exposure and housing and public health regulations concerning lead that may assist them in reducing their children's lead exposure. Although often a lengthy and expensive process, abatement of lead-based hazards and subsequent dust control are cornerstones of treatment for children with exposure to lead resulting in elevated blood lead levels. The use of chelating agents for children whose blood lead levels are less than 45 mcg/dL is not indicated.

Children with blood lead levels of 5-44 mcg/dL

All that was noted for those with blood lead levels > 5 apply for these children. In addition, all who have a venous blood lead level ≥ 15 should have a lead inspection for lead paint hazards. The CDC also has listed accelerated schedules for repeating screening blood lead levels for children with blood lead levels of 5-10, 11-20, and 20-40.

Children with blood lead values of 45 mcg/dL or higher

The clearest management strategies exist for children in this category because they are at the greatest risk of overt lead encephalopathy. Broad consensus exists that such children must be removed from sources of lead in their environments and receive chelation therapy. Any child with a blood lead level of 45 mcg/dL should be referred, if possible, to a pediatrician who is familiar with the pharmacologic management of childhood lead poisoning. This is especially salient as children's blood lead levels have come down so that few practitioners have experience using the various available chelating

agents, their potential side effects, or the management of lead encephalopathy. If such a referral is not immediately available, the treating physician may consider consulting with an individual with such experience, such as a pediatrician not in the area, a toxicologist, or a poison control center.

There are many environmental threats to children that have profound implications for health and development, many of which occur in the homes where these children reside. Secondhand and thirdhand tobacco smoke exposure and lead exposure are two of the most serious and detrimental environmental risks to childhood health in the home. There are many laws, practices and programs that have been enacted to address and improve environmental conditions in the home. Preventive health maintenance visits are a powerful and effective time for the health provider to screen for environmental exposures in their patients in order to ensure the health and safety of these children.

References

Bright Futures Guidelines for Health Supervision of Infants, Children and Adolescents. Third Edition. Elk Grove Village, IL: American Academy of Pediatrics; 2008.

Bright Futures: Guidelines for Health Supervision of Infants, Children, and Adolescents. Second Edition. Arlington, VA: National Center for Education in Maternal and Child Health; 2000.

Weitzman M, Baten A, Rosenthal DG, Hoshino R, Tohn E, Jacobs DE. Housing and Child Health. *Current Problems in Pediatric and Adolescent Health Care.* 2013;43(8):185-224.

Centers for Disease Control and Prevention. Response to the advisory committee on childhood lead poisoning prevention report. Low level of lead exposure harms children: a renewed call for primary prevention. *MMWR Morb Mort Wkly Rep.* 2012;61:383.

DiFranza JR, Aligne CA, Weitzman M. Prenatal and postnatal environmental tobacco smoke exposure and children's health. *Pediatrics.* Apr 2004;113(4 Suppl):1007-1015.

International Agency for Research on Cancer. *IARC Hand-books of Cancer Prevention, Tobacco Control, Volume 13: Evaluating the Effectiveness of Smoke-free Policies*. 2009.

ASRAE/ANSI. *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings (62.2 and 62.1)*. Atlanta, GA. 2013.

Brent RL, Weitzman M. The pediatrician's role and responsibility in educating parents about environmental risks. *Pediatrics.* 2004;113(suppl 3):1167-1172.

Zhou S, Rosenthal D, Sherman S, Zelikoff J, Gordon T, Weitzman M. Physical, Behavioral, and Cognitive Effects of Prenatal Tobacco and Postnatal Secondhand Smoke Exposure. *Current Problems in Pediatric and Adolescent Health.* In press: Available online 25 June 2014.

WHO report on the global tobacco epidemic, 2011: Warning about the dangers of tobacco. *World Health Organization.* 2011;ISBN 978 92 4 156426 7.

Sleiman M, Gundel LA, Pankow JF, Jacob P, 3rd, Singer BC, Destaillats H. Formation of carcinogens indoors by surface-mediated reactions of nicotine with nitrous acid, leading to potential thirdhand smoke hazards. *Proceedings of the National Academy of Sciences of the United States of America.* Apr 13 2010;107(15):6576-6581.

Office on Smoking and Health. Publications and Reports of the Surgeon General. *The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General*. Atlanta (GA): Centers for Disease Control and Prevention (US); 2006.

How tobacco smoke causes disease: the biology and behavioral basis for smoking-attributable disease: a report of the Surgeon General. Rockville, MD 2010.

Cutler-Triggs C, Fryer G, Miyoshi T, Weitzman M. Increased rates and severity of child and adult food insecurity in households with adult smokers. *Arch Pediatr Adolesc Med.* 2008;162(11):1056-1062.

Centers for Disease Control and Prevention. Consumption of cigarettes and combustible tobacco-United States, 2000-2011. *MMWR Morb Mortal Wkly Rep.* 2012;61(30):565-569.

Cobb C, Ward KD, Maziak W, Shihadeh AL, Eissenberg T. Waterpipe tobacco smoking: an emerging health crisis in the United States. *American journal of health behavior.* May-Jun 2010;34(3):275-285.

Eliminating Childhood Lead Poisoning: A Federal Strategy Targeting Lead Paint Hazards [report]. President's Task Force on Environmental Health Risks and Safety Risks to Children. Available at: yosemite.epa.gov/ochp/ochpweb.nsf/content/leadhaz.htm/fi le/leadhaz.pdf.

American Academy of Pediatrics Council on Environmental Health: Pediatric Environmental Health, 3rd edition. Elk Grove Village, IL: American Academy of Pediatrics; 2012.

Lanphear B, Hornung R, Khoury J, et al. Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis. *Environ Health Perspect.* 2005;113(7):894-899.

American Academy of Pediatrics, Committee on Environmental Health. Lead exposure in children: Prevention, detection, and management. *Pediatrics.* 2005;116(4):1036-1046.

4.4 Hygienic requirements on the organization and equipment of child's collective facilities

Ľudmila Ševčíková

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 protection.

All this measures should lead to promotion of children's physical, mental, behavioral and emotional health.

4.4.1 Day nursery, kindergarten – nursery school

Day nurseries are facilities for the youngest age group. These nurseries were expanded in Central and Eastern European countries in the 1950s. Currently, the official policy is that mothers should take care of their children under the age of three years at home. Only in those cases, when a mother has to be employed, or she is in some distress, children under 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. 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 conditions 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.

Kindergartens – nursery schools 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 at this age: inappropriate nutrition, developmental disorders, frequent infection diseases, injures, torture and neglecting.

4.4.2 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 are admitted. They have to be also examined daily to detect any signs of infectious disease (temperature, observation of the skin, mouth cavity, etc.)

From the epidemiological point of view, limitation of the entrance for unauthorized persons is important.

Prevention of the spread of infection in a facility

The number of children in a group is limited from this reason. It is needed to keep:

- principles of group isolation;
- separate objects of personal hygiene (e.g. towels);
- principles of personal hygiene in children and staff;
- provision of suitable ventilation;
- clean-up and disinfection of the rooms, toys, etc.;
- early isolation of sick children and their treatment;
- regular change of sand in a playground (once in a half 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, sunshine, 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.

References

Blair M, Stewart-Brown S, Waterston T, Crowther R. Child Public Health, 1st ed. Oxford: Oxford University Press, 2003: 262. ISBN: 0-19-263192-6.

Ministerial Conference on Environment and Health "Protecting children's health in a changing environment" Parma, Italy, 10–12 March 2010 EUR/55934/5.2 Rev 2, 11 March 2010.

National Research Council and Institute of Medicine. Children's Health, the Nation's Wealth, 1st ed. Washington DC: National Academies Press, 2004: 336. ISBN-13: 978-0-309-09118-3

The Health Behavior in School-Aged Children (HBSC) 2005/2006 Survey: School Report. Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, DHHS, 2008: 22.

United Nations Children's Fund. The state of the world's children 2008. Child survival. New York: United Nations Children's Fund, 2007. Available at: http://www.unicef.org/sowc08 [accessed 23 April 2010].

Wallace, R. (Ed) et al. Wallace/Maxcy-Rosenau-Last Public Health and Preventive Medicine. 15th Edition. The McGraw-Hill Companies, Inc. 2008: 1361.

WHO. Planning to protect children against hazards. WHO, 2007. Available at: http://www.euro.who.int/eehc [accessed 23 April 2010].

4.5 Hygienic requirements on educational process in children and adolescents

Ľudmila Ševčíková

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 regard to developmental and interindividual peculiarities of the child's organism.**

Preschool age is a 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 (causing 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-age 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 toys should not replace **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, children start to play in 2–3 member groups. Application of collective group games before 3 years of age is for children unnatural, inadequate for age possibilities. Gradual accustoming to concentrated activity is realized through a 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, education 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 preschool children it is characteristic to be very tired at standing and monotonous uniform loading (e.g. compulsory forced sitting, regular marching, etc.). Free movement of children at this age is needed with frequent changing of tempo and with frequent breaks. 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 the contact with new environmental factors, particularly in a 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/her 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 gradual increase of intensity** at new stimuli. The adaptation to new conditions of social existence should be prepared at the former stage of socialization.

The stay of children in kindergarten facilitates their transition into 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 a preschool facility during the last years of the preschool age.

Purposive developing of the pupil's personality in agreement with his/her 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 well-organized rest, work performance recovers not only the 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 a negative phenomenon. It has also protecting and stimulating functions, safeguards the organism against excessive depletion of the functional potency and acts as a stimulus of restitution 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 the impact on school performance.

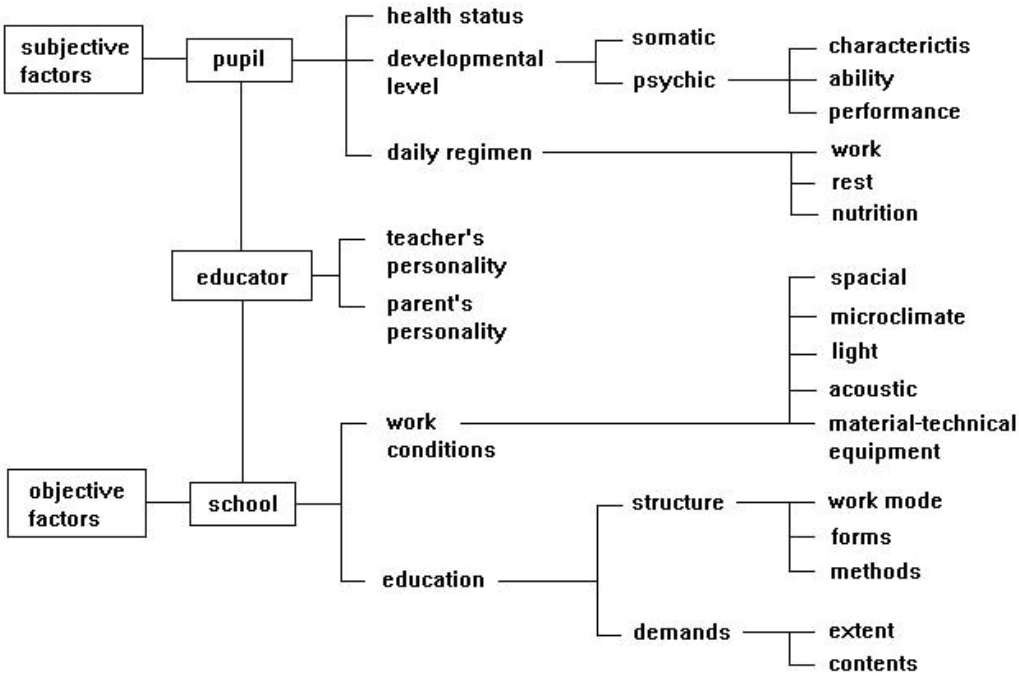


Figure 4.2 Factors of children's load in educational process

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 pauses. That is why the magnitude of load cannot be derived from teaching requirements. The performance also does not reflex loading. Two children at the same performance have different functional output. One of them will overcome the requirements easily. Another one must use reserves for the same performance and without adequate rest; he/she 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 4.2.

Negative effects of these conditions slow down and weaken adaptability of 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 adaptation possibilities of the organism.

Objective and subjective factors, which participate in **overloading of pupils**, act especially at passing from family environment to school and at the beginning of puberty.

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, particularly to:

- long-term paying attention (it is only 12-20 minutes);
- long-term sitting at a desk, which restricts the motor activity and increases 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 increasing the school load has to be respected.

Neuroendocrine rebuilding of the child's organism influences the ability of work and pupil's success in a negative sense. Until 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 the sympato-adrenal system – decrease of its functional activity.

In the classroom's collective there are pupils who differ in abilities – not only in talent – but also in features of temperament, and a 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 or differentiation in teaching process, are not used.

Teachers are usually free in solutions of this problem from the methodic–didactic point of view. At present, the topic task is to rationalize, and to make the educational process more effective. This aim is not available by improving a traditional method. Using the new modern technical means in teaching process supports creative attitudes of pupils to obtained information. Thus, psycho-emotional tension is increasing. The saved time cannot be used for the following intensification of the child's work, but for the rationalization of the work's organization and leisure. The protection of the mental 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 in 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 for 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.

4.5.1 Requirements for the organization of the educational process

Correct organization of the lessons in pedagogical process is aimed at **delay of the beginning of fatigue** and at **break of the fast decrease of work performance.**. 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 effective organization of 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.

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, and on the ability to motivate schoolchildren.

Verbal teaching mode is not suitable for younger schoolchildren, because it influences the second signal system and their fatigue increases more quickly. It is important to use **visual methods** exercising mainly the predominant first signal system in young-

er 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.

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, and conditions of its realization.

Recovery from fatigue is more effective at more frequent and shorter 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 provides possibility for physical activity, which is a physiological need of schoolchildren.

Hygienic principles for constructing the lessons timetables and children daily regimen 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 4.3). 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).

– Number of lessons must be determined with regard to age.

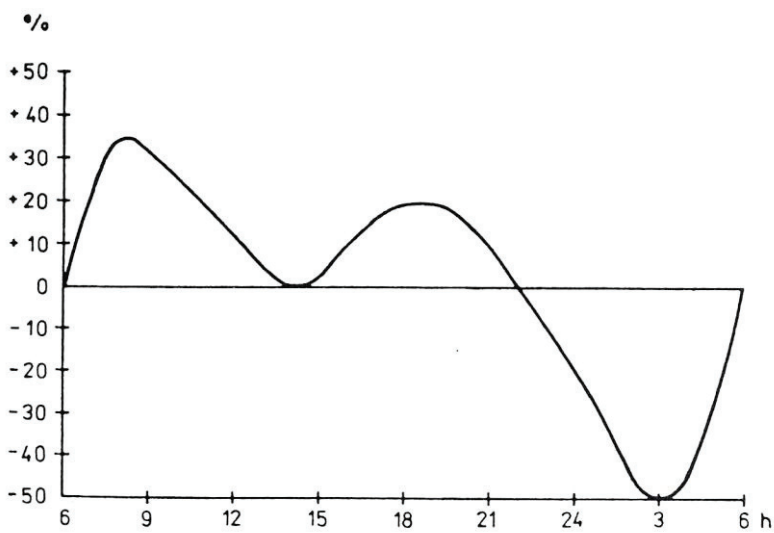


Figure 4.3 Curve of daily physiological efficiency

The school education can content many 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, has been 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.

4.5.2 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' lives. Children's behavior can be influenced by health education, which should be a stable part of 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 the international project 'The healthy school' from the initiative of the WHO started in 1986. According to the 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 a general agreement among European countries about the broad areas of content necessary to be included in school health programs. These include:

- Personal health care - including hygiene and dental health.
- Personal and human relationships - including sexual education and 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 it 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 the following problems:

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 (aged 6-18) 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). 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. In addition, there is ample evidence that increased physical activity improves academic and cognitive performance.

The recommendations for children are 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 programs).

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.

Preventing children from smoking. According to the WHO and U.S. Center for Disease Control and Prevention the goal is to prevent 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 smoking 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.

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.

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 with 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 deal with bullying, violence and racism is an important indicator of the school climate.

Perception of stress in school has been reported in average at 40% of students, which increases with students' age, and was not related to social economic status.

School health education

Schools provide an opportunity for students to learn objective information about a variety of important health topics.

Health Behavior in School-aged Children (HBSC) research network (includes 44 countries and regions across Europe and North America) is an international alliance of researchers that collaborate on the cross-national survey of school students (collects data every four years on health and well-being, health behaviors in their social context). The HBSC administrator survey provides information on school health education programs.

A relatively high percentage of the youth rate their health as fair or poor, high percentage of the youth, mainly girls, report having two or more health complaints, such as backache, stomachache or headache, 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.

References

Blair M, Stewart-Brown S, Waterston T, Crowther R. Child Public Health, 1st ed. Oxford: Oxford University Press, 2003: 262. ISBN: 0-19-263192-6.

Currie C et al., eds. Social determinants of health and well-being among young people. Health Behaviour in School-aged Children (HBSC) study: international report from the 2009/2010 survey. Copenhagen, WHO Regional Office for Europe, 2012 (Health Policy for Children and Adolescents, No.6).

Halfon N, Regalado M, Sareen H, Inkelas M, Peck Reuland CH, Glascoe FP, Olson LM. Assessing Development in the Pediatric Office. Pediatrics, 2004; (6)13: 1926-1933.

Healthy Schools Network. Available at: www.healthyschools.org [accessed 15 April 2008].

Ministerial Conference on Environment and Health "Protecting children's health in a changing environment" Parma, Italy, 10–12 March 2010 EUR/55934/5.2 Rev 2, 11 March 2010.

Musacchio NS, Forcier M. Adolescent Health. In: International Encyclopedia of Public Health. HK Heggenhougen, S Quah (Eds.). Bergen: Elsevier, 2008. ISBN: 978-0-12-373960-5

National Research Council and Institute of Medicine. Children's Health, the Nation's Wealth, 1st ed. Washington DC: National Academies Press, 2004: 336. ISBN-13: 978-0-309-09118-3

Pond K, Kim R, Carroquino M, Pirard P, Gore F, Cucu A, Nemer L, MacKay M, Smedje G, Georgellis A, Dalbokova D, Krzyzanowski M. Workgroup Report: Developing Environmental Health Indicators for European Children: World Health Organization Working Group. Environ Health Perspect, 2007; 115: 1376–1382.

Preventing Drug Use among Children and Adolescents. Bethesda: National Institute on Drug Abuse, U.S. Department of Health and Human Services. Second Edition. October 2003: 49.

Pronczuk de Garbino J et al. Children's health and the environment. A global perspective. Geneva: WHO, 2004: 345.

Ševčíková Ľ, Nováková J, Hamade J et al. Percentile Charts and Anthropometric Data: Growth and Development of Children and Youth in Slovakia. Bratislava: Public Health Authority SR, 2004.

United Nations Children's Fund. The state of the world's children 2008. Child survival. New York: United Nations Children's Fund, 2007. Available at: http://www.unicef.org/sowc08 [accessed 23 April 2010].

Wagner N, Meusel D, Kirch W. Nutrition education for children-results and perspectives. J Publ Health, 2005; 13: 102-110.

WHO. Children's Environmental Health Indicators (CEHI): Presenting Regional Successes, Learning for the Future – Summary. Geneva: World Health Organization, 2009. Available at: http://www.who.int/ceh/indiconcept/en [accessed 2 June 2010].

WHO. Children's Environment and Health Action Plan for Europe. World Health Organization, Geneva. Available at: //www.euro.who.int/childhealthenv/policy/20020724_2 [accessed 2 June 2010].

WHO. Health Behaviour in School-aged Children. WHO, International report from the 2005/2006 survey. Edinburg, HBSC International Coordinating Centre, 2008. Available at: http://www.euro.who.int/__data/assets/pdf_file/0005/53852/E91416.pdf [accessed 20 June 2009].

WHO. Planning to protect children against hazards. WHO, 2007. Available at: http://www.euro.who.int/eehc [accessed 23 April 2010].

5 HOSPITAL HYGIENE

Ľubica Argalášová

One of the major environmental health problems is the specific problem of health care 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.). Indoor air quality is more critical in health care facilities than in most other indoor environments due to many dangerous microbial and chemical agents, especially immunosuppressed persons. In addition, the importance of good indoor climate is not yet universally recognized. Hazards for patients and employees may differ, however, the hospital environment should be safe for all – patients, employees, and visitors.

Even in the richest countries, hospitals are facing huge economic difficulties. Problems are generally largest in old hospitals that may have large wards and poor or no mechanical ventilation. The situation is even more difficult in poor countries. Therefore, there is always a need for efficient and cost-effective control methods.

