8.5

Occupational health

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Abstract

Workers constitute a large and important group, accounting for up to half of the world's population. Occupational health, which involves the 'promotion and maintenance of the highest degree of physical, mental, and social well-being of workers in all occupations' is thus an important component of public health practice.

Work-related injuries and illnesses are estimated to kill 2.2 million people worldwide each year. Globally, there are about 270 million occupational accidents and 170 million victims of work-related illnesses annually. Many cases are unrecognized or not reported. The overall economic losses from work-related injuries and illnesses account for approximately 4 per cent of the world's GNP.

At the workplace, workers may suffer from occupational diseases which may affect almost all organ systems, and are caused by exposure to specific hazards at the workplace; work-related diseases with 'multifactorial' aetiology, where factors in the work environment may play a role, together with other risk factors in the development or aggravation of such diseases, and/or general diseases affecting the working population.

Disease prevention and health promotion in the workforce begin with assessment of the risk of work, and recognition of vulnerable populations including, for example, workers in developing nations, migrant workers, child labour, women workers, or impaired workers. Managing the risks of work may be via primary prevention including elimination of the hazard or substitution with a safer alternative, engineering controls, redesign of the work station or process, administrative controls, education of workers, improved and safer work practices, use of personal protective equipment, good personal hygiene practices, and pre-employment or pre-placement examinations; secondary prevention including periodic health monitoring, detection of evidence of excessive exposure, biological tests of excessive exposure or early effect, and removal of the worker from further exposure; and/or tertiary prevention including planning for emergency response, rehabilitation and return to work, workers compensation. Health promotion at the workplace—which includes promoting healthy lifestyles and community action for health, and creation of conditions that make it possible to live a healthy life—is also important.

Increasingly, occupational health practice has evolved to encompass environmental health issues. Hence the term occupational and environmental health might more accurately describe this important aspect of public health.

Introduction

Workers constitute a large and important population. The World Health Organization (WHO) estimated in 2007 that the global labour force was half of the world's population (about 3300 million) (WHO 2007a). The officially registered working population includes 60–70 per cent of the world's adult males and 30–60 per cent of adult females. Most people between the ages of 22 and 65 spend approximately 40 per cent of their waking hours at work (Leigh *et al.* 1997).

Occupational health, as defined by a joint committee of the WHO and the International Labour Organization, involves the 'promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations' (Forsmann 1983). This definition emphasizes the term health rather than disease, and further implies a multidisciplinary responsibility as well as a mechanism for the provision of health services for the working population. As practised today, the cornerstones of occupational health practice are health protection and health promotion of those who work. In many countries, such activities extend beyond the worker to include his or her family members.

History and development

The Italian physician Bernardino Ramazzini (1633–1714) is often described as the 'Father of Occupational Medicine'. His publication *De Morbis Artificum Diatriba*, which appeared in 1700, was the seminal text in occupational medicine. Ramazzini stated that according to Hippocratic teaching, 'When you come to a patient's house, you should ask him what sort of pain he has, what caused them, how many days he has been ill, whether the bowels are working, and what sort of food he eats'. Following this citation, Ramazzini wrote: 'I may venture to add one more question: *What occupation does he follow?*' Ramazzini described many occupational illnesses that are still seen today, and furthermore, described the principles for their control.

The industrial revolution and occupational health

The major event that profoundly influenced the development of occupational health was the industrial revolution in the

eighteenth century. Dramatic social changes during this period occurred in the western world. These transformations related to newly introduced industrial processes and the setting up of factories, which in turn set in motion a variety of social changes. Previously, most work was done by craftsmen in rural cottage industries. The industrial revolution resulted in work being carried out in factories in urban centres.

Effects were seen both within the community, as well as in the individual worker. Family life was disrupted, with men leaving their families and moving to work in new industrial areas. In industrial areas, health and social problems emerged—such as poor housing and sanitation, alcoholism, prostitution, and poverty. Inside factories, individuals were exposed to long hours of work and uncontrolled occupational hazards; and faced the risk of accidents at work. Child labour and apprenticeship of young children were commonplace, and there was an absence of labour legislation.

As problems of industrialization grew, people of influence and political power campaigned to improve working conditions. Occupational health legislation appeared towards the end of the eighteenth century, and progressively developed to protect the health and rights of workers.

Today, the same phenomena seen during the industrial revolution are being replicated in some developing nations. Even in industrialized nations, the similar problems are still encountered by migrant workers and other deprived sectors of their society.

Occupational health legislation

The first environmental cancer was described by Percival Pott over 200 years ago. This cancer—scrotal skin cancer—occurred in chimney sweeps, and was caused by exposure to polycyclic aromatic hydrocarbon compounds in soot. An early piece of English legislation was the *Act for Better Regulations of Chimney Sweeps and their Apprentices, 1788.* This act stipulated a minimum age of 8 years for chimney sweeps; provided for inspections and hearing of complaints, required that the master not 'misuse or evil treat' the apprentice, and stated that the master 'shall at least once in every week, cause the said apprentice to be thoroughly washed and cleansed from soot and dirt'.

The *Health and Morals of Apprentices Act, 1802* applied to apprentices in the cotton and woollen industry. It limited work to 12 h a day, specified factory walls to be washed and rooms to be ventilated, and allowed voluntary factory inspections by visitors. The *Factory Act, 1819* set 9 years as a minimum age for the worker and limited work hours. Other work environments were covered by other legislation, such as the *Mines Act, 1842*, which prohibited females from working in mines, and allowed for government inspection.

Many countries today have comprehensive occupational health legislation. For example, in the United States, the *Occupational Safety and Health Act* was passed by Congress in 1970. Its goal was 'to assure as far as possible every working man and woman in the nation safe and healthful working conditions'. The *Health and Safety at Work Act,* enacted in 1974 in the United Kingdom, provides a broad legislative framework for the protection of workers through specific regulations. The European Union (EU) adopted a policy in 1989 on the 'Fundamental Social Rights of Workers', emphasizing the need for safety and health protection in the workplace, improvements in living and working conditions, and provision of social protection for workers.

Another recent development of occupational health legislation aims to ensure that employers do not discriminate against applicants and employees with disabilities. One example of this type of legislation is the *Disability Discrimination Act, 1995* in the United Kingdom. Employers should also make reasonable accommodations for a known impairment; unless it would cause undue hardship, such as incurring significant difficulty or expense.

Occupational diseases, injury, and work-related ill health

In most nations, there is no completely reliable source of information on the extent of work-related injuries and diseases. Even so, the International Labour Office (ILO) estimates that work-related injuries and illnesses kill 2.2 million people worldwide each year. Globally, there are about 270 million occupational accidents and 170 million victims of work-related illnesses annually (ILO 2005). An estimated 160 million new cases of work-related diseases occur each year worldwide.

At the workplace, three categories of diseases may be noted in workers. These are:

(1) Occupational diseases: These are caused by exposure to specific hazards at the workplace. However, in some situations these occupational diseases may also occur among the general community as a consequence of contamination of the environment from the workplace, e.g. lead, pesticides. Occupational diseases are cause-specific—e.g. asbestos causes asbestosis.

(2) Work-related diseases: Work-related diseases are 'multifactorial' in origin, where factors in the work environment may play a role, together with other risk factors in the development or aggravation of such diseases. These diseases have a complex aetiology.

(3) General diseases affecting the working population: These are medical conditions prevalent in the community such as malaria, hereditary haemolytic anaemia, or diabetes mellitus, without a causal relationship with work. The unhealthy worker may not be able to be as productive as his healthy counterpart. Furthermore, work may have a deleterious or aggravating effect on the medical condition.

Table 8.5.1 shows the differences between occupational and work-related diseases.

Table 8.5.1 Differences between occupational and work-related diseases

Work-related diseases	Occupational diseases
Occurs largely in the community	Occurs mainly among working population
'Multifactorial' in origin	Cause specific
Exposure to workplace may be a factor	Exposure to workplace is essential
May be notifiable and compensable	Notifiable and compensable

Major types of occupational disease and injury

Occupational illness can affect virtually every organ system. Occupational diseases of the lung and skin are common since these organs have substantial surface areas in direct contact with toxic substances. Noise-induced hearing loss and musculoskeletal disorders are among the most common disorders arising from physical factors in the workplace. Occupational cancer is a major concern because of the high mortality associated with many forms of cancer. Increasing attention has been paid in recent years to diseases affecting the neurological, reproductive, and immunological systems.

Occupational lung diseases

The lung is an easily accessible target organ for airborne toxic substances. Major categories of occupational lung disease include the 'dust diseases' of the lung or pneumoconioses, lung cancer, occupational asthma, industrial bronchitis and other effects of irritants, and infections. Silicosis is the most common pneumoconiosis worldwide. Exposure to silica occurs in a wide variety of work situations such as sandblasting, mining, milling, pottery work, foundry work and work using abrasives. In the United States, over 1 million workers are at risk for developing silicosis each year; more than 200 workers die from silicosis and hundreds more become disabled (NIOSH 2006). The International Agency for Research on Cancer (IARC) has classified crystalline silica as a known human carcinogen (IARC 1997).

Asbestos is another important cause of pneumoconiosis and other lung diseases. Asbestos has been responsible for over 200 000 deaths in the United States and will cause millions more deaths worldwide (Collegium Ramazzini 2004). All forms of asbestos cause asbestosis, a progressive fibrosis of the lungs. All forms of asbestos can also cause lung cancer and malignant mesothelioma. Peto and colleagues (1999) estimate there will be more than 500 000 asbestos-related malignant mesothelioma cancer deaths in Western Europe over the next 35 years. Given the long latency, the future burden of mortality resulting from asbestos will be substantial even if all future exposure were to be eliminated completely.

Bronchial asthma affects about 5–16 per cent of the population in developed countries (Masoli 2004). Population-based estimates in the United States suggest that 15–23 per cent of new-onset asthma cases in adults are work related (NIOSH 2004). In some jurisdictions, occupational asthma has become the most prevalent occupational lung disease, exceeding silicosis and asbestosis. Even so, prevalence studies of occupational asthma usually underestimate the number of affected workers because these workers tend to quit jobs where they suffer such symptoms, although their asthma symptoms and signs may continue even after leaving work.

Many gases, fumes, and aerosols are directly toxic to the respiratory tract by causing acute inflammation. Examples include soluble irritants, e.g. hydrogen chloride, ammonia, sulphur dioxide, which produce effects in the eyes, nasopharynx, and large airways. Less soluble irritants, e.g. nitrogen dioxide, ozone, and phosgene, produce few upper respiratory symptoms, but in high exposure can cause a toxic pneumonitis. Long-term exposure can lead to lung fibrosis.