5.1 Risk factors in hospitals and protection of health

Problems of risk factors in health care facilities include six basic areas:

- problems of infectious diseases;
- effects of ionizing and other types of radiation;
- unfavorable effect of chemical substances;
- psychosocial problems (psychology of work, drug addictions, etc.);
- issue of occupational physiology;
- risk of accidents, menace of personal safety.

5.1.1 Problems of infectious diseases

Problems of infectious diseases are related to hospital staff, patients, and visitors.

Health care-associated infections

Health care-associated infection (HCAI) – also referred to as nosocomial infection – is defined as "an infection occurring in a patient during the process of care in a hospital or other health-care facility that was not present or incubating at the time of admission. This also includes infections acquired in the hospital but appearing after discharge and occupational infections among staff of the facility".

From the definition it is clearly understandable that the occurrence of this infection is linked to health-care delivery and that it may result, although not always, as a consequence of the failure of health-care systems and processes as well as of human behavior. Therefore, it represents a significant patient safety problem. HCAI occurs worldwide

and affects hundreds of millions of patients both in developed and in developing countries. In developed countries, it complicates between 5-10% of admissions in acute care hospitals.

In developing countries, the risk is 2-20 times higher and the proportion of infected patients can exceed 25%. Beyond causing physical and moral suffering to patients and their relatives, HCAIs represent high costs to the health system and consume resources that could be spent on preventive measures or other priorities instead.

HCAIs can be attributed to the following aspects of contemporary medical care:

1. The widespread use of antimicrobial drugs, selection of drug-resistant microorganisms (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 defense – skin ulcers, aspiration tendencies). The very young and the elderly are particularly susceptible to infection.

In order to properly categorize HCAIs **the place of infection transfer** is important (not the place where the infection was found out). Included are infections manifested after dismissing of a patient to home care (e.g. hepatitis B, infection of a new-born by staphylococcus). On the contrary, infections manifested in the hospital, where a patient was admitted with an infection in an incubation period, are not categorized as HCAIs. HCAIs from the epidemiological, preventive and therapeutic point of view are divided into diseases that are specific or non-specific for hospital facilities.

The occurrence of non-specific infections can usually be related to the epidemiological situation in the region of a hospital or to its hygienic level. Specific infections result from diagnostic and therapeutic methods. They spread frequently by inoculation and by implantation of infective agents, often by unknown way, seldom by fecal-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 newborns, infections of burns, infections of the urinary tract after instrumental examinations, infant and newborn 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 patients.

In general, etiological agents causing nosocomial infections may be any microorganism which is able to evoke infectious disease. In addition to classic pathogens like *Staphylococcus aureus*, 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 HCAIs 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 corticoids, antibiotics and on immunosuppressive treatment, chemotherapy, radiotherapy, patients after organ transplantations, after accidents, patients with burns, etc. There is also microbial colonization 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 is why the nurses have to use disposable gloves during nursing of risk groups and premature babies.

The HCAIs 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 anesthesia, 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 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 HCAIs are extraordinarily frequent. Prevalence of nosocomial infections is most frequent in urology departments, intensive care units and surgical departments.

The most prevalent in the Slovak Republic are respiratory infections of the lower and upper respiratory tract (about 28%), infections of the urinary tract, infections of surgical wounds and gastrointestinal infections. **Surgical wound infections** comprise approximately 15% of all HCAIs and are historically the oldest. They originate from en-

dogenous microorganisms (e. g. carriers of *Staphylococcus aureus*), from acute infections in other parts of the patient's body (bacteremia 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 even 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 21% of all HCAIs. Most of them are mild, but the ascendant infection can lead to more serious complications (bacteremia, pyelitis, etc.). Affected patients are a very important source of infection. The principle of the cause is 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, and disorders of consciousness caused by illness or by medication). The very important hazard is due to 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 anesthesiology respirators.

Frequent HACIs are skin infections, infections of mucous membranes and infections of upper respiratory tract.

Very frequent are also bacteremia 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);
- hemodialysis 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 HCAIs 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.

HCAIs are subject to mandatory surveillance and reporting.

Infections related to the occupation of health care workers

The average sick leave of medical staff is lower than in other groups of employees, but on the other hand, their illnesses last longer. In general, health-care workers are absent very rarely (medicaments are easy to access).

Although the risk of infection is possible in any health-care facility, the major hazard is in hospitals, microbiological and virological research centers. 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 (hemodialysis, oncology, transplantation surgery, hematology and biochemical laboratories, surgery, stomatology departments).

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).

Nowadays, there is increasing concern about AIDS in the general population. 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 five 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 disposal of waste contaminated with biologic material.

The rapid increase of tuberculosis in the US and many other countries and simultaneous development of multiple drug resistant strains of Mycobacterium tuberculosis have caused a lot of concern among health care personnel. A very low dose can cause tuberculosis infection. An estimate of one infectious droplet nuclei per 300 m^3 of air has been given as the critical concentration. The risk of microbial dissemination occurs when contaminated material is handled. Disposal of clinical waste and handling of infectious laundry are examples of potentially dangerous operations. New surgical and autopsy procedures also generate potentially infectious aerosol.

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.

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).

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.

5.1.2 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 theaters, 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 Chapter Radiation and health hazards.

The non-ionizing radiation e.g. ultraviolet light, laser, airwaves and electromagnetic fields also represent the health risk in hospitals. Ophthalmologists who work several hours with lasers during a week may suffer from central vision reduction and from changing of color perception.

5.1.3 Unfavorable 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, anesthetics and antiseptics. The skin resistance is reduced owing to repetitive soap washing especially with brushes. Surgical and orthopedic staff members suffer from a syndrome of dry hands. Dentists and their assistants suffer from contact eczema, evoked by using acrylic-monomer materials, local anesthetics, 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. Ciga-

rette 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 colorless gas **ethylene oxide** were 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, the mixture with carbon dioxide in the ratio of 1: 9 is used. 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 vapor 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 1893. Symptoms of chronic poisoning are divided into three categories:

1. Alteration of behavior 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 anesthetics. It is necessary to control the apparatuses and indoor air of the departments.

5.1.4 Psychosocial problems

During 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 re-

lationship 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, and 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 there was 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 spend 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 to 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.

5.1.5 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 unfavorable 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, and 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.

5.1.6 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 faces 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.

5.2 REQUIREMENTS ON HEALTH CARE 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 5.1).

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 5.1 Requirements on surface of basic and supplementary spaces in outpatient departments

Room	Surface [m^2]
Basic spaces:	
Outpatients 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 5.2).

Table 5.2 Microclimate and acoustic requirements on outpatients 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:					
Storeroom					
Offices for employess	10 – 17	30 – 70	10	underpressure	50
Wardrobe and accessories	20 – 22	30 – 70	5	underpressure	40
	20 – 22	30 – 70	10	underpressure	50

The highest permissible concentrations of dust particles and microbiological factors in clean spaces of the health-care facility are in Table 5.3.

Table 5.3 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 to cleanliness requirements
	Dust particles/m³		Non-pathogenic micro-organisms	Pathogenic micro-organisms	
	< 0.5 μm	< 5 μm	KTJ/m³	KTJ/m³	
M 3.5	3,530	0	< 1	< 1	Superaseptic operating theater 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 theater, operating theater 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 theater including operating theater for laparoscopic and arthroscopic procedures, delivery and section room, clean part and storeroom for aseptic medical devices in central sterilization department, ward in the department of anesthesiology 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 theater background M5.5; Surgical room, neonatal unit, nuclear medicine applications, consulting room for endoscopy, room for small and superficial surgical procedures
Comments: The cleanliness grade is appointed by common logarithm of the highest permissible number of dust particles (size from 0.5 μm in 1 m³ of the air); The numbers of particles have been measured out of operation at first 15 – 20 minutes after activity					

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.).

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 the Slovak legislation, which is in accordance with the European law. Hygiene of health facilities and HCAIs are under the control of Public Health Institutes.

5.3 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, and 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 are as follows:

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, and 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.

5.4 OUTPATIENT DEPARTMENTS

Health-care facilities providing outpatient care are established and operate as individual outpatient departments for general practitioners, or as the outpatient health-care centers including more outpatient departments for general practitioners and some outpatient departments for specialists. They can also operate as health centers including more outpatient departments for general practitioners and some outpatient departments for specialists and laboratory examination 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 outpatient departments should be without barriers, enabling disabled patients to move.

Requirements for space and surface area for outpatient health-care facilities are in Table 5.1.

5.5 DEPARTMENTS OF STOMATOLOGY

Many hygienic and epidemiological problems exist also in departments of stomatology. Apart from problems as in other hospital departments, there are specific conditions that need special attention. Specific risk factors include a forced posture at work of the staff, infections (especially viral hepatitis B, before mandatory vaccination), chemical risks – risk of allergy, exposure to mercury, noise and vibration, disinfection and sterilization.

There should be sufficient space conditions in the each workplace, suitable microclimate, lighting and reduction of noise and vibration in 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 the skin and mucous membranes.

In stomatology department HCAIs can occur as well. The sources of them in stomatological departments are: 1. stomatologic patients, spreading pathogenic microorganisms by lung secretions, 2. stomatological personnel and 3. visitors.

Prevention of stomatological HCAIs includes construction and technical measures, hygienic and epidemiological measures, proper disinfection and sterilization practice. The use of protective shield, especially in the treatment of abscesses is useful.

The physical risk factors are noise, vibration, and radiation.

References

Act by the Ministry of Health No. 09812/2008-OL on minimal requirements on personal and material equipment of health facilities.

Klevens RM, Cardo DM. Control of Infections in Institutions. In: Wallace R (Ed): Wallace/Maxcy-Rosenau-Last Public Health and Preventive Medicine. 15th Edition. The McGraw-Hill Companies, Inc. 2008: 333-339.

Notice by the Ministry of Health No. 553/2007 Coll. on requirements on functioning in health facilities.

Sobotová Ľ, Nosková T, Voleková J, Ághová Ľ. Understanding the role of hospitals and their environment in practical training. Management of Environmental Quality. Internat J, 2003; 14 (3): 344-352.

Public Health Authority of the Slovak Republic. The Annual Report. Bratislava: Public Health Authority of the Slovak Republic, 2012:1098

WHO. Prevention of hospital-acquired infections. A practical guide. 2nd edition. WHO/CDS/CSR/EPH/2002.12. WHO, Malta, 2002: 64.

6 HOUSING AND HEALTH

Ľubica Argalášová

Housing is one of the most powerful social and environmental determinants of health. Encompassing the social and physical environment, the inside and the outside of the dwelling, housing influences the personal and collective capacity to attain and maintain a high level of health and physical, mental and social well-being.

6.1 DEFINITIONS

The house. According to the 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 neighbors, and the neighborhood.

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 neighbors (Figure 6.1).

Figure 6.1 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 neighborhood 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 neighborhood, 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 a 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.

6.2 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 was not always managed by optimal urbanization or by optimal hygienic principles. In the period after Second World War, the principles that were 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 were manifested at reevaluation of demands on individual types of comforts (e.g. over evaluation 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 were 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 were 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.

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 was undertaken from 2002 to 2003 in eight European cities (Vilnius, Geneva, Bratislava, Angers, Bonn, Budapest, Forli, and Ferreira) at the initiative of the WHO housing and health program 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 on health in cities or regions in Europe.

6.3 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 lives indoors and the amount of time spent inside the house increases with 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. Indoor climate may be the same as that outdoors, or in sealed modern buildings, it may be modified by heating, cooling, or adjusting of humidity levels.

6.3.1 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", non-ionizing 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 6.1. 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 6.1 Sources and possible concentrations of indoor pollutants

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

Source: Last, 2008

The toxic gases specified in Table 6.1 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 conjunctiva 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 ionizing radiation from any natural or man-made source. More information is provided in Chapter Radiation and health hazards.

Extremely **low-frequency electromagnetic radiation (ELF)** has attracted much attention since the cancer incidence at higher rates than expected among children living close to high-voltage power lines was observed. 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, children, and nonsmoking adults 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 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 over the past century for drinking water pipes, in paints, and sometimes in other coating materials. The health risks from lead are severe, particularly in children. It can cause reversible symptoms such as anemia and digestive problems, but can also cause irreversible damage to the 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 neighborhood. The main indoor noise sources are ventilation systems, office machines, home appliances, and neighbors. Road traffic noise represents a frequent, unavoidable, and continuously increasing environmental factor in big cities throughout the world.

According to the results of the LARES study in panel block buildings in three cities of Eastern Europe sponsored by the 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. More information is provided in Chapter Basic environmental health factors

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 day lighting 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, sulfur compounds, ammonia compounds, smoke, soot, and moisture.

6.3.2 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 survey, it was indicated that the existence of cockroaches strongly depended on the housing characteristics and was favored 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 **molds** find favorable, damp conditions, they will develop and this may happen in buildings. Molds 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 molds find favorable, 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 mold 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 mold 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 mold 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 mold growth and dampness. Substantial mold growth was detected in 32% of all homes surveyed associated with health effects such as asthma, bronchitis, migraine, and depression.

6.3.3 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 dependent 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 neighborhood 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 neighbors 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 neighborhood 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.

6.3.4 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 odors 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.

6.4 SPECIAL HOUSING NEEDS

Public health workers are directly concerned about the quality of housing because of the many ways it can affect health. There are minimum housing standards, with specific details on basic equipment and facilities, fire safety, lighting, ventilation, thermal requirements, sanitation and space requirements (occupancy standards).

The need for hygienic housing conditions includes a requirement for 30 m^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 (6 m^2 for bedrooms, 6 m^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 during the day and 30 dB during the night.

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 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.

6.5 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.

References

Bonnefoy X. Inadequate housing and health: An overview. Int J Environ Pollut, 2007; 30 (3/4): 411-429.

Centers for Disease Control and Prevention and U.S. Department of Housing and Urban Development. Healthy housing reference manual. Atlanta: US Department of Health and Human Services, 2006.

Edwards P, Tsouros AD. A healthy city is an active city: A physical activity planning guide. Copenhagen: WHO Regional Office for Europe, 2008.

Last JM. Housing and health. In: Wallace R (Ed). Wallace/Maxcy-Rosenau-Last Public Health and Preventive Medicine. 15th Edition. The McGraw-Hill Companies, Inc. 2008: 919-923.

Regulation of Ministry of Health of the Slovak Republic No. 259/2008 Coll. specifying requirements for indoor climate environment and the minimal requirements for lower standard flats and on accommodation facilities.

Sobotová Ľ, Liu YH, Burakoff A, Ševčíková Ľ, Weitzman M. Household Exposure to Secondhand Smoke is Associated with Decreased Physical and Mental Health in the USA. Matern Child Health J., 2011; 15 (1): 128-137.

WHO Regional Office for Europe. Housing and Health, Health and environment briefing pamphlet series 41, Copenhagen: WHO Regional Office for Europe, 2004.

WHO Regional Office for Europe. Mould and moisture, Health and environment briefing pamphlet series 42, Copenhagen: WHO Regional Office for Europe, 2004.

World Health Organization. (2011) WHO report on the global tobacco epidemic, 2011: Warning about the dangers of tobacco. Geneva: WHO, 152 pp.

7 CHRONIC NON-COMMUNICABLE DISEASES PREVENTION

Jana Jurkovičová

Non-communicable diseases represent the greatest burden of mortality and morbidity all over the world as well as within the European region; non-communicable disease rates are high and increasing. The factors affecting an individual's susceptibility to developing non-communicable diseases are genetic, biological, behavioral and environmental. The reduction and control of behavioral and environmental risk factors remains the cornerstone of action to reduce the incidence and alter the course of non-communicable 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 non-communicable 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 non-communicable 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 non-communicable 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.

7.1 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 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 favorable changes in risk factors. However, CVD still remains the largest cause of death in the United States, Europe, and Australia.

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 is from stroke. Each year CVD causes over 4.3 million deaths in Europe and over 2.0 million deaths in the European Union (EU).

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.

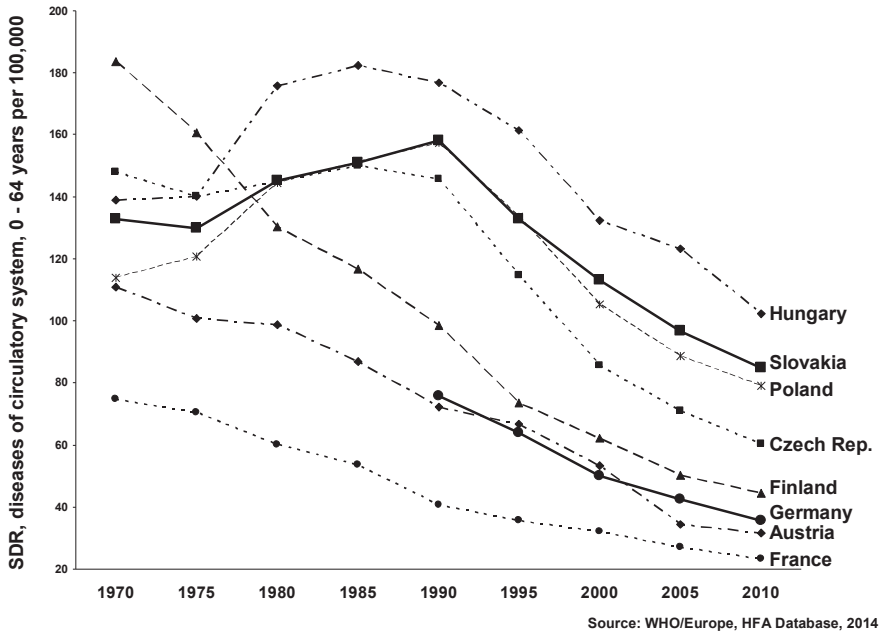


Figure 7.1 Standardized death rate (SDR), diseases of circulatory system, 0 – 64 years in selected European countries during the years 1970 – 2010 (Source: WHO, 2014)

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 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.

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.

Another 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. This study 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 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.

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. 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.

Another well-known large WHO project – **The CINDI** (Countrywide Integrated Non-communicable Diseases Intervention) program, was established in 1982. The CINDI program 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 non-communicable diseases on society by controlling their major risk factors. Thanks to long-term collaboration, a unique body of knowledge and experience has been built up of the prevention of non-communicable diseases through integrated approaches at the community level.

The Program 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 program. A 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 contrib-

utes 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 non-communicable diseases.

The most wide-ranging preventive program in Slovakia was the Cardiovascular Program of the Slovak Republic in the years 1978 – 1989. Representative samples of 484,185 subjects aged 30 – 59 years were examined within this project. The trends of selected cardiovascular diseases and their risk factors prevalence were obtained. 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 programs focused on health improvement, come out from WHO Program Health21 – Health for all in the 21st century. The Health21 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. Target 8 deals with reducing non-communicable diseases: By the year 2020, morbidity, disability and premature mortality due to major chronic diseases shall have been reduced to the lowest feasible levels throughout the region. In particular, mortality due to cardiovascular diseases in people under 65 years shall have been 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 level, 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, 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. 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 behavioral characteristics;
- planning and management of preventive and intervention strategies for non-communicable 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 programs in terms of their quality, focusing on the health outcomes achieved.

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,
- Blood pressure below 140/90 mmHg,
- Total cholesterol level below 5 mmol/L.

7.1.1 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. 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 people.

Gender. Generally, the risk of CVD (especially CHD) development is higher 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. 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.

Hypertriglyceridemia is also associated with CVD risk, but the association is not as strong as it is for hypercholesterolemia. 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, LDL cholesterol should be below 3 mmol/L, and HDL cholesterol should be above 1 mmol/L in men and 1.2 mmol/L in women, respectively.

The issue in the management of dyslipidemia 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, and low fat dairy products,
- weight reduction in obese people and weight maintenance in normal weighing people,
- higher frequency and/or intensity of regular physical activity.

Hypertension. CVD risk is directly related to both systolic and diastolic blood pressure levels. CHD and stroke mortality increase progressively and linearly from blood pressure levels as low 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. 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.

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 (Dietary Approaches to Stop Hypertension, 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).

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 thromboembolism.

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 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 favorable 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-1970s 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.

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 35.1% in 2011/12 with the highest increase in the youngest age groups. Europe as well is expe-

riencing 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.

BMI has been extensively used to define the groups of body weight [kg] / height $[m]^2$ using classifications suggested by the 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. It has been shown that the measurement of waist circumference in addition to BMI gives additional information for CVD risk estimation.

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. Behavior 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. 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.