Occupational cancer

Based on a review of IARC classification, there are 28 definite, 27 probable, and 110 possible human occupational carcinogens. They include chemical substances (e.g. benzene and asbestos), physical hazards (e.g. ionizing radiation), and biological hazards (e.g. viruses). It is estimated that approximately 16 million workers in the EU are exposed to carcinogens at work. The most common cancers due to these workplace exposures are cancers of the lung, bladder, skin, pleura (mesothelioma), liver, haematopoietic tissue, bone, and soft connective tissue.

Occupational cancer accounts for about 4–20 per cent of all cancers in developed countries. The large variability in the estimates arises from differences in data sets used and the assumptions applied. The most commonly accepted estimate is 4 per cent with a plausible range, based on the best quality studies, being 2–8 per cent. However, if one considers only the adult population in which exposure to occupational carcinogens almost exclusively occurs, the proportion of cancer attributed to occupation would increase to about 20 per cent among those exposed (Pearce *et al.* 1998).

Occupational skin disorders

Skin disorders are among the most commonly reported occupational diseases. Approximately one worker per thousand is affected (LaDou 2007). The most common occupational skin disorder is irritant contact dermatitis. Although skin disorders are relatively easily diagnosed, occupational skin diseases are believed to be underreported, so that the actual rate is many times higher than officially reported (NIOSH 2007). Occupational skin disorders are unevenly distributed among industries. A worker in agriculture, forestry, fishing, or manufacturing has three times the risk of developing a work-related skin disease as a worker in other industries.

Occupational infectious diseases

Much attention about infectious diseases has focused on healthcare settings, although infections can be transmitted in other work places, such as research laboratories and animal processing facilities. Within healthcare settings, awareness has grown about the risk of infection by hepatitis, the human immunodeficiency virus (HIV), and tuberculosis (*Mycobacterium tuberculosis*). Needlestick injuries accounted for about 40 per cent of hepatitis B and hepatitis C infections and 4.4 per cent of HIV infections in healthcare workers (Nelson *et al.* 2005). An increased risk of HIV infection has been shown to exist in settings in which workers may be exposed to blood or body fluids (NIOSH 1996).

Transmission of *M. tuberculosis* is a recognized risk in healthcare facilities. After years of declining incidence rates, multidrug-resistant (MDR) tuberculosis re-emerged as a major occupational health problem during the 1990s in major cities in the United States which serve populations with high rates of MDR tuberculosis (CDC 1999).

Emerging infectious diseases also pose a risk to healthcare workers. One example is severe acute respiratory syndrome (SARS), which is caused by a coronavirus. In the 2003 worldwide outbreak of SARS, 20 per cent of patients were healthcare workers (Koh *et al.* 2003). Currently there is concern about risk of infection among healthcare workers caring for patients with avian influenza (Schultsz *et al.* 2005; WHO 2007b).

Infectious diseases can be especially prevalent in developing countries, resulting in higher risks for workers in these countries. Some of the infections result directly from the work, while others are indirectly related to work. Examples include vector-borne diseases like malaria; water- and food-borne diseases resulting from

poor sanitation and inadequate potable water; and zoonoses among agricultural workers.

Occupational reproductive disorders

The overall contribution of occupational exposures to reproductive disorders is not known because there has been little research in this area until recently. More than 84 000 chemical compounds are in the workplace, and about 2000 are added every year. Only about 4000 have been evaluated for reproductive toxicity, and among these, few have been sufficiently evaluated for human reproductive effects. Most of the studies were conducted on animals (Lawson *et al.* 2003). Very few studies have been done on physical and biological agents that may affect fertility and pregnancy outcomes.

It is well documented that lead (Pb) and the pesticide dibromochloropropane cause testicular injury with resultant reduction in sperm count. Also, Pb can cross the placenta in a pregnant woman worker to cause neurological impairment in the foetus. Other substances associated with documented adverse reproductive outcomes include methyl mercury, solvents such as carbon disulphide, carbon monoxide, oestrogens, anaesthetic gases, antineoplastic drugs, ethylene oxide, ethylene glycol ethers, polychlorinated biphenyls, and physical agents such as ionizing radiation (Windham 2007).

Occupational exposures can cause a wide range of reproductive disorders in both males and females. Effects of exposures in males include altered sperm number, shape or function; altered sperm transfer; and altered hormones or sexual performance. Exposures in females may cause menstrual disorders, infertility, chromosomal aberrations, breast milk alteration, early onset of menopause, and suppressed libido.

Reproductive disorders also include adverse effects on the offspring of the exposed worker. Potential foetal effects from maternal exposures include preterm delivery, foetal loss, prenatal death, low birth weight, altered sex ratio of livebirths, congenital malformations, childhood malignancies, infant or childhood illness, and developmental disabilities.

Occupational noise-induced hearing loss

High levels of occupational noise are a persistent problem in all regions of the world. In Germany, 12–15 per cent of the workforce are exposed to hazardous noise levels (Concha-Barrientos 2004). In the EU, noise-induced hearing loss is one of the most commonly reported occupational disease—20 per cent of the workers report they were exposed to high levels of noise for at least half of their working hours. The prevalence of noise exposure is especially high in the manufacturing and construction industries—40 per cent of workers in these sectors are exposed. In the United States, about 30 million workers are exposed to hazardous noise levels at work (NIOSH 2004).

Industries such as manufacturing, mining, construction, transportation, agriculture, and the military are at the highest risk for noise-induced hearing loss. In developed countries, increasing awareness has led to greater implementation of protective measures, whereas in developing countries, industrialization may herald an increase in average noise levels (Concha-Barrientos 2004).

Occupational traumatic injuries

These injuries include such events as amputations, fractures, severe lacerations, eye losses, acute poisonings, and burns. ILO estimates that 2 million people die every year from work-related accidents and illnesses. For every fatal accident, there are another 500–2000 injuries, depending on the occupation (ILO 2002). In Great Britain, the rate of nonfatal major injuries reported in 2005–2006 was 100.3 per 100000 workers. European Statistics at Work reported about 4.7 million accidents at work in the EU which resulted in three or more days away from work in 2001, and about 4900 fatal accidents at work (European Communities 2004).

Work-related diseases

Work-related diseases are diseases in which workplace factors may be associated in their occurrence, but need not be the only risk factor in each case. Common work-related diseases include: Hypertension, ischaemic heart disease, psychosomatic illnesses, musculoskeletal disorders, and non-specific respiratory disease. In these diseases, work may be associated with their causation or may aggravate a pre-existing condition.

Work-related diseases are more common than pure 'occupational diseases'. While prevention of occupational diseases is possible by the elimination of the workplace hazard, work-related diseases cannot be entirely prevented by only addressing occupational hazards.

Work-related musculoskeletal disorders

Work-related musculoskeletal disorders include both acute and chronic injury to the musculoskeletal system, other than acute trauma. These conditions are one of the leading problems affecting workers. In the United States, musculoskeletal disorders account for 34 per cent of all nonfatal occupational injuries and illnesses involving days away from work (NIOSH 2004). More than half of the working population develops low-back injury at some time in their working career. Musculoskeletal injuries are the principal cause of disability of people in their working years.

According to the Labour Force Survey in Great Britain, musculoskeletal disorders accounted for about 75 per cent of self-reported work-related illness in 2005–2006. The commonest musculoskeletal complaint was back pain. Among the 7000 cases assessed per year for industrial injuries disablement benefits, vibration white finger and carpal tunnel syndrome were among the largest categories (HSE 2006).

In the EU, 53 per cent of workers reporting work-related illness had musculoskeletal disorders. About 17–46 per cent of workers report exposure to the risk factors for musculoskeletal diseases. The 1999 Labour Force Survey reported that about 4 million European workers suffered from a work-related musculoskeletal problem (European Communities 2004).

Stress-related ill health

Job stress has been defined as the 'harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources or needs of the worker' (NIOSH 1999). In terms of the magnitude of the problem, NIOSH (1999) reports that:

- 25 per cent of employees view their jobs as the number one stressor in their lives.
- 75 per cent of employees believe that today's worker has more 'on-the-job' stress than a generation ago.
- Problems at work are more strongly associated with health complaints; than any other life stressor—more than even financial or family problems.

- Workers who take time off work because of stress, anxiety, or a related disorder will be off the job for about 20 days.

Individual and situational factors, such as balance between work and family life, social support, individual outlook, and personality, can affect the likelihood of developing stress. However, working conditions often play a significant, and sometimes major role in the causation of stress.

Workplace stress-related hazards (WHO 2003) consist of factors in both work content as well as context. Work content encompasses job content (e.g. meaningless, unpleasant tasks), workload (under as well as overload) and working under time pressure, work schedules (e.g. long, unsociable, inflexible working schedules), degree of participation in decision making, and lack of control of work. Work context includes concerns about career development, status and salary, the individual's role in the organization, issues relating to interpersonal relationships, the organizational culture/climate, and conflict or lack of support in the home–work interface.

Averse health outcomes of job stress are wide ranging, from increased risk of cardiovascular disease, musculoskeletal disorders, psychological disorders (e.g. emotional distress, depression, insomnia), impaired immune function, gastrointestinal disorders (e.g. ulcers), cancer, and even suicide. The organization may face a decrease in work commitment, an increase in absenteeism, lowered productivity, and increasing complaints and poor public image.

General diseases affecting the working population

There are general diseases prevalent in every community. These include infections such as HIV-AIDS, tuberculosis, and malaria, or non-communicable diseases and lifestyle-related diseases such as diabetes mellitus, cardiovascular disease, cancer, and malnutrition. Such diseases may not be caused by work exposures, but can affect work productivity. Workplace factors may also influence the medical condition.

Estimates of cost and economic loss

Total economic losses due to occupational injuries and illnesses are large. The ILO estimated that overall economic losses from work-related injuries and illnesses in 1997 were approximately 4 per cent of the world's gross national product (GNP). According to recent estimates, the cost of work-related health loss and associated productivity loss may amount to several percent of total GNP of a country. For example, the Health and Safety Executive (HSE) has estimated the cost of occupational illness and injury to the British economy to between £13.1 billion to £22.2 billion in 2001–02 (HSE 2004).

In the United States, the direct cost of workplace injuries and illnesses was estimated to be US$45.8 billion, and the indirect costs ranging from US$137.4 to US$229 billion. The National Safety Council estimated that the cost of work injuries in 2002 was US$1060 per worker, with a national total of US$146.6 billion. In addition, employer costs for providing workers' compensation rose from US$52.8 to US$72.9 billion between 1998 and 2002 (NIOSH 2005).