With the exception of glucose management, prevention of CVD follows the same general principles as for people without diabetes. 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 factors that tend to cluster together are as follows: central obesity, hypertension, low HDL cholesterol, raised triglycerides, and raised blood sugar. 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, dyslipidemia, and hyperglycemia 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 the most European countries: children have become less physically active and only in a few countries children do 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.

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 public health 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.

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 in 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 behavior.
- 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 behaviors and lifestyle. Stress management programs have repeatedly been shown to improve not only subjective well-being but also risk factor levels and CVD outcomes.

7.1.2 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 endpoints 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, hemostasis, and body weight, through various mechanisms.

Food lipids are made up of three 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).

Monounsaturated fatty acids (the main representative is the n-9 oleic acid, the most contained in olive oil) have a favorable effect on HDL cholesterol levels when they replace saturated fatty acids or carbohydrates in the diet.

PUFAs belong to two major groups having different chemical compositions: n-6 and n-3. Linoleic acid (LA) 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, hemostatic 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%.

Fruit and vegetables are significant sources of minerals, vitamins and dietary fiber, 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 servings (400 – 600 g) a day.

Plant sterols, flavonoids, and sulfur-containing compounds represent three classes of compounds found in fruits and vegetables (phytochemicals) 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 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.

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 (5 - 6 g daily), 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 hemorrhagic cerebrovascular accidents and, to a lesser extent, ischemic stroke which depends on the dose. There 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.

7.1.2.1 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 non-cardiovascular 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, fish, 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 7.1):

- 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 7.1 Nutritional risk and protective factors in CVD prevention

Risk nutritional factors	**Protective nutritional factors**
Saturated fatty acids	Monounsaturated (n-9) and polyunsaturated (n-6, n-3) fatty acids
Dietary cholesterol	Plant sterols (sitosterol, campesterol) Plant lecithins (phospholipids)
Trans fatty acids	Fiber (in particular soluble)
High amount of animal fats and proteins	Vitamins C, E, A, D
Sugar (sucrose)	Folic acid, vitamins B_6, B_{12}
Salt (sodium)	Magnesium, potassium, calcium
Alcohol (in high dose, > 30 g pure ethanol/day)	Selenium, copper, manganese, chrome
Sugar-sweetened soft drinks	Phytochemicals (allium compounds, polyphenols, carotenoids, some fungi substances, etc.)
High energy intake, low daily meals frequency	Low energy intake, higher daily meals frequency

7.2 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 2), but the total number of new cases of cancer in Europe appears to have increased (Figure 3). The most common form of cancers in EU is prostate and breast cancers, followed by colorectal and lung cancers. Lung cancer is the most common cause of death from cancer, followed by breast, prostate, and colorectal cancers (Figure 4). Cancer death percentage of total cancer deaths in EU in men and women is shown in Figure 5. There are great differences in standardized death rate of all malignant neoplasms among Eu-

ropean countries (Figure 6). Cancer remains an important public health problem in Europe and ageing of the European population will cause these numbers to continue to increase even if age-specific rates remain constant.

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.

Figure 7.2 Trends of standardized death rates of all malignant neoplasms per 100,000, all ages, in selected European countries during the years of 1970 – 2010
(Source: WHO, 2014)

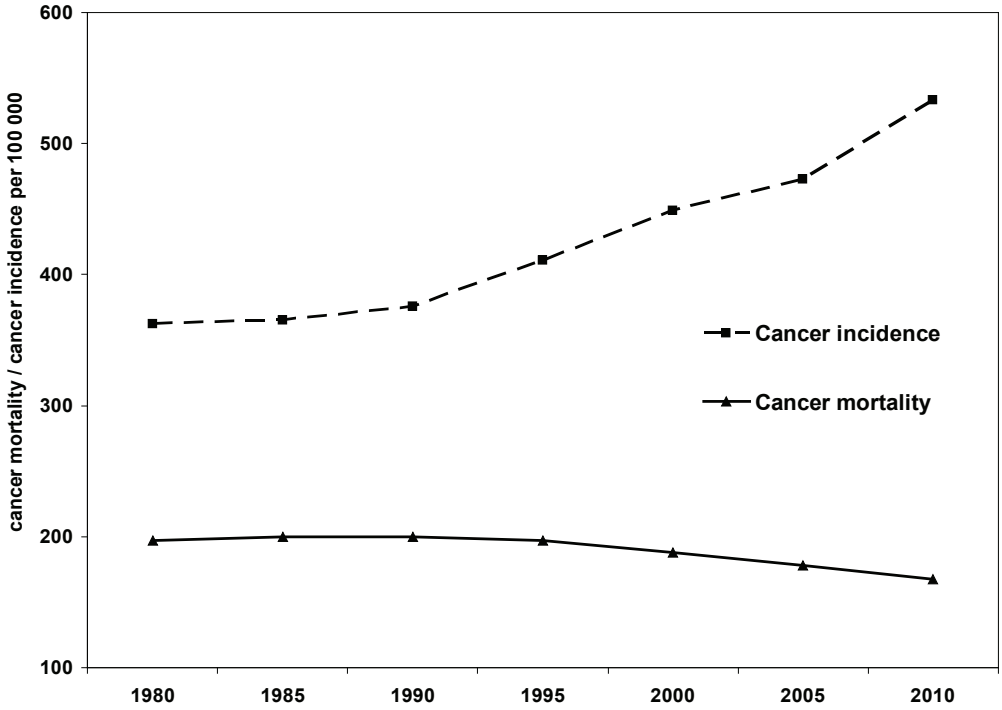


Figure 7.3 *Cancer incidence and cancer mortality per 100,000 in EU during the years of 1980 – 2010 (Source: WHO, 2014)*

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.

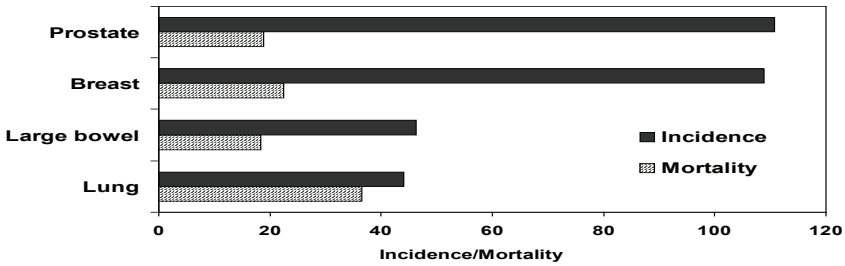


Figure 7.4 The most frequent cancers in both sexes in EU, 2012 (Source: IARC, EUCAN)

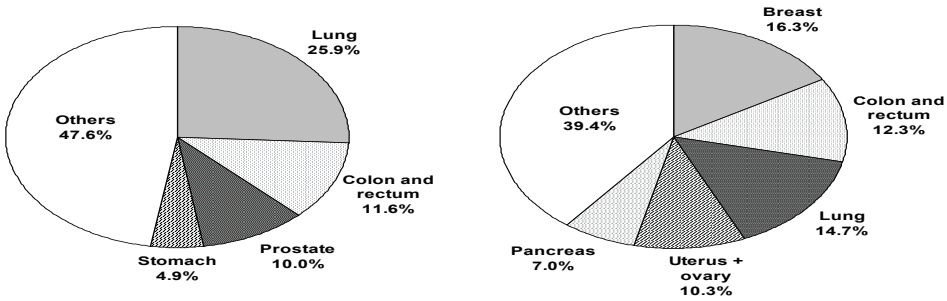


Figure 7.5 Cancer deaths percentage of total cancer deaths in men and women in EU, 2012 (Source: IARC, EUCAN))

7.2.1 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 behavior, 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 second-hand 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, esophagus, and stomach. People who use smokeless tobacco (snuff or chewing tobacco) are at increased risk of cancer of the mouth.

Non-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).

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 esophagus, 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.

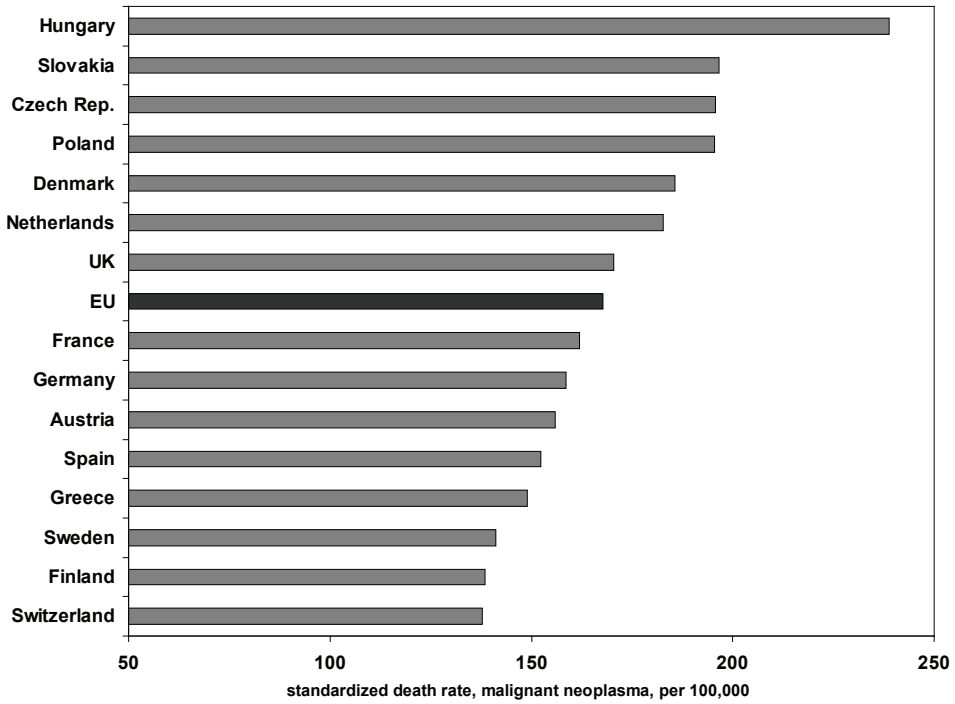


Figure 7.6 Comparison of standardized death rate of all malignant neoplasms per 100,000, all ages, in selected European countries in 2010 (Source: WHO, 2014)

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 ageing of the skin and skin damage that can lead to skin cancer. This is the main cause of melanoma and non-melanoma 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.

7.2.2 The most frequent types of cancers

Lung cancer is one of 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 (secondhand 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 in animal fat and alcohol. The most important preventive approach is lifelong abstinence of all tobacco products.

Colorectal cancer incidence increases both in men and in 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 the 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.

Breast cancer is the most frequent death cause of all cancer death in women in the EU with increased incidence. The highest prevalence is in 50 - 70-year-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 giving birth, 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 fruits, vegetables and fish. Possible risk factors are dietary fat and physical inactivity. For men, risk factors include advanced 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.

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 behavior. The highest prevalence is in 40-55-year-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 deliveries, 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 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 had an increased incidence in the 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. Skin cancer risk factors include also the arsenic exposure – analysis demonstrate a positive correlation between human cumulative arsenic exposure and non-melanoma skin cancer incidence.

7.2.3 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 secondhand smoking.
- A healthy diet includes plenty of foods that are high in fiber, vitamins, and minerals. This includes whole-grain bread and cereals and 5 to 9 servings of fruits and vegetables every day. In addition, 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 behavior.
- Avoiding physical and chemical carcinogens exposure.
- Vaccination (hepatitis B, HPV).

7.3 DIABETES AND DIABETIC COMPLICATIONS PREVENTION

Diabetes mellitus is a disease defined by abnormalities of fasting or postprandial blood glucose level and is frequently associated with disorders of the eyes, kidneys, nerves, and the 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. 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 shown in Figure 7.7.

There are two types of diabetes: type 1, starting in children, and type 2, which represents up to 90% of all diabetic patients and affects mainly persons over 50 years of age with an unhealthy life style and obesity. With ongoing ageing of the population, further increase of diabetes morbidity is expected.

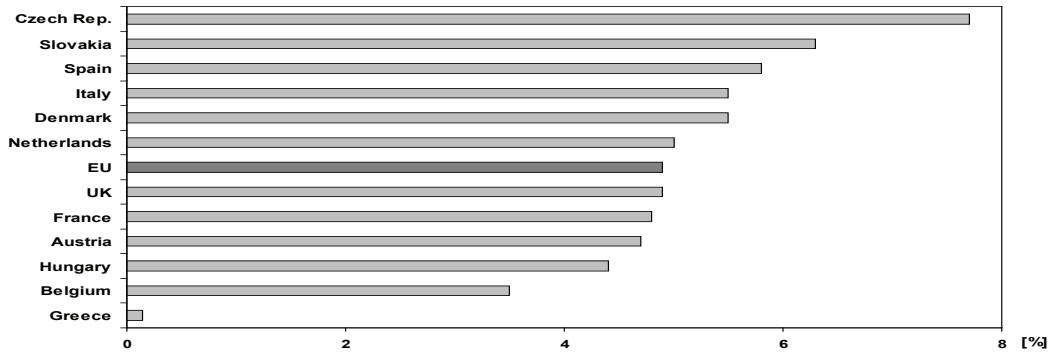


Figure 7.7 Diabetes prevalence (%) in selected European countries (Source: WHO, 2014)

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.

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.
- 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 one drink for adult women and two drinks for adult men.
- 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.

7.4 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 ageing 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 the life. Broken hips in elderly individuals are associated with increased mortality.

Following risk factors were selected for osteoporosis:

- Physical inactivity. This speeds the onset of osteoporosis with ageing;
- Insufficient nutrient and calcium intake;
- Low bone mineral density;
- History of a prior fracture after the age of 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 growth 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. An early identification of individuals in high risk of fractures (densitometry) together with the pharmacological treatment also plays an important role .

The main principles in osteoporosis prevention are as follows:

- The sufficient calcium intake – daily calcium intake of 1,000 – 1,500 mg – can 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 reduction.
- 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.

7.5 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 non-malignant chronic diseases of the respiratory system can be directly related to patterns of cigarette smoking. Despite the limitations of available data, mor-

tality 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.

7.5.1 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. 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 non-specific 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.

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.

7.5.1.1 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 secondhand 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.

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.

7.5.2 Asthma

Asthma is a common disease, whose prevalence has been increasing worldwide. Asthma is a chronic inflammatory disease of the airways. 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.

7.5.2.1 Asthma risk factors

- Familiar and genetic factors. It 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 atopic basis for asthma.
- Respiratory tract infections.
- Air pollutants.
- Smoking (current as well as secondhand 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.

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.

7.6 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".

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.

7.6.1 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 the current situation untenable. 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.

7.6.2 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 non-communicable 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 non-communicable 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.

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 and public health 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 secondhand 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 treatment, needs to be seen as an important component of both undergraduate and postgraduate education.

7.6.3 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.

7.6.4 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 a 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.

7.6.5 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 on the general population as well as on specific unselected populations (school, family, community);

– Selective prevention, targeted on 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.

References

Allender S, Scarborough P, Peto V, Rayner M. European cardiovascular disease statistics 2008. 2008 edition. British Heart Foundation Health Promotion Research Group Department of Public Health, University of Oxford.

Appel LJ, Brands MW, Daniels SR, Karanja N, Elmer PJ, Sacks FM. Dietary Approaches to Prevent and Treat Hypertension: A Scientific Statement From the American Heart Association. Hypertension 2006; 47: 296-308.

Bencko V, Rameš J, Fabiánová E, Götzl M. Non-Melanoma Skin Cancer Incidence in Relation to Arsenic Exposure: 20 Years of Observation. In Recent Advances in Quantitative Methods in Cancer and Human Health Risk Assessment. Edler L, Kitsos CP (Eds.). Wiley, Chichester, 2005:383-394.

Buse JB, Ginsberg HN, Bakris GL, Clark NG, Costa F et al. Primary Prevention of Cardiovascular Diseases in People with Diabetes Mellitus: A Scientific Statement from the American Heart Association and the American Diabetes Association Circulation 2007; 115; 114-126.

Calza S, Decarli A, Ferraroni M. Obesity and prevalence of chronic diseases in the 1999-2000 Italian National Health Survey. BMC Public Health 2008, 8: 140.

Capewell S, Morrison CE, McMuray JJ. Contribution of modern cardiovascular treatment and risk factor changes to the decline in coronary heart disease mortality in Scotland between 1975 and 1994. Heart 1999; 81:380–386.

Chobanian AV, Bakris GL, Black HR, et al. Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension 2003; 42: 1206-1252.

Cole ZA. Dennison EM, Cooper C. Osteoporosis epidemiology update. Curr Rheumatol Reports 2008; 10: 92-96.

De Backer G, Ambrosioni E, Borch-Johnsen K, et al. European guidelines on cardiovascular diseases prevention in clinical practice. Third joint task force of European and other societies on cardiovascular disease prevention in clinical practice. Eur J Cardiovasc Prev Rehabil 2003; 10(Suppl. 1): S1-S74.

European health for all database (HFA DB) WHO/Europe. Last update April 2014.

Executive summary of the Third report of the National cholesterol education program (NCEP) Expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult treatment panel III). JAMA 2001; 285: 2486-2496.

Flegal KM, Carroll MD, Ogden CL, Curtin LR Prevalence and Trends in Obesity Among US Adults, 1999-2008. JAMA 2010; 303(3): 235-241.

Graham I, Atar D, Borch-Johnsen K, et al. European guidelines on cardiovascular disease prevention in clinical practice: full text. Fourth Joint Task Force of the European Society of Cardiology and other Societies on Cardiovascular Disease Prevention in Clinical Practice. Eur J Cardiovasc Prev Rehab 2007; 14(Suppl 2): S1-S113.

Health statistics yearbook of the Slovak Republic 2012. Bratislava: Institute of National Health Information Center 2014: 255. ISBN 978-80-89292-34-9

Health21: The health for all policy framework for the WHO European Region. Regional Office for Europe. Copenhagen, European Health for All Series No. 6: 230. http://www.euro.who.int/document/health21/wa540ga199heeng.pdf

Howard BV, Kritchevsky G. Phytochemicals and Cardiovascular Disease. Circulation 1997; 95: 2591-2593.

International Agency for Research on Cancer, EUCAN. Major cancer types in European countries for 2012. Available at: eco.iarc.fr/EUCAN/Defaultsaspx

Kabir Z, Bennett K, Shelley E, Unal B, Critchley JA, Capewell S. Comparing primary prevention with secondary prevention to explain decreasing Coronary Heart Disease death rates in Ireland, 1985–2000. BMC Public Health 2007, 7:117.

Kris-Etherton PM, Harris WS, Appel LJ. Fish Consumption, Fish Oil, Omega-3 Fatty Acids, and Cardiovascular Disease Circulation 2002; 106; 2747-2757.

Lau EMC. Epidemiology of osteoporosis. Hong Kong: The Chinese University of Hong Kong, School of Public Health, Prince of Wales Hospital: 1-16.

Mancia G, De Backer G, Dominiczak A, et al. 2007 Guidelines for the Management of Arterial Hypertension: The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). J Hypertens, 2007; 25: 1105–1187.

Mancia G, Laurent S, Agabiti-Rosei E, et al. Reappraisal of European guidelines on hypertension management: a European Society of Hypertension Task Force document. J Hypertens, 2009; 27: 2121–2158.

MONICA WHO Programme. http://www.who.int/inf-pr-2000/en/pr2000-10.html

Obesity and Overweight in U.S. adults age 20 years and over. Center for Disease Control and Prevention. Available at: www.cdc.gov/nchs/fastats/obesity-overweight.htm

Perk J, De Backer G, Gohlke H, et al. European Guidelines on cardiovascular disease prevention in clinical practice (version 2012). The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of nine societies and by invited experts). Eur Heart J, 2012; 33: 1635–1701. doi:10.1093/eurheartj/ehs092

Pirasteh A, Hidarnia A, Asghari A, Faghihzadeh S, Ghofranipour F. Development and validation of psychosocial determinants measures of physical activity among Iranian adolescent girls. BMC Public Health 2008, 8: 150.

Reiner Z, Catapano AL, De Backer G, et al. ESC/EAS Guidelines for the management of dyslipidaemias. The Task Force for the management of dyslipidaemias of the European Society of Cardiology (ESC) and the European Atherosclerosis Society (EAS). Eur Heart J; 2011; 32: 1769–1818. doi:10.1093/eurheartj/ehr158

Santos AC, Ebrahim S, Barros H. Gender, socio-economic status and metabolic syndrome in middle-aged and old adults. BMC Public Health 2008, 8: 62.

Schaefer EJ. Lipoproteins, nutrition, and heart disease. Am J Clin Nutr 2002; 75: 191–212.

Topol EJ (Ed). Textbook of cardiovascular medicine. 2nd Edition. Philadelphia: Lippincott William and Wilkins, 2002: 3-246.

Unal B, Critchley JA, Capewell S. Explaining the Decline in Coronary Heart Disease Mortality in England and Wales between 1981 and 2000. Circulation 2004; 109:1101-1107.

Unal B, Critchley JA, Capewell S. Modelling the decline in coronary heart disease deaths in England and Wales, 1981-2000: comparing contributions from primary prevention and secondary prevention. BMJ 2005; 331: 614-617.

Vamos EP, Kopp MS, Keszei A, Novak M, Mucsi I. Prevalence of diabetes in a large, nationally representative population sample in Hungary. Diabetes Res Clin Practice 2008; 81(3): e5-e8.

Verschuren WMM, Jacobs DR, Bloemberg BP et al. Serum Total Cholesterol and Long-term Coronary Heart Disease Mortality in Different Cultures Twenty-five Year Follow-up of the Seven Countries Study. JAMA 1995; 274: 131-136.

Vrentzos GE, Papadakis JA, Ganotakis ES, Paraskevas KI, Gazi IF, Tzanakis N, Nair DR, Mikhailidis DP. Predicting coronary heart disease risk using the Framingham and PROCAM equations in dyslipidaemic patients without overt vascular disease. Int J Clin Pract, 2007; 61(10): 1643–1653.

Windler E, Schöffauer M, Zyriax BC. The significance of low HDL-cholesterol levels in an ageing society at increased risk for cardiovascular disease. Diabetes Vasc Dis Res 2007; 4:136–142.

World Health Organization Regional Office for Europe CINDI Highlights 2005 http://www.euro.who.int/document/E89308.pdf

8 RISK ASSESSMENT APPLIED TO ENVIRONMENTAL MEDICINE

Ľubica Argalášová

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.

8.1 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 intervention. 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 a 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 8.1).

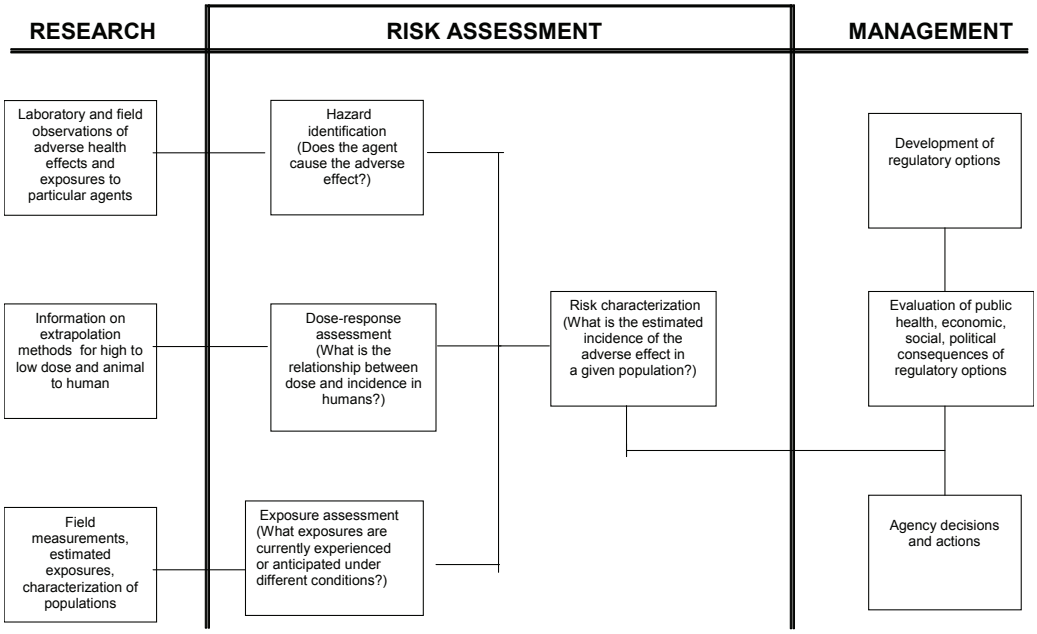


Figure 8.1 Elements of Risk Assessment and Risk Management
Source: Kawecki and Lee, 1992

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.

8.2 RISK ASSESSMENT

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 8.1).

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 8.1.

Table 8.1 Types of epidemiological studies

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

Source: Bonita et al, 2006

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.

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 carboxyhemoglobin 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 non-carcinogens (thought to have a threshold) and carcinogens (thought to be non-threshold). Theoretically, the shape of the dose–response relationship should look like an S or like a cumulative normal distribution (Figure 8.2) 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.

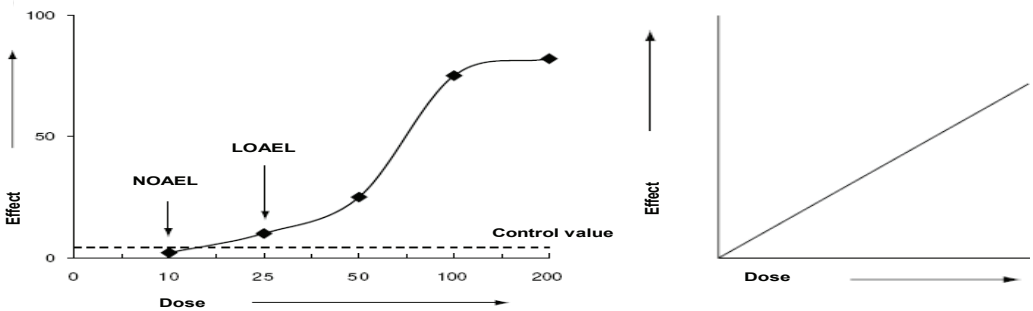


Figure 8.2 Characteristics of dose-response curves for threshold (left) and non-threshold (right) toxicological effects NOAEL – the no-observed-adverse-effect level LOAEL – the lowest-observed-adverse-effect level
Source: Gardiner and Harrington, 2005

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 8.1). Risk characterization, as well as the other steps of the risk assessment process, is different in carcinogens and non-carcinogens (more detailed explanation and calculations see in the textbook Occupational Health, Toxicology).

8.3 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 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.

More detailed description of the Risk Management Decision Framework can be seen in the textbook Occupational Hygiene, Toxicology.

8.4 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. However, there are 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.

References

Bencko V. a kol. Hygiene & Epidemiology. Selected chapters. Charles University in Prague – The Karolinum Press. Prague 2011. 270 pp. ISBN 978-80-246-0793-1

Bonita R, Beaglehole R, Kjellström T. Basic epidemiology. Geneva: WHO, 2006: 213.

Gardiner K, Harrington JM. Occupational Hygiene. Third edition. Malden, Massachusetts: Blackwell Publishing Ltd. 2005: 510. ISBN-13: 978-1-4051-0621-4

Gochfeld M, Burger J. Environmental and ecological risk assessment. In: Wallace, R. (Ed): Wallace/Maxcy-Rosenau-Last Public Health and Preventive Medicine. 15th Edition. The McGraw-Hill Companies, Inc. 2008: 545-561.

Kawecki JM, Lee SD. Governmental regulation of exposure to environmental chemicals and physical agents. In: Tarcher AB et al. Principles and practice of environmental medicine. New York: Plenum Publishing Corporation, 1992: 569-579.

Robson MG, Toscano WA. Eds. Risk Assessment for Environmental Health. John Wiley & Sons, Inc. 2007: 628.

U.S. Environmental Protection Agency. [online]. [Last update 28. 4. 2014] [Accessed on 30.11.2014] http://epa.gov/riskassessment/guidance.htm#guide

8.5 HEALTH RISK ASSESSMENT AND HUMAN EXPOSURE TO ENDOCRINE DISRUPToRS

Vladimír Bencko

Human exposure to **endocrine disruptors** (EDs) is widespread and is considered to pose a growing threat to human health.

Endocrine disruptors are chemicals that may interfere with the body's endocrine system and produce adverse developmental, reproductive, neurological, and immune effects in both humans and wildlife. A wide range of substances, both natural and man-made, are thought to cause endocrine disruption, including pharmaceuticals, dioxin and dioxin-like compounds, polychlorinated biphenyles, DDT and other pesticide, and plasticizers, such a bisphenol A (NIEHS, 2015).

Recent advances in molecular and genetic research and better understanding of mechanisms of blastic cell transformation have led to efforts to improve risk assessment for populations exposed to this family of xenobiotics. In risk assessment, low dose extrapolation of cancer incidence data from both **experimental animals** and **epidemiology studies** has been largely based on models assuming **linear correlation** at low doses, despite existence of evidence showing otherwise. Another weakness of ED risk assessment is **poor exposure data** in **ecological studies**. Those are frequently rough estimates derived from contaminated items of local food basket surveys. Polyhalogenated hydrocarbons and arsenic can be treated as examples. There is growing sense of urgency to develop a **biologically based dose response model of cancer risk**, **integrating** emerging data from **molecular biology** and **epidemiology** to provide more realistic data for risk assessors, public health managers and environmental issues administrators.

8.5.1 Exposure assessment

8.5.1.1 Polyhalogenated hydrocarbons

One of the crucial difficulties in exposure assessment of endocrine disruptors is their **ability** (of many of them) to **cross the placental barrier**. Because of that, the potential exists for **in utero exposure** of the developing organism, as well as exposure of neonates **during critical developmental periods**. **Breast-fed infants** may be exposed to a wide spectrum of endocrine disruptors during sensitive developmental periods at levels 10-40 times higher than levels the general population is exposed to. This led to the Czech Republic's decision to join the WHO/EURO co-ordinated comprehensive program aimed at evaluating the potential health risk and controlling environmental exposure to polyhalogenated hydrocarbons. As part of a project supported by the Czech Ministry of Environment, we extend this study to several areas of the Czech Republic.

To give comparable results with those from the previous rounds of studies using pooled milk samples, the **same study protocol** was used with the exception of pooling the samples. Breast milk samples from well-defined groups of mothers living in areas with different exposure levels were collected. Only a few regions and countries can be identified in which observed levels of the selected groups of polyhalogenated hydrocarbons - dioxins (PCDDs), dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) in human milk fat are higher or lower than those found in human milk from

the other countries. Levels of all compounds were significantly lower in Albania and Hungary. No consistent ranking applies for the countries with respect to levels of the different compounds analysed.

Table 8.2: PCDD/F's and marker PCB's (sum of IUPAC 28, 52, 101, 138, 180) concentrations in human milk in European countries A = exposed region, B = control region

	PCDD/F TEQ pg/g fat		Marker PCB's ng/g fat	
region:	A	B	A	B
WHO study 1993				
Austria	10.7	10.9	381	303
Belgium	26.6	20.8	261	276
Croatia	13.5	8.4	220	218
Czech Republic	18.4	12.1	1069	532
Finland	21.5	12	189	134
Hungary	8.5	7.8	61	45
Lithuania	13.3	14.4	322	287
Norway	10.1	9.3	273	265
Russia	15.2	5.9	197	102
Slovakia	15.1	12.6	1015	489
Spain	25.5	19.4	452	461
United Kingdom	17.9	15.2	130	131

Source: Bencko V, Skulová Z, Krečmerová M, Djien Liem AK (1998): Selected polyhaloganated hydrocarbons in breast milk. Toxicol.Lett.96: 341-345

Despite the presence of PCBs, PCDDs and PCDFs in breast-milk and detection of adverse health effects in highly exposed populations, it was **not considered justified to either limit breast-feeding or eliminate specific food items from the diet**. Primary measures to control and reduce the input of these chemicals into the environment were and still are considered the most effective way to limit and **minimize exposure**.

It is recommended that, despite the presence of PCBs, PCDDs and PCDFs in human milk, **breast-feeding should be encouraged** and promoted on the basis of **convincing evidence** of the **benefits** of human milk to the overall **health and development of the infant**. The only rational recommendation to mothers living in polluted areas and practising breast-feeding of their babies is as follows: **Do not try to lose your body weight during breast-feeding** period to get slim. Otherwise, you will **mobilize** your subcutaneous fat containing the **stored lipophylic xenobiotics** including dioxins and PCBs. This fat will constitute non- negligible part of fat of your breast milk offered to your babies.

The results obtained have shown high levels of PCBs in exposed regions of the Czech Republic and Slovakia but not in the dioxin-like fraction, which fell within the standard range of comparable values from elsewhere in Europe. PCDD/PCDF levels fell in the some lower range of values in comparison with e.g. Benelux countries.

While it is important to consider infant's exposure to TCDDs/Fs and PCBs in breast milk, there are several difficulties in using the data available for health risk assessment. For realistic **exposure assessment** in adults, **blood measurements** are considered a most **appropriate**. Nevertheless, even in this case individual data, usually scattered over a wide range of values, are difficult to treat rationally in cancer risk assessment decisions. In this case, we **calculate doses from food basket surveys** applying the **toxic equivalent factor** (TEQ) concept recently used for e.g. the 1999 Belgian PCB and dioxin incident.

8.5.1.2 Arsenic

Since the mid-1950s power plants in central Slovakia burned local low grade coal with an arsenic content ranging originally from 800 to 1500 g/ton dry weight in the form of sulfides and despite the use of electrostatic eliminators, during the first decade of operation about half a ton of arsenic was emitted daily according to rather conservative calculations. A considerable portion of the emissions was in the form of arsenic trioxide contained in a fine portion of the solid phase of the emissions, mostly condensed at the surface of fly ash particles.

To describe the **human exposure in environmental settings** arsenic determination was carried out in **hair** and **urine samples** taken from groups of **10-year-old boys**, each group numbering 20 to 25 individuals, residing in the region polluted by arsenic emissions (Fig.8.3). The samples were taken from the boys **living at various residential places up to approximately 30 km away from the source of emissions**. In all the materials

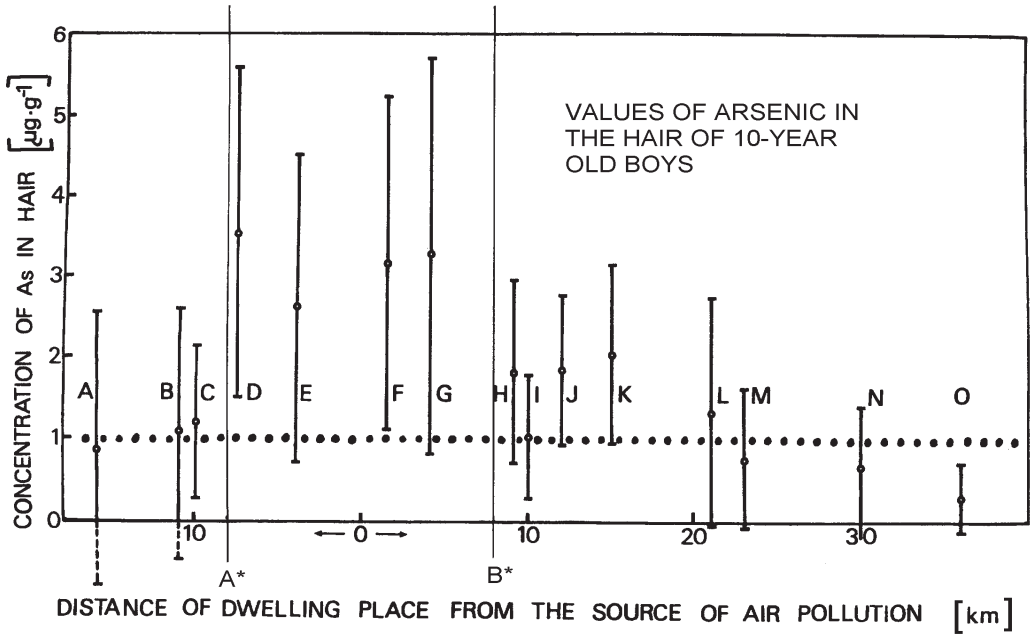


Figure 8.3 Values of arsenic in the hair of 10-year-old boys
A, B* Vertical lines delimitating a most exposed part of the Prievidza district: 7.5 km Dotted line: limit value of A "normal" arsenic hair content.*

Quoted from Bencko V.: Use of human hair as a biomarker in the assessment of exposure to pollutants in occupational and environmental settings, Toxicology, 101, 1995, 29-39.

examined, considerably elevated concentrations of arsenic were found. The results corresponded to the theoretical ideas on spreading of emissions from elevated sources in the open air and tend to establish the applicability of arsenic determination in the **hair** as **suitable** means for **monitoring contamination of the environment by arsenic**. Considerable variability among individual arsenic values in the hair makes group examination a necessity. (For details, see Chapter Biological Monitoring).

The same applies to the blood and urine sampling, which is complicated by several technical difficulties concerning sampling, transport, and storage of the collected samples. Levels in urine reflect the quantities of arsenic inhaled or ingested after their absorption into the blood, and give a more realistic picture of possible total **daily intake** during the **recent days**.

Human health aspects

In highly exposed **power-plant workers** - engaged in **stoking**, **boiler maintenance** and **boiler cleaning** – there appeared some clinical manifestations of arsenic exposure such as **nasal septum perforations** and **neurotoxicity lesions** and **immunotoxicity** parameters.

The most interesting finding in this respect was a high prevalence of **abnormal values of coeruplasmine** (CPL) (43%) in the exposed group in comparison with none in the control group, which is considered to predict immunosuppressive effects of high CPL levels in the exposed group of workers. This corresponded well with the observed increased incidence of malignant tumors in this group in comparison with the mortality pattern of workers in power plants burning "normal" coal. The prevalence of persons with two and more extra-normal parameters was 51% in the exposed group in comparison with 3.7% in the control group.

Population based epidemiological study beginning in the mid-1970s covered the entire population of the Prievidza district, Central Slovakia, with the primary goal of following up the **incidence** of all types of **malignancies** in this area. Study attempted to obtain a complete **district register of malignant tumors** within an administrative unit of about 125,000 population. This project was feasible due to our previous structure of national health care system, which operated in this country. Each cancer patient or any person suspected of any malignancy was referred to the district oncologist who was responsible for the final diagnosis and for the therapy of the patient. Originally, our intention was to perform a 10-year study. However, the data collection efforts and a comprehensive nature of the health care system permitted extending this study to 20 years. The study was initiated in 1976. The **results** of the **first year** were **eliminated** as the system of **data collection** and trials of how our questionnaire was constructed and implemented were **fine-tuned**.

The **district** was **split into two areas** marked off by a 7.5-km circle around the power plant burning coal with high arsenic content. This circle was established using **biological monitoring** of human exposure within the particular locality. The exposure rates were established by analysis of hair samples mentioned above. The **criterion of** "**higher exposure**" was arsenic content exceeding, on the average, hair concentrations of 3 μg/g of arsenic. In a 7.5-km radius of the exposed region, there lived about two-tenths of the district population under study. Values up to 1 μg/g are considered normal. For example, the population in Prague showed approximately 0.2 μg/g, which is less than one-tenth of the mean value, which predominated in this heavily emission-loaded area. Analysis of the database collected suggests a **significant increase** of **non-melanoma skin cancer incidence** in the most polluted part of the district compared with the data relevant for the rest of the district and for the entire Slovak Republic. The incidence of non-melanoma skin cancer is even **markedly influenced** by exposure to arsenic in **occupational settings**.

Considering the relatively **long period of latency**, so frequently described in arsenic-caused cancers, we may assume that the changed tumor incidence pattern was a result of arsenic exposures during the years characterized by the much less favorable environmental conditions from the end of the 1950s to the mid-1970s (see Fig.8.4).