Under-recognition of occupational ill health

Although recording of workplace injuries is reasonably accurate in most developed countries, surveillance systems generally result in substantial under-estimates of actual cases of occupational illness. One explanation for under-recognition of occupational disease is the inherent difficulty in diagnosing occupational diseases and in establishing cause-and-effect relationships. The link between occupation and disease may sometimes be unclear, because most occupational diseases are not distinct clinically and pathologically from diseases associated with non-occupational aetiologies. For example, skin cancer caused by polycyclic aromatic hydrocarbons is similar in appearance to that caused by sunlight. Similarly, solvent-induced encephalopathy may easily be attributed to old age. Only in rare instances, such as the associations between asbestos and mesothelioma (Selikoff *et al.* 1964) and between vinyl chloride monomer and angiosarcoma of the liver (Creech & Johnson 1974), is the causal association between occupational exposure and disease readily established on clinical grounds alone.

Another cause of the under-recognition of occupational disease is that the majority of chemicals in commerce have never been evaluated with regard to their potential toxicity. Only 7 per cent of the approximately 80 000 chemicals commonly used in industry have been screened for toxicity, and less than half of these have been studied thoroughly (LaDou 2007). Such toxicity testing often concentrate primarily on high-dose, acute effects, and on the long-term risk of cancer. Toxicity testing of reproductive, neurological, and other adverse effects remains quite limited.

The long latency which typically elapses between occupational exposure and onset of illness is a third factor which may obscure the occupational aetiology of chronic disease. For example, few occupational cancers appear within 10 or even 20 years of first exposure. Similarly, chronic neurotoxic effects of solvents may become evident only after decades of exposure. In such instances, it is unlikely that the worker will be diagnosed as having a disease of occupational origin.

Lack of awareness among health practitioners about the hazards found at work is a fourth cause of underestimation of occupational disease, reflecting the fact that most physicians are not adequately trained to suspect work as a cause of disease (Institute of Medicine 1988; Goldman *et al.* 1999). Very little time is devoted in most medical schools to teaching physicians to take a proper occupational history, to recognize symptoms of common industrial toxins, or to recall known associations between occupational exposures and disease.

Compounding this lack of medical awareness is the limited ability of many workers to provide an accurate report of their exposures. Workers may have had multiple toxic exposures in a variety of jobs over a working lifetime. In most countries, there are no requirements to inform workers of the hazard of the materials with which they work. Even in the United States, employers' reporting requirements remain limited under the Hazard Communication Standard and state right-to-know laws. In many instances, a patient may not know about all his or her past occupational exposures.

Finally, given the potential financial liability associated with the finding that a disease is of occupational origin, employers may be resistant to recognizing the work-relatedness of a disorder, especially in cases where personal habits or non-occupational pursuits are possible contributory factors. Since employers are often in the best position to recognize causal associations between workplace exposures and disease, this conflict of interest represents an obstacle to obtaining accurate estimates of the burden of occupational illness.

Globalization and workers' health

Globalization is defined as an 'increase in the total world economic activity as a consequence of the liberalization of trade and the

elimination of the hindrances to the transfer of capital, goods, and services across the national border' (Rantanen 2000).

Rapid technological innovation and the proliferation of multinational organizations are driving the formation of a global economy that has a substantial impact on workers' safety and health. Technological change is creating fundamental transformations in the ways corporations organize production, trade goods, invest capital, and develop new products. Technology allows virtually instantaneous communication among widely dispersed operations. Advanced manufacturing technologies have changed patterns of productivity and employment. Improved air and sea transportation has greatly accelerated the flow of peoples and goods. These developments have created greater interdependence among firms and nations. At the same time, the rapid rate of innovation means that competitive advantages are fleeting and companies must function with ever increasing efficiency to survive in the global economy.

The strategy is for corporations to be agile and rapidly responsive to market demands (Menzies 1998). This strategy has led to concepts such as computer-integrated manufacturing, just-in-time manufacturing, and lean production. Quality circles, total quality management, and other 'cultural training' programmes train workers to identify with the competitive goals of management. New technologies have been implemented to increase productivity and make flexible work schedules possible. However, these technologies can also mean loss of control for workers, increased work speed, and more repetitious work—each of which has been associated with increased job stress (Schnall *et al.* 2000). Employment is both more flexible and less secure as corporations use technology to ensure that individual workers are dispensable and that they conform to the competitive needs of the corporation. Consequently, there has been a dramatic growth in contracted work and non-standard forms of employment, such as part-time and home-based work.

Shift work and irregular work hours have increased significantly among those who are employed. About 20 per cent of workers in the EU countries engage in shift work, and about the same number are involved in some night work (European Communities 2004). The ILO found that one in five (or 614.2 million) workers worldwide put in more than 48 h of work a week, often earning only a bare minimum (ILO 2007b).

The contingent workforce (which includes self-employed, temporary, and part-time workers) typically have less training about hazards, less access to occupational health services, and less access to other social services (e.g. medical and unemployment insurance or programmes). It is difficult under these circumstances for traditional forms of labour protection, such as government regulations and representation by unions, to function efficiently.