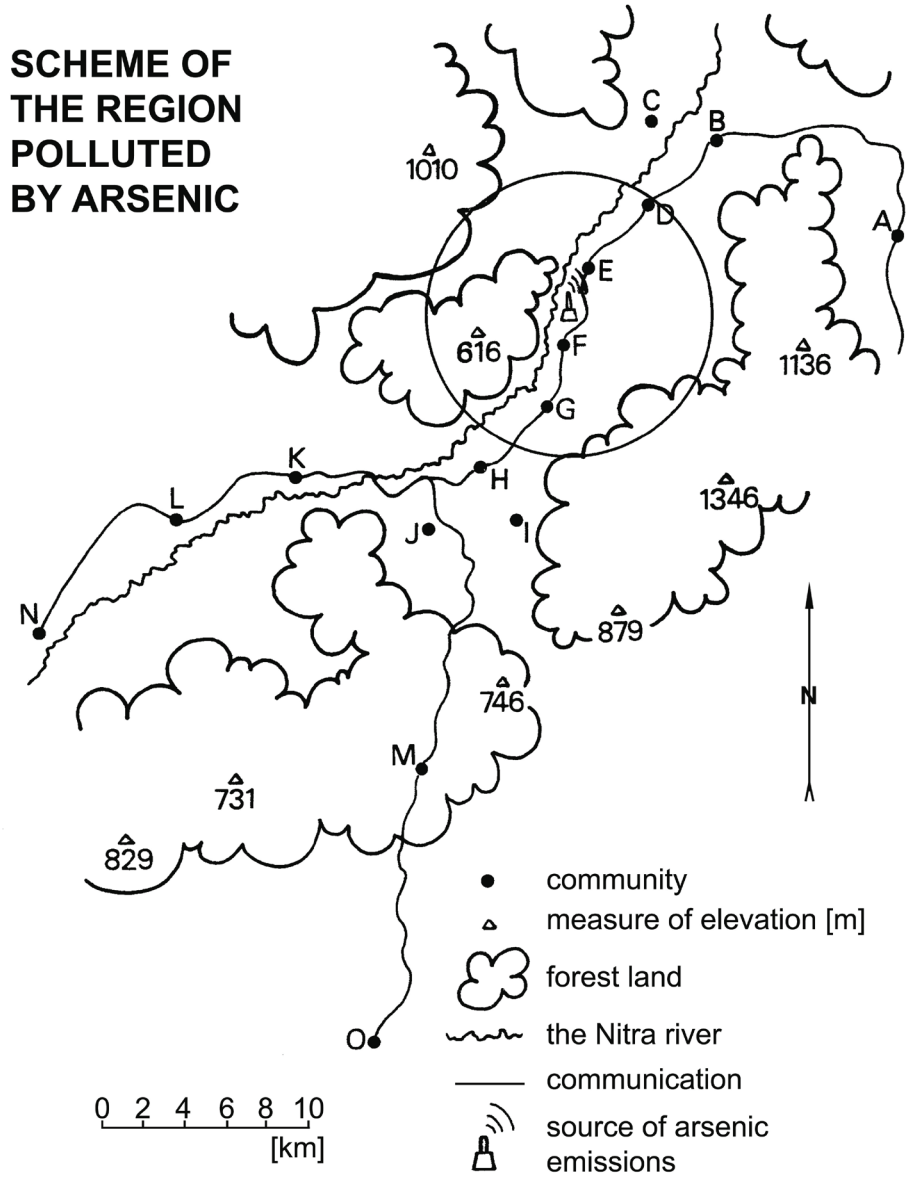


Figure 8.4 Scheme of the region polluted by arsenic
The circle round the source of emissions marked "o" of the most polluted part of the district. (Quoted from Bencko V.: Use of human hair as a biomarker in the assessment of exposure to pollutants in occupational and environmental settings, Toxicology, 101, 1995, 29-39).

Meta-analysis of the database of the malignant tumors obtained by the population based epidemiological study covers all types of malignancies, including lung and kidney carcinoma, which has already been associated with arsenic exposure.

Hazard identification was based on toxicological information about appropriate polluting agents in the scientific literature. The "Unit Cancer Risk" for lung cancer was derived from the WHO guideline. **A "Unit Risk" represents the excess risk of**

cancer, resulting from a lifetime exposure to a unitary concentration of carcinogen. Exposure assessment was based on inhalation exposure model constructed on behavioral patterns of the population and location of residence. **Inhalation exposure** was determined by **year** and **place of residence** for each population subgroup, using the estimated environmental concentrations and the respective profile of exposure. The background level of pollutants for the population working but not living in the Nováky area was assumed to be the reference values of the central Slovakia region. Long-term exposure assessment was based on the use of a **time weighted average** (TWA) exposure, representative for the entire period of time for which exposure to arsenic was considered. TWA exposure measured in $\mu g.m^{-3}$ is expressed by the following formula:

$$TWA = \frac{\sum_{i=1}^{n} C_i}{n} \quad [\mu g \cdot m^{-3}],$$

where C_i = annual average concentration, n = number of years.

TWA exposure was calculated over the whole lifetime or just for a limited number of years.

Risk was characterized in quantitative way as **expected incidence of lung cancer cases associated with the exposure**. The risk was characterized for the various population subgroups and temporal scenarios.

The results obtained seemed to suggest that **arsenic** is probably a promoter, or **epigenetic carcinogen**, rather than a true genotoxic carcinogen – similarly as in a case of arsenic-exposure-related non-melanoma skin cancer incidence. The non-threshold concept of arsenic carcinogenicity seems not to be supported by the results of database meta-analysis.

8.5.2 Cancer risk assessment

The earliest attempt to incorporate biological information into a dose-response model carcinogen risk assessment was the **multistage model** that was based on the assumption that cells progress from a normal to a malignant stage through an arbitrary number of stages that occur in sequence without considering cell proliferation in the intermediate stages. This concept rather **oversimplified the process of blastic cell transformation** because of the absence of cell proliferation in the model. A next development was represented by a **deterministic two-stage model of carcinogenesis**, assuming that the growth of initiated cells follows an exponential growth function. The advanced form of this approach is known as the MVK model. The main feature of this class of models is that the **proliferation of initiated cells is taken into account**. The work of Moolgavkar and colleagues has attracted a great deal of attention in the last two decades in the risk assessment community.

8.5.2.1 Current trends

The present approach to quantitative risk assessment artificially separating **physiologically based pharmacokinetic** (PBPK) model and **biologically based dose response** (BBDR) model needs to be substantially improved. The modeling procedure must go beyond the current organ-tissue based PBPK model as well as the hard-to-modify two-stage BBDR model. It is clear that a model must be **flexible** and **ca-**

pable of incorporating information about pharmacokinetics, cell signaling response, and tumor formation.

A limitation of the present approach to cancer risk assessment is **low dose extrapolation of cancer incidence data** from both animal (experimental) and human (epidemiology) studies that are most frequently based on models that **assume linearity at low doses/exposures**. There are situations in which this assumption could be considered unreasonable. However, because of the lack of data and no alternative methodology for risk extrapolation at hand, the model of low-dose linearity continues being used **despite existence of qualitative evidence showing otherwise**. This is specifically relevant in the case of many **non-genotoxic carcinogens modulating mitogenic stimulation or suppression of apoptosis** - processes regulated by signaling through its impact on **gene expression**. Dioxins (TCDD) can serve as an example of non-genotoxic carcinogen, endocrine disruptor acting through the Ah receptor. It is a general consensus that in order to resolve this problem we need to develop a methodology incorporating biological data on mechanisms operating at cellular or molecular level. The advantage of **focusing on key steps – initiation**, **proliferation**, and **progression** of carcinogenesis – is that these steps are relatively **easy to be identified**. Another aspect of a growing importance is a **chemical hormesis** approach.

Hormesis is observed phenomena of biphasic dose response with low dose stimulation or beneficial effect and a high dose inhibitory or toxic effects in some toxins.

Chemical hormesis was observed in a wide range of taxonomic groups of xenobiotics and even physical factors like ionizing radiation involved agents representing highly **diverse risk factors, many of potential environmental relevance**.

References:

Bencko V. Risk assessment and human exposure to endocrine disruptors. In: Molecular Epidemiology in Preventive Medicine. W.A. Jendrychowski, F.P. Petera, M. Maugeri. International Centre for Studies and Research in Biomedicine in Luxemburg, 2003: 315-327.

Bencko V, Skulová Z, Krečmerová M, Djien Liem AK (1998): Selected polyhaloganated hydrocarbons in breast milk. Toxicol.Lett.96: 341-345

Becko V. Use of human hair as a biomarker in the assessment of exposure to pollutants in occupational and environmental settings. Toxicology, 1995: 29-39.

Clayton D, Hills M. Statistical Methods in Epidemiology. Oxford: Oxford University Press, 1993.

Collective of authors: Epidemiology (in Czech). Karolinum Prague: Charles University of Prague, 2002: 168.

Colton T. Statistics in Medicine. Boston: Little, Brown and Company, 1974.

Doc Santos Silva I.: Cancer Epidemiology: Principles and Methods. Lyon: IARCPress, 1999.

Fabiánová E, Hettychová L, Koppová K, Hrubá F, Marko M, Maroni M, Grech G, Bencko V. Health risk assessment for inhalation exposure to arsenic. Cent Eur J Public Health. 2000:8(1):28-32.

Greenberg RS, Daniels SR, Flanders WD, Eley JW, Boring JR. Medical Epidemiology. New York: Lange Medical Books, 2001.

IARC Handbook of Cancer Prevention, Vol. 6: Weight Control and Physical Activity. Lyon: IARCPress, 2002.

National Institute of environmental health sciences. Endocrine disruptors. [31 March, 2015]. Available at: http:// niehs.nih.gov/health/topics/agents/endocrine

Parkin DM, Whelan SL, Ferlay J, Teppo L, Thomas DB. Cancer Incidence in Five Continents Vol. VIII. IARC Scientific Publication No. 155. Lyon: IARRCPress, 2002.

Riboli E, Lambert R. Nutrition and Lifestyle: Opportunities for Cancer Prevention. IARC Scientific Publications No. 156. Lyon: IARCPress, 2002.
Stewart BW, Kleihues P. World Cancer Report. Lyon: WHO/IARCPress, 2003.
Zvárová J. Basic Statistics for Biomedical Disciplines (in Czech). Prague: Charles University of Prague, 2001.

9 PSYCHOSOMATIC AND PSYCHOSOCIAL ASPECTS OF RISK PERCEPTION

Vladimír Bencko

When evaluating **perception of environmental risks,** some psychosocial and psychosomatic factors may be of fundamental importance. This is the case in particular where our knowledge of the true health consequences of exposure to given factor is incomplete or its action is within the range of values where we do not anticipate biological effect. This applies not only in the case of **indoor environment** but e.g. to **non-ionizing electromagnetic radiation** and **electroionic microclimate**.

A serious consequence of the syndrome of mass hysteria is the fact that due to differently motivated disinformation part of the population can really suffer from some psychosomatic symptoms. Those imply objective suffering and **deterioration quality of life** for those affected.

9.1 SCIENTIFIC AND SOCIAL MODELS OF HEALTH AND ILLNESS

When contemplating the problem of a healthy environment in relation to a sick one, it is necessary to define the relationship of ***health*** and ***illness*** in general.

Currently, health is conceived as a condition of physical, psychic, and socioeconomic well-being. Contrarily, illness involves an extensive set of different experience or behavior of the affected person. Different experience in the negative sense against the generally accepted standard implying the deteriorated or endangered subjective condition or social function, feeling of undesirability, of being unwelcome and/or unexpected. The illness induces some activities whose aim is an improvement of the condition.

Every society responds to such impaired function by charging a number of individuals or institutions whose duties are to evaluate and interpret the actual condition, and provide the necessary measures. **Medicine** (being and institution and scientific discipline as well) whose representatives are the physicians is expected to **react to** these **social needs**. Medicine tries to build up a scientific model of illness, its diagnosis, treatment and prevention, yet this model often is neither identical nor congruent with the social one. There is a difference between *illness* and *disease*, same as difference of views concerning the therapeutical and preventive approach.

The priority of the **scientific approach** is the attempted **objectivity** and **criticism** in collecting data and interpreting them. On the contrary, the **social model** is mostly based on **subjective** and strongly **emotional attitudes**. Both, the expert and lay com-

munity, are not immune against the harmful influence of myths. Science, however, is closer to truth, but not exceptionally, the science-based as well as lay models tend to misinterpret the situation, as confirmed by history. Science using objective methods is able to reflect its own failures but the **subjective views often resist any logical argumentation**. Nevertheless, even science operates with some traditional elements. Max Planck had once put it, *the new scientific truth would not win by convincing the opponents, but rather by letting the opponents die, and the new generation then adopts a new, and own truth.*

If rationally removing harmful effects and providing for a healthy living environment we have to **consider** both the scientific and social aspects, i.e. the **views** and **needs of people** living in particular environment.

The assessment of ecological and health risks from the planned industrial, transport, and other construction activities in our country becomes an **indispensable part** of their **audit**. Of course, the public health aspect of such activities is no novelty any longer as all above cited projects had legally been controlled and approved by the district or regional hygienists, within the scope of the **preventive supervision**.

Whereas the initial phase of risk assessment, its identification or exposure are of pure scientific character, the **actual risk assessment** increasingly assumes the **arbitrary aspects** (e.g. safety coefficients), risk **communication**, its control and **management**. By way of psychological aspects, the decision-making then becomes a sheer **political issue**. As illustrating examples, we can use problems related to conflicting views concerning health effect of electromagnetic field and electronic microclimate.

9.2 PSYCHIC INFECTION AND MASS HYSTERIA

As every expert knows, dealing with clients may sometimes bring about a number of both material and psychological problems. Besides, addressing a group of individuals who, moreover, feel endangered is more complicated still, especially when these groups previously organized in harmony and certain hierarchy start to change in disorganized ones whose behavior rather suggest the behavior of masses or mob. The mass psychology may appear whenever a sufficient number of persons are gathering around one point of common interest.

The psychology of the group never makes a mere sum of the member's psychology but it has its own individual characteristics. The group as a whole shows better quality than the most inferior members, but a worse judgment and lower IQ compared to the best individuals of the group, and it is prone to getting influenced rather by emotion than reality. Another characteristic is a behavior of the group as a mob (aggressive, panicking, etc.) whose doings are almost always worse than those of an individual.

The basic characteristic of mass dynamics is the "psychic infection" due to increased suggestibility responsible for the sensation of symptoms and subsequent chain reactions. A person in the mob then is capable of acts he would never had committed as an individual on his own. The cases of mass psychoses are well known from many literary descriptions of "mass hysteria" in real or supposed exposure to the toxic substances, or in health problems connected with the sick indoor environment (sick building syndrome) usually found in air conditioned houses.

In such cases, the **symptoms** can be **considered "objective"**, i.e. the **patient really suffers** from them. They remind of symptoms of **acute distress** but they are less intensive and last for a longer time, e.g. for many days, weeks, or months. The affected is aware of the overall stress and tension, fright, shyness, of sensations of oppressiveness and worries, when addressing other people, and vague stressing uncertainty for the fu-

ture. All these symptoms are accompanied by **chronic fatigue**, **headache**, **insomnia** and other subacute **vegetative disorders**. As the syndrome is not fully invalidating, the patient feels chronically unwell in both his daily duties and his reaction towards other people. Often his capacity of sense making activities becomes reduced as the result of chronic fatigue and **impaired concentration**.

The symptomatology fully corresponds to the term **"somatization"** introduced in the ICD-10 international classification. The point is that **emotion** – here a very strong one – **finds** its **vegetative correlate** occurring in the **somatic sphere**. The "interpretative model" of the patient being *xenochtonous* in our case (the cause of all trouble comes from outside) and the patient is aware of it (sick building, nearby radar station, TV tower, waste incineration plant, etc) plays an important role in further development.

The **mass reaction** can practically be manifested by two syndrome levels: in one the **state of anxiety** prevails, in other **motoric symptoms** prevail (e.g. the medieval processions of flagellants praying for aversion of pest). The symptoms may appear separately or combined, or occur in turn in the patient. **Mass hysteria** afflicts men less frequently than women, especially those living in poorer socioeconomic conditions. Mass hysteria is closely connected with the problems of "sick indoor environment" illness. Here is important the firm conviction of outside noxae responsible for any kind of symptoms, further tendency to **hypochondria** and **stress** and also hostile attitudes of the patient to anybody to blame for these conditions, in practice materialized by endless weary court trials. In a sense, also collective insistence on UFO and other paranormal encounters belong to this category.

Yet, not all mass-occurring pathological symptoms are mass-hysteria-related. For example, the mass poisoning of school children in the school canteen in London can be mentioned, manifested by gastrointestinal troubles shortly after lunch. The complex microbiological, hygienic, and toxicological examination included a questionnaire for children, which showed a significant link between the symptoms and consumption of raw cucumber (relative risk 6.1). Microbiologically the cucumbers were safe but pesticide contaminated, as proved by toxicology. In the discussion, the authors warn against any **overhasty diagnosis** of **mass hysteria**.

Even when the concentration of toxicants fails to reach the risk values, other factors may be involved, e.g. ambient temperature, air humidity, etc., which have up to now not been included in our models but which are able to objectively influence the clinical course, morbidity and mortality rate. There even may occur combination of the actual infection and mass hysteria. In some people, evident **hypersensitivity** to some substances exists: their pathophysiological reaction then is capable of **psychogenic effects** on the environment.

Nevertheless, we presume the psychosocial aspects may be of basic importance in understanding the potential health risks. Furthermore, when **our knowledge** of actual health effects of human exposure is **incomplete** or the **intensity** of **exposure oscillates** in **levels raising doubts** as to possible biological effects.

Very serious problems, mostly in psychologically unstable patients, are **neuro-psychic** and **psychosomatic symptoms resisting to treatment**. Despite the difficulty in objectification, they represent suffering that **should not be underrated** considering the **quality** of **patient's life**.

The prevention of such conditions can either be systematic: early educational or popularization campaigns, specific health education orientated to the development of industrial, transportation, or other types of constructions, and integration of the local civic activities in the program. The purpose of this should not be a cheap belittling of the risk but **reasonable explaining** of its **acceptable rate**, and also the likely **advan-**

tage to come from the realization of the structures. **Any later efforts** to inform the public about the true state of affairs is normally **accepted with distrust or hatred**, in belief this information had been well-paid by the government, industry tycoon, army, or some other institution trying to camouflage the actual condition.

9.3 CHALLENGES OF PREVENTION

It is therefore recommended to carry out a **relevant**, competent **epidemiological pilot study** on potential incidence of some health problems (tumors, congenital malformations, etc.) **still before starting the structures**, to compare – using a set of reliable data, when the building had already been approved for use – the incident phenomenon with the **previous conditions**. Such a study, of course, is no alibi. In cases of positive findings, the study could serve as basis for **rational measures** to minimize the health risk due to the operation of the particular facility. The concept of **health risk minimization** must be included as a leitmotif in all stages of the design and realization, covering all potential risks for the environment and human health.

In medicine, until our days, the **Hippocrates' statement** still holds: *Life is short, and Art is long; the occasion is fleeting, experience fallacious, and judgment difficult. The physician must not only be prepared to do what is right himself, but must also* ***make the patient****, the attendants, and* ***externals to co-operate****.* If we honor this in therapy, we should do so in preventive medicine twice as much.

References

Rothman KJ, Greenland S. Modern Epidemiology. Philadephia: Lippincott Williams &Wilkins, 1998.

Beaglehole R, Bonita R, Kjellstrom T. Basic Epidemiology. World Health Organisation, 1993. Epidemiological Methods in Public Health. London: LSHTM, 1996.

Altman DG. Practical Statistics for Medical Research. 2nd edition. London: Chapman&Hill, 1994.

Dawson-Saunders B, Trapp RG. Basic and Clinical Biostatistics. London: Prentice-Hall, International Inc., 1994.

Wassertheil-Smoller S. Biostatistics and Epidemiology. New York: SpringerVerlag, 1995.

10 DISASTERS

Helena Rapantová

10.1 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, and 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 that 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.

10.2 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 dawn 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) have emerged since the Industrial Revolution and they are usually 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 this distinction has no 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.**

10.3 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, and 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, until 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 23,000 – 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 lives, while material damages cannot be avoided.

According to some definitions, epidemics also belong to 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.

10.3.1 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 little 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 widespread outbreaks of **di-**

arrheal 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 catchment 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 main cause of weather-related disasters. **Slow flooding** occurs mainly in the lower-lying flat lands and deltas, during seasonal weather variations, when contributory rivers breach 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 in absorbing and retaining water (deforestation, balks abolishment etc.).

Among mitigation strategies considering flood and its consequences, there takes an important place 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, and 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.

10.3.2 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 thermophilic bacteria by smoldering (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 setting 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.

10.3.3 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** ranging from 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.

10.3.4 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, and 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).

10.3.5 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 cannot be predicted, but the likelihood and the intensity of it can.

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 kill 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.

10.4 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 until 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 Itai-itai disease, due to cadmium poisoning, both occurring 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 Bloc 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 consequenc-

es 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.

10.4.1 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 it 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.

10.4.2 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, confirmed in writing, the 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.

10.4.3 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 the 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 non-governmental relief organi-

zations (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.

10.4.4 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 have 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 (see more in Chapter 12).

10.5 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 there is a vanished sense of security, fear of another calamity, hypervigilance, 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).

10.6 Disaster PREVENTION 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, and lack of disaster prevention planning.

The low mortality in the developed community with the 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 is provided in the National Response Plan (NRP) achievable in developed nations. Efforts at disaster planning and response during complex emergencies, in developing nations in particular, 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 the 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 ambulance. 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 pull 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.** play E**mergency departments** play **a**n important triage and treatment role in disaster response. 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 at the decontamination can be 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 do not 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-borne 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 per 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 persons 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 (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 the people living in areas, where 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 representatives 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 of 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 **air-borne 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 at ameliorating the ecological, economic 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 far 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 customs; where existing facilities such as graveyards or crematoria are inadequate, alternative locations or facilities should be provided.

For workers routinely handling bodies, there 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 non-governmental agencies. Medical planners should be prepared to support shelters with physicians, nurses, 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 details 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.**

A 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.

References

Cieslak TJ et al. Disaster Preparedness and Response. In: Wallace RB. (Ed) et al. Wallace-/Maxcy-Rosenau – Last Public Health and Preventive Medicine. 15 Edition. The McGraw-Hill Companies, Inc. 2008: 1285-1294.

Goolsby CA et al. Disaster Planning. Available at: http://emedicine.medscape.com/article/765495

Kundzewicz ZW. Disaster Aftermath. In: Encyclopedia of Public Health. Kirch W (Ed.) New York: Springer Science+Business Media, LLC 2008. ISBN 978-1-4020-5614-7

Watson JT et al. Epidemics after Natural Disasters. Available at: http://emedicine.medscape.com/viewarticle/550435

Young Landesman L. Public Health Management of Disasters. The practice guide. 2nd edition. Washington DC: American Public Health Association, 2005: 446.

11 BIOLOGICAL WEAPONS. BIOTERRORISM IN THE CONTEXT OF PUBLIC HEALTH

Cyril Klement

In March 2005 the international community commemorated the date of entry into force of the Convention on the Prohibition of the Development, Production, Stockpiling of Bacteriological (Biological) and Toxin Weapons. This global agreement is unusual and momentous indeed. The State Parties recognized the importance to eliminate retaining of biological weapons as well as biological and toxin weapons disarmament or re-disarmament spontaneously. However, violation of the Convention or non-compliance therewith shall not mean freeing from the obligations emerging from it.

As for the Convention itself up to this date we can state the following:

- It still exists in its original wording;
- No state has backed out of it;
- The fact is that a number of states has increased from original 46 states when the Convention entered into force to contemporary 168 states.

Some authors characterize biological weapons and their impact on human health as the reverse side of public health because it refers to use of bacteria, viruses, toxins and fungi and their impact on humans, animals, and plants causing disease, incapacitating or death.

The events from 11 September 2001 changed a view of the world and brought the threat of terrorism, including bioterrorism, up to date.

The Government of the Slovak Republic issued the document "Biological protection of the inhabitants of the Slovak Republic" after 11 September 2001. One of the tasks of the document is also preparation and additional training of health workers in the issues of biological weapons. The Slovak Republic became a member of the North-Atlantic Treaty Organization (NATO) and the European Union (EU). Both these groups as well as the United Nations Organization strive to address combating terrorism and the issue of biological weapons via their programs.

The UN created a separate body for the issue of biological weapons named the United Nations Monitoring, Verification and Inspection Commission (UNMOVIC) as a successor organization of UNSCOM (United Nations Special Commission). Unfortunately, in June 2007 the organization was dissolved in contradiction to needs and there is no organization having mandate to inspect biological weapons at the moment.

Not only military structures, but also the civil ones face many threats including terrorism and proliferation of the weapons of mass destruction. Civilian population is also a target of threats whether by direct use of chemical, biological and radio-nuclear substances, or by consequences of potential terrorist attacks on the critical infrastructure. In this case, civil emergency planning shall be used where necessary to reinforce existing links between civil and military structures, governmental and non-governmental environment. Such cooperation has a decisive share in success and smooth progress of military operations.

Awareness of these connections makes the problems complete as it is not simple and it is multisectoral. Awareness of potential danger is something what international community calls for.

Biological weapons and bioterrorism could cause a significant crisis of public health. Having caused death of five people, the "anthrax letters" consequently verified the flexibility of health and non-health structures and their capability in cooperating effectively in issues, which are complex from the point of view of its content and logistics in the United States and subsequently in the world, including Slovakia.

The relation between public health and preparedness to address the issues of biological weapons and outbreak of communicable diseases is illustrated in the scheme below.

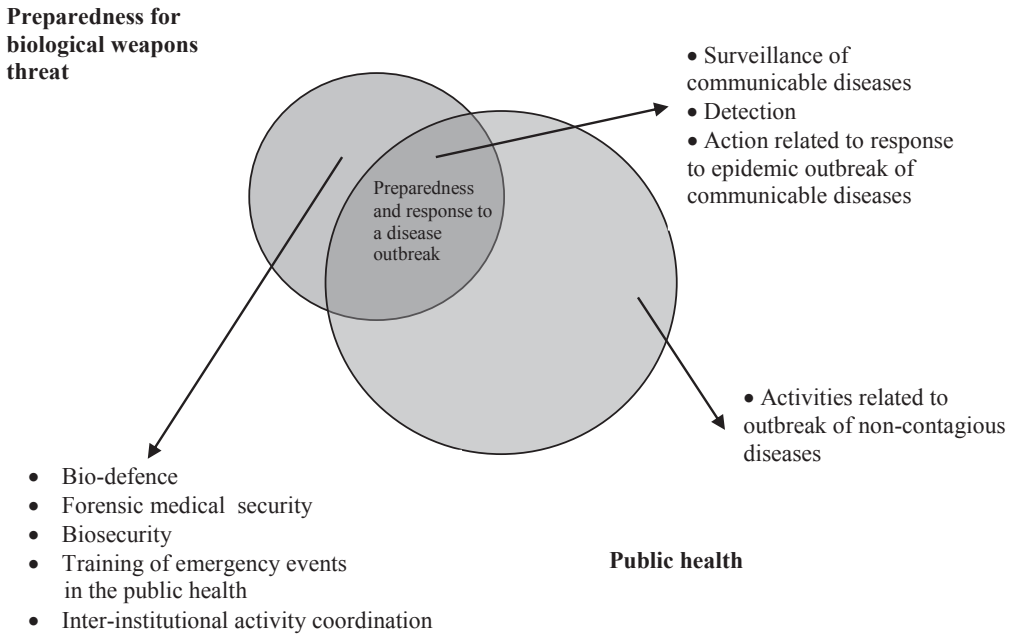


Fig. 11.1 The scheme representing overlapping of activities and overall preparedness in the process of assuring response to the outbreak of agents released by biological weapons and threat in relation to the epidemics of communicable diseases in the sector of public health.
Source: D.P.Fidler and L.O.Gostin "Chapter 4: The Securization of Public Health „ in: D.P. Fidler and L.O. Gostin (eds.), Biosecurity in the Global Age: Biological Weapons, Public Health and the Rule of Law, (Stanford, Stanford University Press, 2008) pp.136.

11.1 TerRORISM aND bioterRORISM

Europeans consider terrorism to be one of the key challenges the European Union is facing today. The terrorist attacks in Madrid, London, New York, and elsewhere in the world made it clear that terrorism is a threat to all countries and all peoples. Terrorists target our security, the values of our democratic societies and the basic rights and freedoms of our citizens. Terrorists may resort to non-conventional means such as biological weapons or other materials designed for their preparation. After terrorist attacks from 11 September 2001, first 10 confirmed cases of pulmonary anthrax resulting from

deliberate release of *Bacillus anthracis* bacterium were ascertained in the United States. In the connection even Europe had to face many hoaxes on anthrax spread. There were 840 samples of dangerous consignments investigated through 2001-2011 in the Slovak Republic. Some of these materials have the capacity to infect thousands of people, contaminate soil, buildings and means of transport, destroy agriculture and infect animal populations or hit foodstuff and feedstuff at any stage in the food supply chain. The risk of "bioterrorist" attack has been statistically low but its consequences can be devastating. If a deliberate introduction of deadly pathogens or a naturally occurring disease outbreak or introduction of pathogens or diseases from third countries were to occur in the European Union, it is possible that it could affect several Member States simultaneously or spread across borders and have considerable economic and social impact.

In order to improve the ability of the EU and – in our case – of the Slovak Republic to prevent, respond and recover from a biological incident or deliberate criminal activity, the coherence of actions in different policy sectors requires that all relevant stakeholders in the Member States and at EU level be consulted, e.g. national authorities responsible for risk prevention and response. Furthermore, these are the authorities that are in charge of the public health (i.e. human, animal and plant health), customs authorities, civil protection authorities, law enforcement authorities, armed forces, bioindustry, epidemiological and health institutions, academic institutions and institutes dealing with biological research.

11.2 FREQUENTLY USED DEFINITIONS

The risks from dangerous biological materials and pathogens have to be reduced and preparedness enhanced in Europe through a biological all-hazards approach – generic preparedness in the framework of overall crisis management capability. Indeed, such an approach aims at taking into consideration all potential risks from a terrorist attack, other intentional release, accident or naturally occurring disease, so as to be prepared to handle **all crisis situations relating to the protection of food supply chain, water and water resources and population health**. The reason for taking a biological all-hazards approach is that appropriate security practices cannot be built without a strong safety culture. Moreover, in the early stages of an incident it is very often difficult to identify the causes and sources of a disease. In the case of an intentional release, law enforcement authorities shall play an important role. It is useful to make clear some terms that are relatively frequent in relation to this issue.

Each language has elementary words by the means of which the process of mutual communication is developed. Systemic approach within interdisciplinary approach and appropriate "dictionary" creates conditions for clear and unambiguous communication of experts in such a complex field that the issue of biological weapons and bioterrorism refers to. The experts are as follows: public health workers, microbiologists, epidemiologists, clinicians, biochemists, molecular biologists, veterinary surgeons, phytopathologists, lawyers, diplomats, policemen, and intelligence service specialists.

Following terms were selected for the publication. There are many more definitions necessary for communication among experts with different education; however, these are the most significant ones:

Australia Group is an informal group of 34 countries whose aim is to minimize the risk that export of chemical and biological dual-use material and devices will be misused for proliferation of chemical and biological weapons.

The Australia Group was established in 1985 in response to the violation of the Geneva Protocols from 1925 in the Iran-Iraq war taking into account the fact that

Iraq acquired most of materials and devices for its offensive chemical program from international chemical industry by the means of foreign trade. At their annual meetings in Paris the Member States of the Australia Group strive for harmonization and efficiency increase of license and other administrative measures adopted to control the foreign trade with dual-use materials and devices. In 1990 the Australia Group adopted measures to prevent the abuse of export of dual-use biological material and devices. The check lists of the Australia Group contain dual-use biological devices that could contribute with their properties and parameters to offensive biological research, development and production (installations with high bio-safety level, fermenters, specially designed centrifuges, tangential flow filtration devices, lyophilisators, positive pressure biological protective suits, bio-safety cabinets of Class III and aerosol inhalation chambers). The Australia Group also controls human, animal and plant pathogens included in its lists.

Food safety is a term standing for determined standards related to food safety, best processing practices and quality control of agricultural products at all stages of the processing chain. It also differs from the term "food security" defined by the World Health Organization as an access to sufficient, safe and nutritious food.

Biological weapons are biological agents, toxins or bioregulators in connection with the means for their dissemination in the attack area (munitions) and with the means for their transport to the attack area (delivery systems). Optimal biological agents for biological weapons should meet ten traditional Rosebury's criteria:

- High infectivity (small infectious dose);
- High morbidity rate connected with elimination of affected ones from activity or high lethality rate;
- Possibility of agent's mass production;
- High resistance of agents to external influences in the process of their dissemination and stockpiling;
- Possibility of infection by infectious aerosol;
- High contagiousness;
- Absence of possibility of prophylactic immunization;
- Treatment of disease is difficult or ineffective;
- Impossibility or high difficulty of detection and identification of agent used;
- Limited risk of retroactivity (transmission of agent or disease back to the invader).

Biological agents are pathogenic microorganisms (bacteria, Rickettsia, Chlamydia, Mycoplasma, viruses and microscopic fungi) that are able to cause disease to humans, animals, or plants. The effect of biological agents is connected with their reproduction in the infected organism.

Biological laboratory is a facility where microorganisms, their constituents and derivates are collected, processed or stored. Biological laboratories include clinical laboratories, diagnostic facilities, regional and national reference centers, public health laboratories, research centers (academic, pharmaceutical, environmental, etc.) and production facilities (production of vaccines, medicaments, wide range of genetically modified organisms, etc.) for human, veterinary and agricultural purposes.

Bio-preparedness refers to a wide range of activities related to public health protection. In other relation – laboratory environment, researchers, health care as well as production plants, field research and transport.

The terms **Biosafety** and **Biosecurity** may refer to different issues. The aim of bio-preparedness is not to duplicate the legal framework set up to ensure food and product safety, including emergency measures in cases of accidents or of new information related to safety of a specific product, but the aim is to complement this framework

and thus, to improve security and the prevention in case of deliberate criminal acts, accidents as well as the response to naturally-occurring outbreaks.

Biosafety and biocontainment refer to measures focused on prevention of unwanted, unintentional or random release of biological material into environment that could result in human, animal or plant diseases.

Biosecurity refers to measures focused on the prevention of illegal obtaining of pathogens, toxins and other bioactive substances of biological origin and their potential abuse in contradiction to the provisions of the Convention on the Prohibition of the Development, Production, Stockpiling of Bacteriological (Biological) and Toxin Weapons.

Bioregulators are natural substances usually of peptide character (e.g. endothelin, substance P) that participate in regulation of basic physiological functions, e.g. body temperature, blood pressure, and sleep. If an organism is exposed to such substances from external environment, imbalance of regulated processes will occur resulting in incapacitating or death of the exposed organism.

Bioterrorism is a deliberate abuse of biological agents to cause human or animal disease motivated politically, religiously or ideologically.

Bioremediation is a use of biological organisms such as plants or microbes through whose addition hazardous substances may be removed from the environment. These organisms decompose and detoxify dangerous chemicals in the environment. In these technologies genetically modified microorganisms with adjusted "appetite" for toxic particles are used with advantage.

Biorisk is likelihood or a chance that it comes to certain unfavorable incidents like for example unforeseen infection or unauthorized access, loss, theft, abuse, defalcation or intentional data publication leading to potential harm.

Biocrime refers to a deliberate abuse or threat of abuse of biological agents (biological weapons) to cause disease of humans, animals and plants. Unlike bioterrorism (agroterrorism) this act is motivated by personal reasons (financial profit, revenge, etc.).

Convention on the Prohibition of the Development, Production, Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (BTWC) – an international convention that entered into force on 26 March 1975 and that prohibits development, production, stockpiling and other acquirement of biological agents of such type and in such quantities that have no justification for prophylactic, protective and other peaceful purposes. The BTWC also prohibits weapons, equipments and means of delivery designed for such agents and toxins for aggressive purposes or in armed conflict.

The BTWC obliged the State Parties to destroy or divert to peaceful purposes all biological agents, toxins, weapons, equipments and means of delivery prohibited by the Convention. The State Parties have been obliged to facilitate mutual exchange of equipments, materials, scientific and technical information related to the use of biological agents and toxins for peaceful purposes to the highest possible degree. So called Confidence-Building Measures (CBMs) were adopted at the Second Review Conference in 1986 in order to reinforce the BTWC compliance. In the framework of the CBMs, the BTWC State Parties declare information on research centers and laboratories of highest biological protection level P4 as well as information on national research and development projects on biological weapons protection, information on contagious disease epidemics and intoxication by toxins whose picture deviates from standard, on vaccine production facilities producing vaccines to be applied in human medicine and on past offensive and defensive activities running in respective country after 1 January 1946 annually. The CBMs are not legally binding for the State Parties. Main deficiency of the BTWC refers to absence of effective and legally binding verification regime.

Emerging pathogens – the term describes a range of infectious microorganisms that have recently drawn increased attention of clinicians, infectologists and epidemiologists. Epidemiological properties of some of them like for example Human Immunodeficiency Virus (HIV), *Borrelia burgdorferi* (causing Lyme disease) and hantaviruses have been defined in detail. Epidemiological studies can clarify reasons and indicate countermeasures against many of such pathogens undoubtedly whether being really "new", i.e. newly-emerged (or newly-discovered or newly-determined) microorganisms or long-existing "old" microorganisms where it has been established that they are able to infect humans or that have drawn physicians' attention repeatedly.

Epidemiology refers to a scientific discipline examining the conditions for outbreak and dissemination of diseases within population and possibilities of defense against the outbreak and dissemination.

Genetically Modified Organisms (GMO) are organisms whose genetic material was altered by using techniques generally known as "recombinant DNA technologies". The recombinant DNA technologies are able to combine DNA molecules from multiple sources into one molecule in vitro. The GMOs are often not able to be reproduced in nature and in generally, the term shall not include organisms whose genetic structure has been altered by conventional breeding or mutagenic breeding referring to methods preceding the discovery of recombinant DNA technologies.

Valuable Biological Materials (VBMs) are biological materials that require (depending on their owners, users, administrators, supervisors, or regulators) administrative surveillance, inspection, responsibility and specific protective and monitoring measurements in laboratories in order to protect their economic and historic (archive) value and/or the population from the perspective of potential harm. The VBMs may include pathogens and toxins as well as non-pathogenic organisms, vaccine strains, food, genetically modified organisms (GMOs), cell components, genetic elements and extraterrestrial samples.

Infection refers to the presence and development or dissemination of an infectious agent in the macro-organism. An infection and infectious disease are not synonyms of this term. Infection may result in clinically evident (manifest) illness (typical and atypical infection) as well as infection without clinical symptoms (latent and unapparent infection). The presence of living microorganisms on inanimate objects shall not refer to an infection but to a contamination.

Infectious dose refers to the amount of pathogenic biological agent necessary for causing a disease in the susceptible host after invading their organism. It is frequently expressed as an agent dose causing a disease to 50% of exposed individuals (ID_{50}).

Infectivity refers to the feature of a biological agent reflecting relative easiness in its ability to invade and spread in host's organism. The pathogens with high infectivity have low infectious dose and are able to cause disease when a small amount of infectious particles invade the organism (1-10^3 microorganisms). The pathogens with medium infectivity are characterized by the infectious dose of approximately 10^4–10^6 microorganisms, whereas the infectious dose of pathogens with low infectivity refers to more than 10^7 microorganisms. Examples: high infectivity – *Francisella tularensis* (10–50 microorganisms, inhalation exposure), medium infectivity – *Bacillus anthracis* (8500–50000 microorganisms, inhalation exposure), low infectivity – *Vibrio cholerae* (10^6–10^9 microorganisms, peroral exposure). Infectivity has no relation to the incubation period and to the severity of caused disease.

Disaster is a large-scale emergency event emerging as a consequence of cumulation of destructive factors of natural disasters or an accident that has serious direct impacts on population, material values, and environment, or on the functioning of public administration (Chapter 11).

Critical infrastructure refers especially to the facilities of particular significance, further significant facilities, selected information and communication media, facilities for production and supply of water, electricity, oil and natural gas as well as further parts of state assets and assets of natural persons and legal entities stipulated by the Government of the Slovak Republic or another competent state administration body that are necessary for coping with crisis situations, protection of the population and assets, providing for minimum functioning of the economy and state administration as well as its external and internal security, and that needs to be protected in a special way. These are facilities, services and information systems vitally important for the population and state management whose failure to function or destruction may endanger state security interests.

Public health crisis refers to a sequence of events coming after public health threat when there is restricted time period for decision-making and high degree of uncertainty causes overload of normal response capacities and harms competent institutions.

Medical intelligence refers to a category of intelligence activity resulting from collection, evaluation, analysis and interpretation of foreign medical, bio-scientific and environmental information that is of interest to strategic planning, and to military medical planning and operations for the conservation of the fighting strength of friendly forces and the formulation of assessments of foreign medical capabilities in both military and civilian sectors.

Laboratory biosecurity describes protection, inspection and responsibility for valuable biological materials (VBMs, see the definition below) in laboratories to prevent unauthorized access, loss, theft, misuse, defalcation, or intentional data publication.

Public health microbiology is a field related to humans, animals, food, water and environmental microbiology with the focus on human health and diseases. It requires laboratory scientists who are capable in working especially in the fields of epidemiology and clinical medicine effectively. The public health microbiology laboratories or laboratories with this function play the central role in detection of communicable diseases, monitoring, prompt response to the outbreak of single diseases and providing for scientific evidences for the prevention and control of diseases.

Emergency situation refers to a hazard to life, health, assets and environment, state economy as well as public administration bodies determined in terms of time and space and caused by negative impacts of emergency events, requiring the use of procedures, instruments, sources and powers and tools of the crisis management.