The global economy has also led to shifts in the distribution of occupational hazards among regions of the world. In the industrially developed nations, the principal shift has been from a manufacturing-based economy to an economy that is based on the provision of services and transfer of information. Consequently, exposure to classical hazards such as silica, asbestos, and heavy chemicals are becoming less important in these nations, while exposure to new synthetic materials and solvents, as well as the ergonomic exposures associated with repetitive work before computer terminals, have become more important (Mustard 1997). In developing nations, major hazards have resulted from the export of dangerous industries, materials, and occupations from the industrially developed nations. In some instances, this export can lead to devastating disasters such as the explosion in the chemical plant at Bhopal, India, that killed several thousand people. Another example is the international boom in the microelectronics industry, which now employs hundreds of thousands of workers worldwide, occasionally under poorly controlled and exploitative conditions. Multinational corporations account for 70 per cent of world trade. They play a dominant role in global manufacturing and trade and carry a large responsibility for economic development (LaDou 2007).

The global economy has led to the negotiation of trade agreements, such as the North American Free Trade Agreement, which define conditions of work in the context of trade facilitation and barriers. In some cases, agreements have led to standards that raise the level of protection to workers in countries where previously such protections were minimal; however, in many cases, agreements have encouraged de-unionization and movement away from work protections in order to 'harmonize' protections at a low, but common level among trading partners (Armstrong 1998). A major challenge for nations and international organizations is to implement policies that balance the demands of the global market economy with appropriate protections for workers' health and well-being.

Globalization affects nations selectively. Countries such as China, Argentina, Brazil, India, and the Philippines have seen economic growth and reduction in poverty rates in the past 20 years through globalization. On the other hand, 2 billion people in countries such as Pakistan and much of Africa are becoming more isolated from the world community and are seeing stagnant economies and increasing poverty (LaDou 2007).

Special populations of workers

Recognition has increased that workplace hazards impact disproportionately on some worker populations—such as those in developing nations, as well as child labourers, women workers, and impaired workers (IPEC 1999). These populations are especially impacted because of the interaction between their work roles and broader roles in society, as well as by their particular exposures in the workplace.

Workers in developing nations

More than 80 per cent of workers in the global workforce are from the developing world (Rosenstock 2005). Workers' health should be viewed in the context of national development. Occupational health policy makers in many nations must consider a balance between adverse impacts on workers' health and the economic advantages of rapid development by allowing foreign investigators access to low-cost labour and conditions of weak labour protections.

The relationship between workers' health and development is complex for many reasons (Jeyaratnam 1998). For example, workers in many developing countries may be affected by poor nutrition or endemic diseases, such as malaria, in which work may aggravate the condition, or which make the worker more susceptible to the effects of workplace exposures. Workers in these countries also generally have lower educational backgrounds and are often inadequately trained to handle the new technologies and potential hazards. There may be high turnover with little management investment in worker training.

Working conditions in tropical developing countries may present special hazards because of climate and building ventilation issues in production facilities. Much of the production equipment is imported from developed countries so that replacement parts and service may be unavailable. The machinery may be used or considered obsolete for use in the developed countries, while new and safer equipment may be unavailable or too expensive.

The social organization of work in developing countries also affects workers' health. In addition to the large number of workplaces with a small number of workers, large proportions of the workforce work in the 'informal' sector. This sector consists of small, often home-based businesses that have no government registration and oversight. For example, recent estimates of the proportion of informal non-agricultural employment were about 58 per cent for Latin America and 75 per cent in sub-Saharan Africa. The informal economy accounts for 90 per cent of women working in non-agricultural sectors in India and Indonesia, and 95 per cent in Benin, Chad, and Mali (Rosenstock 2005).

Finally, countries of the developing world may have access to advanced technologies from the developed world without having developed legal or administrative infrastructure to control their adverse impacts on the work force (Jeyaratnam 1998). Even if developing countries adopt standards and legislation from more developed nations, there often is a shortage of trained personnel to recognize and manage workplace hazards.

Child labour

Children are an important population of workers worldwide. The ILO estimated that in 2004 there were 218 million children who were engaged in economic activity, with at least 126 million of them in hazardous work (ILO 2006a). Sub-Saharan Africa has the highest proportion of children engaged in economic activities, at about 26 per cent. Child labour also exists in many industrialized countries. Child labour has become an important issue because the children are often exploited in the workplace and denied basic human rights, such as access to education. Additionally, many children work in dangerous jobs and they may be more susceptible to workplace hazards (Warshaw 1998).

Poverty is the primary reason why children work. Poor households need the money, and children commonly contribute around 20–25 per cent of family income. Furthermore, if the family has a tradition of engaging in a hazardous occupation, it is likely that the children will continue in the trade.

Many children work in hazardous occupations and are at greater risk of suffering ill effects than adult workers. These children may have greater exposure to hazards than adult workers in the same occupation because children tend to be given the most menial jobs, which may involve higher exposures to toxic substances. Children are more susceptible to the same hazards faced by adult workers because they differ from adults in their anatomical, physiological, and psychological characteristics. Children using hand tools designed for adults run a higher risk of fatigue and injury. Personal protective equipment may also not fit and provide adequate protection. Furthermore, children may not be as aware as adults of workplace dangers, or as knowledgeable of precautions to be taken at work. Children are also more vulnerable to psychological and physical abuse than are adults, and suffer deeper psychological damage when they are denigrated or oppressed.

A resurgence of child labour is occurring in developed nations as well. Each year in New York State, for example, more than 1000 children receive workers' compensation awards for injuries incurred on the job; over 40 per cent of these awards each year are for permanent disability (Belville *et al.* 1993).