Emergency event refers to a severe incident that is difficult to anticipate in terms of time and limited in terms of space. It is caused by a natural disaster, technical or technological accident, operation breakdown or deliberate human action that caused disruption of system stability or running processes and activities, endangered human life and health, tangible and cultural assets or the environment.

Focus of infection is a locality where the process of infection dissemination takes place. The following refers to its integral part: source (sources) of infection, susceptible hosts that could have been exposed to infectious agents as well as all constituents of external environment of the locality.

Threat is a likelihood that an unfavorable event like deliberate causing of harm, injury, disturbance, or damage occurs.

Public health threat refers to an incident, state or substance whose existence implies potential rapid, direct or indirect threat for the affected public in the extent sufficient for outbreak of crisis.

Preparedness is used in a generic way covering all aspects such as prevention, protection, first response capacity, prosecution of criminals/terrorists, surveillance, research capacity, response, and recovery. The term shall also cover the steps taken to

minimize the threat of deliberate contamination of the food supply through biological agents and to protect against biological warfare.

SIPRI - Stockholm International Peace Research Institute – is an independent research institution dealing with the issues related to the production of weapons, transfer of weapons, proliferation of the weapons of mass destruction and disarmament.

Surveillance (enhanced epidemiological inspection) refers to a continuous (ceaseless) analysis, interpretation and feedback of systematically collected data – on the condition of continuous use of methods that are characterized by feasibility, uniformity and rapidity (although sometimes to the exclusion of accuracy or completeness). Based on observation of trends in the course of time, at respective place and within respective population, certain changes may be determined or anticipated and this enables execution of adequate actions including investigation and control actions (focused on combating respective disease). The data sources may be in direct connection with the disease or with the factors affecting occurrence of the disease. Thus, it may refer to the following:

1) Information on mortality rate and sickness rate on the basis of death certificate, case records and medical records obtained from sentinel GPs or reports;
2) Laboratory diagnoses;
3) Reports on epidemics;
4) Data on vaccination coverage and on side effects of the vaccination (vaccination responses);
5) Records on absence from work due to sickness;
6) Disease determinants as biological changes of the agent, vectors or the reservoir;
7) Sensitivity to disease on the basis of skin tests or serological overviews (e.g. serum bank).

Early Warning System – within surveillance of respective disease it refers to a specific procedure that shows each deviation from common or commonly observed frequency of a certain phenomenon as soon as possible. For example, routine monitoring of death rate related to pneumonia and influenza in large American cities is used as an early warning system for identification of influenza epidemic. In developed countries the change in the average weight of children is the early warning signal for malnutrition.

Biosafety level 1 (BL 1) includes teaching laboratories working with well-known and precisely defined strains, which are not known as causal agents for healthy adult population. Many causal agents connected with human diseases complying with BL 1 criteria are causal agents of opportunist infections or they are vaccine strains.

Special equipment of the laboratories is not necessary.

Biosafety level 2 (BL 2) covers methodologies, equipment and construction solutions usable for clinical, diagnostic, teaching and other laboratories working with a wide range of microorganisms original within respective area and causing human diseases. The work on open bench tops is allowed when complying with proper microbiological procedures; risk of aerosol origin is rather low. Primary risk for the personnel working with these agents lies in percutaneous or mucous exposure as well as in ingestion of the infectious material. Most of agents that it is worked with on the BL 2 level are not spread by aerosol or droplets; safe equipping with laminar flow cabinets and safety centrifuges is used to minimize personnel's exposure.

Biosafety level 3 (BL 3) covers methodologies, equipment and construction solutions usable for clinical, diagnostic, teaching, research and production laboratories where it is worked with original or exotic agents with potential possibility of air transmission that can cause a potential fatal disease. Primary risk for the personnel emerges from autoinoculation, ingestion and inhalation of the infectious aerosol.

On BL 3 level, great emphasis is put on primary and secondary barriers to protect the society and environment from the exposure of the infectious aerosol. All laboratory operations must be conducted within laminar flow cabinets or other covered facilities, e.g. aerosol chamber. Secondary barriers include controlled access to the laboratory and ventilation equipment minimizing potential leakage of infectious aerosol from the laboratory.

Biosafety level 4 (BL 4) covers all methodologies, equipment and construction solutions allowing the work with dangerous and exotic pathogens that may cause life-threatening diseases transmitted by aerosol and for which vaccines or other treatments are not available. Primary risk for the personnel lies in the exposure to infectious aerosol, exposure of hurt skin and mucous membranes to infected droplets and in the autoinoculation. The whole manipulation with potentially infectious diagnostic material, infected animals, isolates and models represents high risk for the laboratory personnel, society, and environment. Complete protection of the personnel from the infectious aerosol is ensured by working in the laminar flow cabinet of third class or by using a positive pressure personnel suit with a segregated air supply. From the perspective of construction, the laboratory is placed in a separate building or in a completely isolated area with special ventilation equipment and with the operation that is conducted in such a way that minimizes the risk of contamination of the environment by viable causative agents of dangerous infections.

Vaccination – originally, vaccination referred to inoculation against smallpox virus. Nowadays, the term is used as a synonym with the procedures for immunization against all communicable diseases. Original use of the word was limited to smallpox vaccination. It was the first method to prevent a fatal disease by the means of immunization of humans. Jenner's invention led to worldwide eradication of variola directly.

Public health shall be defined as each effort focused on protection and strengthening of well-being, prevention of disease and enhancement and prolonging of life under equal conditions for all by the means of organized activities within and beyond the health sector.

Source of infection (source of causative agent) is a man or an animal (it may be a sick individual or a carrier) who keeps and in most cases also secretes the infectious agent via portals of exit of infection where the agent may be transmitted on the susceptible host directly or indirectly.

11.3 BiologICAL AGENTS TAKEN INTO CONSIDERATION AS A BIOLOGICAL WEAPON OR A TOOL OF BIOTERRORISM

The classification of risks is based on the risk of these biological agents in relation to the national security and their features emerging from their internal characteristics (Classification based on the assessment according to the Center for Disease Control and Prevention, Atlanta, Georgia, USA).

Category A includes organisms that can be easily disseminated or transmitted from person to person, result in high mortality rates, have the potential for major public health impact, might cause disruption of social relations and bonds and to cause public panic, require special actions to be taken in the public health and its preparedness for situations of this type.

The agents are as follows:

- *Bacillus anthracis* causing anthrax;
- *Clostridium botulinum* causing botulism;

- *Yersinia pestis* causing plague;
- Variola virus causing variola /smallpox;
- *Francisella tularensis* causing tularemia;
- Viruses of viral hemorrhagic fevers causing viral hemorrhagic fevers.

Category B refers to second category. It is characterized as follows:

1. Agents causing selected diseases are not disseminated as easily as in Category A;
2. The agents cause moderate morbidity rates of single diseases and low mortality rates compared to category A;
3. The agents require specific efforts when building diagnostic capacity and enhanced disease surveillance.

The agents and diseases belonging to this category are as follows:

- *Brucella species* causing various types of brucellosis;
- *Clostridium perfringens* producing epsilon toxin;
- *Burkholderia mallei* causing glanders;
- *Coxiella burneti* causing Q fever;
- *Ricinus communis* causing ricin toxin;
- *Staphylococcus aureus sp.* causing staphylococcal enterotoxin B.

Category C

The third most hazardous category is a group comprising emerging pathogens that could be engineered for mass dissemination in the future because of their

1. Availability;
2. Ease of production and dissemination; potential for high morbidity and mortality rates and thus major health impact.

Agents and diseases belonging to this group are as follows:

- Hantavirus causing the pulmonary syndrome;
- *Mycobacterium tuberculosis* causing multidrug-resistant tuberculosis;
- Nipah virus causing infection caused by Nipah virus;
- Tick-borne encephalitis virus causing tick-borne encephalitis;
- Viruses of tick-borne hemorrhagic fever causing tick-borne hemorrhagic fever;
- Yellow fever virus causing yellow fever.

Various organizations and institutions created relatively different classification schemes that contain bacteria, viruses, fungi, protozoa and toxins. The organizations and institutions are as follows: the United Nations, World Health Organization, Center for Disease Control and Prevention, list of agents pursuant to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, the North-Atlantic Alliance, Australia Group, and European Union.

11.4 OVERVIEW OF RELEVANT AREAS OF THE EU POLICY IN COMBATING BIOLOGICAL RISKS

Combating biological risks relies on cross-cutting commitments: disarmament and non-proliferation cooperation and assistance. From this point of view, a holistic biological risk reduction approach combining the 1972 Biological and Toxins Weapons Convention, non-proliferation suppliers group, Australia Group and public health assistance tools would offer a unique benefit, linking security and development. The EU external action instrument has a concrete added-value in this regard. At multilateral and regional level, the EU aims at enhancing the collective response capability to a biological event, including bio-terror acts.

Virtually, everything that is done at the different levels to anticipate a possible defense against biological risks and bioterrorism is of relevance. A number of policies could be usually strengthened to this effect as follows:

- Improving disease surveillance and detection systems (A practical example is the network for epidemiological surveillance and control of communicable diseases in the Community set up by the Decision No. 2119/98/EC of the European Parliament and of the Council of 24 September 1998.);
- Enhancing cross-border cooperation and communication;
- Facilitating international laboratory cooperation and developing mechanisms for international sharing of medical countermeasures.

Such actions are already in place at EU level and could be further enhanced to the benefit of the EU as a whole in the event of a naturally-occurring outbreak or a bio-terror attack. Cross-border cooperation is critical to any effective strategy of preparedness and response. For this reason a European-level approach is necessary and appropriate as are efforts to coordinate activities in order to reduce biological risks and enhance preparedness.

This should also be done in the spirit of broader international cooperation. The EU and its Member States should continue working with and further strengthen cooperation on bio-preparedness within various fora such as the United Nations, the Biological Toxins and Weapons Convention, Australia group, G8, NATO, etc. Within the international context, particular emphasis could be placed especially on enhancement of early recognition and detection of diseases on the global scale and on better promotion of the European approach to the issue of biological risks.

Many specific measures exists at EU and Member State level to ensure bio-safety and civil protection, but need to be adapted to cope with deliberate attacks. Therefore, each new measure to address possible deliberate releases may be based on existing measures.

Europe-wide exercises, trainings and exchange of specialists dealing with preparedness and responses to terroristic scenarios were organized under the Community mechanism for civil protection assistance (Council Decision 2001/792/EC, EURATOM).

The key challenge to the area of food supply chain and agricultural industry is the introduction of a pathogen or contaminant into the food supply chain of humans or animals. Mitigating actions are the same as for a natural outbreak, e.g. early detection, sound traceability systems, rapid control and eradication measures, contingency plans and overall coordination. Nevertheless, our tools could be developed to face bioterrorist attacks during which pathogens could be introduced simultaneously in a number of different locations across the EU and to cope with simultaneous outbreaks of different diseases that could overpower the established response capacities, and thereby affect public health and have a negative impact on trade and economy of the Member States and the Union as a whole.

As for contaminants in foodstuffs, the EU has already taken measures to minimize the risks. The basic principles of the EU legislation on chemical contaminants in food are stated in the Council Regulation (EEC) No. 315/93. Other legislative instruments adopted in the field of Food Safety could also be of relevance. The traceability is ensured through the Regulation (EC) No. 178/2002, which makes it an obligation for food business operators to be able to identify any person from whom they receive food/raw materials. Furthermore, the operators must be able to identify businesses to which they supply products. The same requirements apply to importers with this “one step back – one step forward” approach. The Regulation (EC) No. 178/2002 also provides for emergency measures and crisis management.

On the public health front, various actions have already been undertaken, such as the creation in 2002 of the Health Security Committee consisting of Highly-Level Representatives from the Member States and the Commission, a platform for cooperation between public health laboratories in all Member States, a system for the sharing of information on smallpox emergency plans between Member States and the Commission, as well as a directory of experts who can be asked for advice or investigation in cases of deliberate release of harmful agents and pathogens. Moreover, lists are kept of possible biological and chemical agents and pathogens that may be used by terrorists (smallpox, anthrax, botulinum toxin, etc.) and a guidance document on the treatment of patients exposed to pathogens has been produced by the European Medicines Evaluation Agency (EMEA).

In this context it is also important to mention the Directive (EC) No. 2000/54 on the protection of workers from risks related to exposure to biological agents at work. This Directive refers to biological agents rather than microorganisms, including also genetically modified organisms (there is also important legislation related to genetically modified organisms: the Directive No. 90/219/EEC amended and supplemented by the Directive No. 98/81/EC on restricted use of genetically modified microorganisms stipulating the rules of classification of equipments as well as emergency plans having cross-border impact.), cell cultures and human endoparasites, which may be able to provoke infection, allergy or toxicity. Although toxicity and allergenicity are included in the definition of biological agents, four risk groups are based on the level of risk of infection.

Regarding the enhancement of security, a Commission proposal for a Council Directive on the identification and designation of European Critical Infrastructure and the assessment of the need to improve their protection should also be mentioned.

The proposal considers the health sector to be one of the critical infrastructure sectors.

It is complemented by the inspections carried out by the Food and Veterinary Office, which is part of the European Commission's Directorate-General for Health and Consumer Protection, the TRACES system as well as 11 sectoral Rapid Alert Systems operational 24 hours/7 days a week, such as the Rapid Alert System for Food and Feed (RASFF), Rapid Alert System – Biological Chemical Threats (RAS-BICHAT) for cases of terroristic attack with the use of biological and chemical substances, the Monitoring and Information Center of the Community mechanism for civil protection and ARGUS, the secure general rapid alert system. In the Slovak Republic the RAS-BICHAT system is ensured by the Ministry of Health by the means of the Department of Crisis Management. Europe-wide exercises with the topic of smallpox occurrence and influenza pandemic were carried out, in which the Slovak Republic participated, too.

At the session on May 6, 2003 confirmed on June 2, 2004 the Council asked the Commission to consider "the elaboration of general preparation plan in the field of communicable diseases and health hazard".

Most of or even all Member States have plans to address "distress", "unexpected" or "crisis situations" that are generally usable in specific situations or threats like natural disasters or industrial accidents or other events caused by human activity. The Emergency situation response plan consists of the whole range of activities to protect the public, assets and environment containing "complex" approach, procedure in the case of "threat of any kind", "multi-sectoral" and "inter-sectoral" (or "related to all governmental units" or "integrated") approach and all elements to help the Member States in the effort to achieve the state of "prepared public".

11.5 key PRINCIPLES OF BIO-PREPAREDNESS

There is a large and complex legal framework at domestic level or at EU level. Before new legislation is commenced to use, first of all the tools like peer evaluation, awareness raising campaigns and supportive financial programs should be used. Existing structures and groups of experts including the public health should be used for implementation. **The measures should be proportionate, affordable, sustainable and reliable** in terms of threats they seek to minimize and respond to. **They need to be executed in advance.**

Implementation of the results and recommendations arising from this consultation could be enhanced by a European Bio-Network (EBN). The EBN would be an advisory structure which would pull together European expertise on bio-preparedness from different sectors.

The European Community has already put in place tools and mechanisms, initially developed for food safety and the fight against frauds. These instruments could be built on and used for the purpose of further reducing biological risks, including bio-terrorism. In order to be prepared to prevent bio-terrorism or natural outbreaks, new approaches should be considered in addition to existing tools where necessary.

11.6 Slovak republic and legislation related to biological weapons

Existing legislation of the Slovak Republic dealt with the prohibition of biological weapons marginally only, namely in the Act No. 179/1998 Coll. on Trading with Military Material as Amended. The act was amended through the Act No. 21/2007 of 13 December 2006 on Dual-Use Goods and Technologies and on Changing and Supplementing of Certain Acts. There is no stipulation of issues of primary civil character related to the prohibition of biological weapons in significant regulations on treatment with biological substances in the context of their potential abuse for military purposes including the Criminal Code (Articles 232, 295, 298 and 299 related to mass destruction weapons or high-risk substance).

In the legislation of the Slovak Republic biological agents as such have occurred in the Decree of the Government of the Slovak Republic No. 47/2002 Coll. on Health Protection While Working with Biological Agents of 16 January 2002. The Decree regulates conditions for work with biological agents like bacteria, viruses, parasites, fungi, and toxins.

Unlike that **the act dealing with biological weapons as such (Act No. 218/2007 Coll. on the Prohibition of Biological Weapons) regulates rights and obligations of natural persons, entrepreneurs belonging to the category of natural persons and legal entities in the field of the prohibition of the development, production, stockpiling, possession, use and destruction of biological weapons.** Its core refers to specifying high-risk biological agents and toxins that may be used in the way violating the **Convention on the prohibition of bacteriological (biological) and toxin weapons from 1972 that became effective in 1975 where the Slovak Republic accessed to it in 1993.**

The act regulates handling of them, stipulates the performance of state administrations and imposes sanctions in the field of the prohibition of bacteriological (biological) and toxin weapons. It is a kind of parallel to the Act on the prohibition of chemical weapons from 1998 and especially it complements the legislative framework of the SR regulating the field of non-proliferation and prohibition of the weapons of mass destruction.

11.7 CONVENTION ON THE PROHIBITION OF THE DEVELOPMENT, PRODUCTION, STOCKPILING OF BACTERIOLOGICAL (BIOLOGICAL) AND TOXIN WEAPONS AND ON THEIR DESTRUCTION

The Convention on the Prohibition of the Development, Production, Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (BTWC) is an international convention that entered into force on March 26 1975 prohibiting the development, production, stockpiling and other acquiring of biological agents of such types and in quantities that have no justification for prophylactic, protective or other peaceful purposes. Its text is as follows:

The State Parties to this Convention,

Determined to act with a view to achieving effective progress towards general and complete disarmament, including the prohibition and elimination of all types of weapons of mass destruction, and convinced that the prohibition of the development, production, stockpiling of chemical and bacteriological (biological) weapons, and their elimination through effective measures will facilitate the achievement of general and complete disarmament under strict and effective control,

Recognizing the important significance of the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed in Geneva on 17 June 1925, and conscious also of the contribution which the said Protocol has already made and continues to make, to mitigating the horrors of war,

Reaffirming their adherence to the principles and objectives of that Protocol and calling upon all States to comply strictly with them,

Recalling that the General Assembly of the United Nations has repeatedly condemned all actions contrary to the principles and objectives of the Geneva protocol of 17 June 1925,

Desiring to contribute to the strengthening of confidence between peoples and the general improvement of the international atmosphere,

Desiring also to contribute to the realization of the purposes and principles of the Charter of the United Nations,

Convinced of the importance and urgency of eliminating from the arsenals of States, through effective measures, such dangerous weapons of mass destruction as those using chemical or bacteriological (biological) agents,

Recognizing that an agreement on the prohibition of bacteriological (biological) and toxin weapons represents the first possible step towards the achievement of agreement on effective measures also for the prohibition of the development, production, stockpiling of chemical weapons, and determined to continue negotiations to that end,

Determined, for the sake of all mankind, to exclude completely the possibility of bacteriological (biological) agents and toxins being used as weapons,

Convinced that such use would be repugnant to the conscience of mankind and that no effort should be spared to minimize this risk,

Have agreed as follows:

Article I

Each State Party to this Convention undertakes never under any circumstances to develop, produce, stockpile or otherwise acquire or retain:

1. Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;

2. Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.

Article II

Each State Party to this Convention undertakes to destroy, or to divert to peaceful purposes, as soon as possible but not later than nine months after the entry into force of the Convention, all agents, toxins, weapons, equipment and means of delivery specified in article I of the Convention, which are in its possession or under its jurisdiction or control. In implementing the provisions of this article all necessary safety precautions shall be observed to protect populations and the environment.

Article III

Each State Party to this Convention undertakes not to transfer to any recipient whatsoever, directly or indirectly, and not in any way to assist, encourage, or induce any State, group of States or international organizations to manufacture or otherwise acquire any of the agents, toxins, weapons, equipment or means of delivery specified in Article I of the Convention.

Article IV

Each State Party to this Convention shall, in accordance with its constitutional processes, take any necessary measure to prohibit and prevent the development, production, stockpiling, acquisition or retention of the agents, toxins, weapons, equipment and means of delivery specified in Article I of the Convention, within the territory of such State, under its jurisdiction or under its control anywhere.

Article V

States Parties to this Convention undertake to consult one another and to cooperate in solving any problems which may arise in relation to the objective of, or in the application of the provisions of, the Convention. Consultation and cooperation pursuant to this Article may also be undertaken through appropriate international procedures within the framework of the United Nations and in accordance with its Charter.

Article VI

1. Any State Party to this Convention, which finds that any other State Party is acting in breach of obligations deriving from the provisions of the Convention, may lodge a complaint with the Security Council of the United Nations. Such a complaint should include all possible evidence confirming its validity, as well as a request for its consideration by the Security Council.

2. Each State Party to this Convention undertakes to cooperate in carrying out any investigation which the Security Council may initiate, in accordance with the provisions of the Charter of the United Nations, on the basis of the complaint received by the Council. The Security Council shall inform the State Parties to the Convention of the results of the investigation.

Article VII

Each State Party to this Convention undertakes to provide or support assistance, in accordance with the United Nations Charter, to any Party to the Convention which so requests, if the Security Council decides that such Party has been exposed to danger as a result of violation of the Convention.

Article VIII

Nothing in this Convention shall be interpreted as in any way limiting or detracting from the obligations assumed by any State under the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on 17 June 1925.

Article IX

Each State Party to this Convention affirms the recognized objective of effective prohibition of chemical weapons and, to this end, undertakes to continue negotiations in

good faith with a view to reaching early agreement of effective measures for the prohibition and their development, production and stockpiling and for their destruction, and on appropriate measures concerning equipment and means of delivery specifically designed for the production or use of chemical agents for weapons purposes.

Article X

1. Each State Party to this Convention undertakes to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the use of bacteriological (biological) agents and toxins for peaceful purposes. Parties to the Convention in a position to do so shall also cooperate in contributing individually or together with other States or international organizations to the further development and application of scientific discoveries in the field of bacteriology (biology) for prevention of disease, or for other peaceful purposes.

2. This Convention shall be implemented in a manner designed to avoid hampering the economic or technological development of the State Parties to the Convention or international cooperation in the field of peaceful bacteriological (biological) activities, including the international exchange of bacteriological (biological) agents and toxins and equipment for the processing, use or production of bacteriological (biological) agents and toxins for peaceful purposes in accordance with the provisions of the Convention.

Article XI

Any State Party may propose amendments to this Convention. Amendments shall enter into force for each State Party accepting the amendments upon their acceptance by a majority of the State Parties to the Convention and thereafter for each remaining State Party on the date of acceptance by it.

Article XII

Five years after entry into force of this Convention, or earlier if it is requested by a majority of the Parties to the Convention by submitting a proposal to this effect to the Depositary Governments, a conference of State Parties to the Convention shall be held at Geneva, Switzerland, to review the operation of the Convention, with a view to assuring that the purposes of the preamble and the provisions of the Convention, including the provisions concerning negotiations on chemical weapons, are being realized. Such review shall take into account any new scientific and technological development relevant to the Convention.

Article XIII

1. This Convention shall be of unlimited duration.

2. Each State Party to this Convention shall in exercising its natural sovereignty have the right to withdraw from the Convention if it decides that extraordinary events, related to the subject matter of the Convention, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other State Parties to the Convention and to the United Nations Security Council three months in advance. Such notice shall include a statement of the extraordinary events it regards as having jeopardized its supreme interests.

Article XIV

1. This Convention shall be open to all State Parties for signature. Any State which does not sign the Convention before its entry into force in accordance with paragraph (3) of this Article may accede to it at any time.

2. This Convention shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited by the Governments of the United States of America, the United Kingdom of Great Britain and Northern Ireland and the Union of Soviet Socialist Republics, which are hereby designated the Depositary Governments.

3. This Convention shall enter into force after the deposit of instruments of ratification by twenty-two Governments, including the Governments designates as Depositaries of the Convention.

4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Convention, it shall enter into force on the date of deposit of their instrument of ratification or accession.

5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification or of accession and the date of entry into force of this Convention, and of the receipt of other notices.

6. This Convention shall be registered by the Depositary Governments pursuant to the Article 102 of the Charter of the United Nations.

Article XV

This Convention, the English, Russian, French, Spanish and Chinese texts of which are equally authentic, shall be deposited in the archives of the Depository Governments. Duly certified copies of the Convention shall be transmitted by the Depositary Governments of the signatory and acceding States.

In witness whereof the undersigned, duly authorized, have signed this Convention.

Done in triplicate, at the cities of London, Moscow and Washington the tenth day of April, one thousand nine hundred and seventy-two.

This Convention abbreviated in English like BWC or BWTC is not a list of prohibited agents of biological weapons but it is rather focused on the purposes of their use and contains the criterion of general purpose as basic principle.

Practically, the Convention is the first document of international significance on real disarmament and on elimination of whole one type of the weapons of mass destruction.

The Slovak Republic has been participating in the process related to the detailing of the Convention at the Meeting of the State Parties and at the Meetings of Experts for a long period since 1993.

In relation with adopting the Act No. 218/2007 on the Prohibition of Biological Weapons it is necessary to state that from the practical viewpoint the Regional Public Health Authority having its seat in Banská Bystrica is considered to be a "national recognized authority" and from the viewpoint of the organizational structure it is the Information Center for Bacteriological (Biological) and Toxin Weapons established on 15 October 2001.

11.8 the tasks of the public health in case of potential occuRrence of biological agents cogitable as biological weapons or Tools of bioterrorism

Biological agents cogitable as biological weapons or tools of bioterrorism affect the health of an individual, population, environment, water, air, food as well as animals and plants. (A specific form of bioterrorism refers to agro-terrorism, i.e. deliberate abuse of biological agents (biological weapons) to cause disease of animals or plants, having political, religious, or ideological motivation.)

In this relation the public health should act as follows:

- to collaborate on the realizing the fact that biological weapons may be used for example in bioterrorism;
- to further create conditions for informing both the experts and the lay public about this serious issue and to contribute to the process of realizing the gravity of the issue of biological weapons;

- to enhance controls of diseases and detection systems especially by the means of systematic enhancing the quality of laboratory diagnostics of communicable diseases in the laboratories of the public health via cooperation among the bodies of the public health and university health education;
- to enhance early detection and identification of diseases of global impact and better support of the European attitude to the issue of biological hazards.

11.9 ENVIRONMENTAL EFFECTS AND CONSEQUENCES OF THE USE OF BIOLOGICAL WEAPONS (short-term and long-term)

11.9.1 Short-term consequences

The most significant short-term consequence of the use of biological weapons is their ability to cause mass casualties. The losses cause and determine strategic procedures in the strategy of preparedness to such event. The potential for overwhelming medical resources and infrastructure is intensified by the fact that psychological reaction is related to terror and panic as a consequence of the biological attack and especially this fact may have more severe consequences compared to that caused by assault with conventional weapons. A graphic example of such situation and its short-term consequences is the attack with chemical agents in Japan during 1994-1995 when the nerve gas sarin was used. A similar case refers to anthrax envelopes in the U.S. and many European countries, including Slovakia.

11.9.2 Long-term consequences

The long-term consequences of the use of biological weapons include delayed, prolonged and environmentally mediated health effects felt far beyond the time and circumstances of employment of the weapons.

Some biological agents may cause physical or mental defects of organism and these consequences are present months or years after the biological weapons have been used.

The long-term consequences of releases of biological weapons are especially chronic illnesses, delayed effects, new infectious diseases becoming epidemic and effects mediated by ecological changes.

Biological agent of particular concern is *Brucella species* causing chronic illnesses. For example, *Brucella melitensis* infection has more acute progress compared to *Brucella abortus* infection and *Brucella suis* infection. *Brucella melitensis* especially affects bones, joints and causes endocarditis. Relapses, fatigue, weight loss may last for months and years.

Francisella tularensis infection results in prolonged fatigue and weakness lasting for months and years.

The viral encephalitides may have long-term effects on the central and peripheral nervous system. Delayed effects of biological agents placed in the biological weapons may cause carcinogenesis, teratogenesis, and possibly mutagenesis. The truth is that the information comes especially from experimental studies performed on animals or refers more to the use of chemical weapons. There is a well-known teratogenic effect of TORCH complex (toxoplasmosis, rubella, cytomegalovirus, herpetic infections).

If some biological weapons are used, this may result in the **disease becoming endemic** either in human populations or in suitable vectors such as arthropods and in other hosts such as rodents, equids, or cattle.

Bacillus anthracis spores are highly resistant especially to environmental degradation and can persist, particularly in soil, for long periods and by infecting and reproducing in animals they can establish new foci.

The biological weapons are usually aimed at humans, animals, or plants and after they have been used they have a secondary impact on the environment and with regard to their environmental stability they persist in the environment for years. An example of that is the occurrence of *Bacillus anthracis* spores on Gruinard Island at the northwestern coast of Scotland where the effect of anthrax as a biological weapon was tested during the Second World War in 1940. (Finally, *Bacillus anthracis* was not used as a biological weapon even if the Allies planned on doing so). There was quarantine on the island lasting for 48 years and first after that time period decontamination procedures became successful.

Microbes causing gastro-intestinal infections of humans such as *Salmonella* and *Shigella* could establish new long-term reservoirs. *Salmonella* strains could do likewise in domestic animals. Particular attention should be paid to deliberate and hostile reoccurrence of smallpox that was eradicated and this measure brought great advantages and enhancement of overall health condition to the populations and individuals in many countries, especially in the developed ones.

Finally, there is the possibility of **effects of biological weapons mediated by ecological changes**.

New foci of diseases might become established as a result of ecological changes caused by use of biological agents infective for humans and animals or as a result of the use of anti-plant agents. These could exert adverse long-term effects on human health via reductions in the quality and quantity of the food supply derived from plants or animals. They have huge impacts of economic character via direct effects on agriculture and indirect ones via business and tourism.

11.9.3 Psychological aspects of possible use of weapons and weapon systems

Disregarding the possibility of real use of biological weapons and the ability to cause physical injury and illness, the threat of using biological agents itself may work as a psychological weapon. In fact, it is a military term standing for moral attacks by the means of these weapons, and at the same time having in mind its effect on the populations.

11.10 PREVENTION AND MEASURES IN CASE OF THE USE OF BIOLOGICAL WEAPON AGENTS

Prevention and measures whether the agents of biological weapons have been used may be summarized in the points as follows:

- Identification of hazards;
- Evaluation of hazards and determination of initial risk;
- Introduction of epidemiological measures to reduce the risks emerging from the use of biological agents used in preparation of biological weapons;
- Evaluation of needs and monitoring of activities.

11.10.1 Identification of hazards

(Assessment of whether bio-attack took place)

- Initial hypothesis of potential pathogen source, its dispersion or dissemination;
- Use of rapid biological detection techniques to determine the pathogenic agents;

- Identifying the pathogen and its characteristics (resistance to antibiotics, vaccines, etc.);
- Dispersion place and period of assumed pathogen dispersion; direction and velocity of its dissemination;
- Testing the hypothesis on the basis of laboratory findings and epidemiological dissemination.

11.10.2 Evaluation of hazards and determination of initial risk

- Estimating the scope of contaminated area;
- Estimating the number of persons being at risk for infection;
- Estimating necessary sources and tools essential for eradication of the epidemics;
- Clinical and epidemiological definition of the case;
- Distribution of cases (time, place, humans, animals).

11.10.3 Introduction of epidemiological measures

- Declaration of the state of threat to the population;
- Mobilization of workers and necessary tools;
- Protection of rescue workers and healthcare workers;
- Informing the public and giving instructions to affected ones;
- Active surveillance: searching for ill persons;
- Hospitalization of ill persons and immediate introduction of appropriate therapy;
- Providing health care to ill persons, whether in non-medical or domestic treatment;
- Establishment of centers for distribution of antibiotics;
- Providing the post-exposure prophylaxis for population exposed to infection risk;
- Providing the transport of dead bodies and their cremation;
- Providing the transport and incineration of dead animals;
- To consider whether to decontaminate the contaminated surfaces or re-vaccinate the population of the affected area.

11.10.4 Evaluation of needs and monitoring of activities related to the use of biological weapons

- Monitoring of local sources with equipment;
- Requesting of required equipment from central sources (antibiotics, vaccines, etc.);
- Monitoring of effectiveness of measures executed;
- Adjustment or change of activities according to local needs.

11.11 THE PRINCIPLES OF PROTECTION OF THE INDIVIDUALS AND THE POPULATION

Different technologies and strategic procedures may be used to protect the individuals in the process of physical protection against contamination by biological agents. The individual protection is a measure that is crucial in the process of protection from using biological agents. The collective protection of population is elaborated thoroughly in the system of civil protection of the population.

11.11.1 Individual protection

The risk-reducing measures refer to systems of administrative management, systems of technical management and measures and physical protection.

Administrative management systems

When using biological weapons, under administrative management systems we have in mind a set of regulations and measures allowing effective action in one or several resorts. A typical example refers to the *Action plan against terrorism* and *System of biological protection for the Slovak population*. Further, the system of warning, evacuation, building barriers - cordoning off the entry to the affected areas is a part of it, too. The risk itself is not prevented by using the administrative management systems only. However, the fact is that the systems are relatively easy to apply and as for the price, they are more advantageous compared to other risk management methods and they should be used where possible with no exception.

Basically, we can state that administrative management systems are just an important complement to the system of measures but they themselves are not able to eliminate the risk itself.

Systems of technical management and related measures

Under technical management systems we have in mind technologies and procedures such as air flow control in respective installations, filters and various technical forms of barriers used to provide physiological environment. In this way the contact between the staff and hazardous substances can be prevented and at this stage use of personal protective equipment is not necessary. An example is the use of laminar flow cabinets of different levels. (Explanation of the terms such as Biosafety, Biocontainment and Laminar flow cabinet is to be found in the glossary.)

Physical protection

In spite of physical protection, risk cannot be prevented and it is necessary, by the means of the systems of technical management and administrative measures, to continue in creating conditions for the activity of health and non-health workers within the risk of biological weapons in order to achieve the shortest time of exposure possible. The way how to achieve the aim is the individual and collective protection of population.

The personal protective equipment refers to all equipment worn and held at work even in case of the use of chemical weapons. Such equipment must provide an effective protection from existing, i.e. biological hazards. It must fit ergonomically and cannot be harmful to health. In case of use of biological weapons and in case of bioterrorism, respiratory protection and skin protection plays the most significant role.

Respiratory protection

The majority of the most hazardous biological agents enter the organism through the respiratory system. The respiratory system is considerably vulnerable as a result of its functional and anatomic structure. There are two main types of protection of the respiratory system providing respiratory protection of the organism:

- Air-purifying devices such as for example military gas masks, and
- Air-supplying devices.

The air-purifying devices such as gas masks remove gases, vapors or aerosols from inhaled air. Of course, the devices are not able to eliminate oxygen deficit. The protection-ability depends on filter capacity and its selectivity of different contami-

nants. Attachments supplied with the gas masks according to military requirements eliminate known biological and chemical harmful substances. In the latest models of gas masks the aerosol filters are combined with activated charcoal in order to eliminate dust, gases and vapors.

Two key problems may occur when using these types of respirators:

- Filtration capacity is not adequate to the type and quantity of the contaminant;
- Glass visors and face-pieces of the mask do not fit properly.

The selectivity problem is likely to be solved by using masks and filters used by the armed forces as these are suitable for the majority of known biological and chemical agents. In spite of that even the most modern filters may be overcome if high concentration of gases and vapors are used or the filters are clogged mechanically in case of use or occurrence of intolerable concentrations of mechanical impurities.

The major problem is the issue of face-pieces and glass visors tight-fitting as mentioned above.

Devices designed for air filtration refer to the following: a mouthpiece, a half mask, a mask and complete protective clothing with mask. The greatest danger reducing protective capability of this device is negative pressure in the mask.

There are respirators with additional electric device creating slight excess pressure in the respirator of the mask.

They are designed especially for the personnel treating patients if there is a suspicion for highly virulent infections.

The air supply devices shall supply air independently from the external atmosphere and supply the protective clothing with non-contaminated air. In these cases it may refer to a stationary device and a mobile device. Stationary systems are equipped with a hood and helmet if some workers were not able to wear a mask. The stationary system provides clear air in an absolutely independent way. The only limiting factor is the length of nasal hose.

Use of such systems requires well-trained personnel and maximum protective effects can be achieved with such personnel only.

Skin protection

In spite of the fact that in case of the use of biological weapons the respiratory tract is the most vulnerable one, a thorough skin protection is also a crucial factor of individual's protection. Such protection shall be provided by using gloves, shoe covers, boots, and full-body safety clothing.

The effectiveness of such protection is achieved by and depends on the following:

- Permeability of the material for biological agents;
- Non-leakage of respective device.

It may be stated that there is no impermeable material for an unlimited time period. Single materials have specific resistance to single noxious substances. Of course, the resistance depends on the fact whether there are some mechanical microscopic damages or not. Even "impermeable" material cannot provide total skin protection. The latest military models of such protective equipments protect skin from both chemical and biological noxious substances effectively.

Specific cases

Some groups of inhabitants are not able to wear individual protective equipment protecting them from the use of biological weapons. It refers especially to small children and people with pulmonary dysfunction. It is similar with patients with head injury and facial injury. Psychological problems connected with wearing such equipment and clothing may play a role as well, especially in case of these population groups.

11.11.2 Collective protection of the population

The collective protection of the population shall be provided as follows:

-via shelters not specially prepared for the protection from chemical and biological substances, and;

- via specially adjusted space.

In general, it may be stated that all premises and buildings as well as means of transport are likely to secure protection from biological weapons to some degree, if they are airtight enough. This may be ensured by using adhesive plastic films on windows and ventilation vents as well as by using the sealing tapes. Such measure prevents the access of the biological and chemical substances, but of the air too, unfortunately. There are two moments being a limiting factor of requirements to adjustment and operation of buildings and shelters that should protect the individuals and collectives from the effect of biological or chemical weapons:

- Leak-tightness and resistance of sealing; and
- Air volume per person.

Implementation of totally airtight system is very difficult, if not impossible. Sooner or later the contaminants penetrate to such space. In the course of time even a paradox situation may occur leaving the outside concentration of contaminants on a decreasing level and increasing level inside the shelters. Monitoring of the concentrations indoors and outdoors is an absolute necessity.

Another no less significant problem is the accumulation of carbon dioxide inside the premises and supply of oxygen to temporary or permanent shelters. The air volume per person should be 10 m^3.

Specially constructed shelters and premises are constructed as airtight or pressurized shelters with non-contaminated air whose sufficient volume and quality is ensured within technical determinateness of the equipment. Such systems and equipments require regular maintenance and control.

Nowadays, modern buildings are equipped with built-in airconditioning and thus, there is the possibility to supplement such equipment with highly efficient filters. Therefore, a pressurized shelter can be built.

There is an example of building such shelters in Switzerland where population protection has been built systematically and for a long time.

Some factors can be considered to be as disadvantages of such ensuring of collective protection of the population, including price, availability in the time of need, or restricted mobility.

References

Klement C., Mezencev R. a kol.: Biologické zbrane. BONUS, Bratislava, 2008, 378 s. ISBN:978-80-969733-2-3

Klement C., Rovný I., Maďarová L., Sirág P.: Surveillance infekčných ochorení, bioterorizmus a medzinárodná spolupráca. Výsledky vyšetrovania podozrivých zásielok po 11. septembri 2001. In: Acta Universitatis Matthiae Belii, Séria chémia., No. 8 (2004), p. 58-68 – Banská Bystrica: Univerzita Mateja Bela

Green Paper on Bio-Preparedness, 11951/07 COM. (2006) 787, final version. Treaty on European Union.

Klement C. a kol.: Medzinárodné zdravotné predpisy – teória – legislatíva – implementácia - súvislosti. Vydavateľstvo PRO, 2009, 438. ISBN 978 – 80-89057 – 24 -5

Klement C. a kol.: Mimoriadne udalosti vo verejnom zdravotníctve. PRO Banská Bystrica, 2011, 663 s. ISBN: 978-80-89057-29-0
Matousek J., Benedík J., Linhart P. CBRN - Biologické zbraně. SPBI,Ostrava, 2007, 186 s. ISBN:978-80-7385-003-6
McLaughlin K., Nixdorff K. Biological Weapons Reader, BioWapons Prevention Project, Geneva, 2009, pp.196
Klement C., Mezencev R., Bajgar J. Biologické a chemické zbrane. PRO, Banská Bystrica, 2014. 784 s. ISBN 978 – 80- 89057 – 43 -6.

Acknowledgements

This publication is the result of the research supported by the ESF-OPV project „MPH study programme development at Comenius University in Bratislava in English language (Master of Public Health).“ ITMS code of the project: 26140230009

Moderné vzdelávanie pre vedomostnú spoločnosť/
Projekt je spolufinancovaný zo zdrojov EÚ