The issue of child labour has received increasing attention (Warshaw 1998; IPEC 1999). This is reflected in the number of organizations involved in the cause of children and child workers. For example, the International Programme on the Elimination of Child labour (IPEC) was launched in 1992 and, as of 1999, developed into a 90 country alliance. The aim of IPEC is the elimination of child labour, giving priority to its worst forms. The 'worst forms' comprise all forms of slavery or practices similar to slavery; the use, procurement or offering of a child for prostitution or production of pornography; the use, procurement, or offering of a child for illicit activities; and work which is inherently likely to harm the health, safety, or morals of children (IPEC 1999). Withdrawing children from the worst forms of child labour requires improved legislation and enforcement, improved methodologies for identifying the children, rehabilitation of the children, provision of viable alternatives to the children, and raising awareness at all societal levels.

The effort of IPEC in the elimination of child labour is beginning to pay off. The last 4 years have seen an 11 per cent reduction in the number of child labourers. Hearteningly, the greatest drop has been in the number of children involved in hazardous work. The number of children in the 5–14 age group involved in hazardous work has fallen by 33 per cent. The number of children at work in Latin America and the Caribbean has declined the most, by two-thirds in the last 4 years. However, the rate of child labour is still disparately high in sub-Saharan Africa (ILO 2006a).

Women workers

About 42 per cent of the global workforce is female (Messing 2006). Women are a special worker population because of the significant interplay between their roles in society, socioeconomic condition, and occupation. Women's roles in virtually all societies are defined in relation to their reproductive functions and responsibilities as family caregivers. Paid employment of women has increased in most countries, but this employment has increased the conflict between paid work and women's traditional family responsibilities. In many societies, early marriage, repeated child bearing, low education, and poverty all disproportionately impact on women workers (Loewenson 1999). The dual roles of women as workers and unpaid caregivers is especially challenging for sole-support mothers, who comprise 20–30 per cent of households worldwide.

Employment of women in most societies is characterized by occupational segregation, under-employment—doing seasonal and part-time work below their level of education, and barriers to advancement. Occupational segregation means that women tend to be clustered into a small number of occupations while being under-represented in most others (Stellman 1999). For example, professional women tend to be in teaching, nursing, and other healthcare specialities. In manufacturing, women tend to have jobs in assembly and small machine operations. Women in developing countries tend to be employed in sectors such as agriculture, textiles and clothing, food processing, and social services (Loewenson 1999). Compared with men, women work for smaller industries or organizations, have less opportunity for work control, and face the psychological demands of people-oriented or machine-paced work

(Paltiel 1998). Women are more likely to work in the informal sector, in specific types of informal work such as domestic work, street vending, and sex work, with their accompanying low social status and lack of legislative protection. While some countries have enacted laws prohibiting gender discrimination, many countries still have formal restrictions on women's employment.

Gender differences are observed in the rates of occupational injuries and illnesses, but these differences are primarily because of differences in the conditions of work or exposures, rather than due to genetic differences (Stellman 1999). As mentioned, women tend to work in different occupations than men, with a different distribution of hazards. Even when employed in the same industry, women generally do different jobs or different tasks from men so their exposures may be different. Even when doing the same task, women may have different levels of exposure because of variation in the effectiveness of engineering controls and personal protective equipment—which are generally designed for men.

Impaired workers

Around 470 million people with disabilities are in the working age group. Many people can make constructive contributions in the workplace although they have some type of physical impairment. In the United Kingdom, the *Disability Discrimination Act, 1995* prohibits employers from discriminating against applicants and employees with disabilities. Employers also should make reasonable accommodations for a known impairment.

A number of countries (e.g. China, Cambodia, and Tanzania) have established legislation for people with disabilities, prohibiting discrimination and covering various aspects of the rights of disabled people, including employment. Some countries (e.g. France, Germany, and Japan) go one step further and impose quotas on some enterprises to employ a certain percentage of disabled persons. Other countries, e.g. India and Japan, use employment promotion measures to ensure workplace accessibility and provide employment services in the form of job placement agencies. Singapore provides tax reductions as a financial incentive to compensate employers for any financial burden resulting from the employment of disabled persons (ILO 2007a). In 2006, the UN adopted a Convention on the Rights of Persons with Disabilities (ILO 2006b).

Reasonable accommodations are changes made to the work environment, job responsibilities or conditions of work that provide opportunities for workers with special needs to perform essential job functions. Reasonable accommodation can cover the special needs of persons with impairments or those workers with chronic or recurrent disease, including persons with AIDS. Accommodation may include technical assistance devices; customization, including personal protective equipment and clothing; and changes to processes, location, or timing for essential job functions. Surveys conducted by DuPont showed that employees with disabilities perform equally or better compared to employees with no disabilities. Additional adjustments in the workplace were required by only 4 per cent of disabled persons of employable age (ILO 2007a).

Migrant workers

There are an estimated 150–190 million migrants in the world—2 per cent of the world's population—including migrant workers, refugees, asylum seekers, and permanent immigrants. The number has increased dramatically with globalization. The vast majority of migration is from developing to developed countries. Three-quarters of all migrants lived in 28 countries in 2005, with one in five migrants living in the United States. Many migrants move to seek work. According to the UN, 'migrant workers' are persons who are to be engaged, are engaged, or have been engaged in remunerated activities in a State of which they are not nationals (UN 1990). Some migrant workers stay permanently in their new countries, while many return to their original homes after working for a period of time.

Migrant workers are a particularly vulnerable population for many of the same reasons that were described for workers in developing countries, e.g. they may be affected by poor nutrition and endemic diseases, they often have lower educational backgrounds, and they are inadequately trained for the potential work hazards. Migrant workers face additional obstacles because they may not speak the language of the host country; they often are not familiar with the health and safety practices and regulations, nor their rights in the host country; they may have temporary housing and limited access to medical care and other social services; they may be impacted by racism and xenophobia in their workplaces and communities; and they may not have full legal status, which makes them vulnerable to exploitation (Holmes 2006; McKay *et al.* 2006).

The UN and other international agencies have established programmes to monitor the status of migrants, including migrant workers. In July 2003, the UN 'Convention on the Protection of the Rights of All Migrant Workers and Their Families' entered into force. The Committee on Migrant Workers (CMW), which is linked with the UN, monitors implementation of the convention. Interestingly essentially all of the countries that ratified or signed the convention are countries of origins of migrants. The migrant-receiving nations of Europe and the United States have not ratified the convention, although there is growing awareness in Europe of the importance of addressing the rights of migrants. A key concept in the convention is that migrant workers are entitled to enjoy their human rights regardless of their legal status. In particular, the convention seeks to put an end to the illegal or clandestine recruitment and trafficking of migrant workers and to discourage the employment of migrant workers in undocumented situations, in which they are most vulnerable to exploitation (OHCHR, from: www.unhchr.ch/html/menu2/6/cmw/features.htm).

Assessing the risk of work

Health protection begins with an assessment of risk. Risk assessment is a structured and systematic procedure that is dependent upon the correct identification of hazards and an appropriate estimation of the risks arising from them (HSE 1995). The purpose for risk assessment is to ensure that a valid decision can be made for measures necessary to control exposure to substances hazardous to health arising in the workplace. Risk assessments are legal requirements in many countries. It can be either a qualitative or quantitative process.

Expertise, effort, and detail required for risk assessment depends on the nature and degree of risk, and the complexity of the work process. Adequate controls are determined based on several factors, such as the toxicity of substance, numbers exposed, acceptability of risk, legal requirements, costs, and availability of control measures.

Hazard and risk

There is a distinction between the terms 'hazard' and 'risk'.

A *hazard* is a substance, agent, or physical situation with a potential for harm in terms of injury or ill health, damage to property, damage to the environment, or a combination of these. Hazards can be

Table 8.5.2 Types of hazards at the workplace and their health effects

Type of hazard	Examples	Health effect
Physical	Noise Local vibration	Noise-induced hearing loss Traumatic vasospastic disease
Chemical	Various chemicals, e.g. solvents, heavy metals	Intoxications, fibroses, cancers, allergies, nervous system damage
Biological	Bacteria, fungi, viruses	Infections, allergies
Ergonomic	Repetitive work, work-rest schedules	Musculoskeletal injuries mental stress, lowered productivity and work quality
Psychosocial	Organizational stress, conflicts	Work dissatisfaction, burnout, depression

physical, chemical, biological, ergonomic, or psychosocial in nature (Table 8.5.2). *Hazard identification* is the process of recognizing that a hazard exists and defining its characteristics.

Risk relates to the likelihood of the harm or undesired event occurring, and the consequences of its occurrence. It is the probability that the substance or agent will cause adverse effects under the conditions of use and/or exposure, and the possible extent of harm. It is thus a function of both exposure to the hazard and the likelihood of harm from the hazard. *Extent of risk* covers the population that might be affected by the risk, the numbers exposed, and the consequences.

Risk assessment is the process of estimating the magnitude of risk, and deciding if the risk is tolerable or acceptable. A tolerable risk may not always be acceptable. It merely refers to a willingness to live with a risk to secure certain benefits, and in the confidence that the risk is being properly controlled (Sadhra & Rampal 1999). The levels of tolerability of risk are different for different countries, and in different working populations and the general public.

Risk assessment process

The process of risk assessment and management should take into account both routine and non-routine activities and conditions, including foreseeable emergency situations. Hazards that are intrinsic to these situations or generated by such activities should be identified.

Exposed persons should be identified, including non-employees and those who are susceptible and therefore at higher risk because of illness or other medical conditions. Existing control measures, if any, should be evaluated.

The health risks from the hazards should be determined and assessed, and a decision made if the risk is acceptable or tolerable. Unacceptable risks should be eliminated or reduced with new or improved control measures, and their effectiveness monitored. Such a process should be a team effort, involving the workers themselves as well as personnel with the relevant expertise. If needed, further corrective actions should be implemented. At the same time, workers should be informed of the hazards, risks, and appropriate measures that can be taken to protect themselves.

The steps for risk assessment for chemical, biological, ergonomic, and psychosocial hazards may differ, as illustrated by the following examples. The assessments for chemical or physical exposures are generally more objective and precise than the assessment for psychic stressors. As an example, an initial assessment for a chemical exposure might include the following steps:

1. List substances in the area to be assessed.
2. Determine which are actually used.
3. Evaluate workers concerns.
4. Assess the tasks of workers, their exposure, and methods of handling.
5. Obtain suppliers' data sheets.
6. Evaluate data sheets.
7. Inspect places where the substances are handled.
8. Evaluate method of control.
9. Perform environmental monitoring for the chemical if needed.
10. Decide on acceptability or tolerability of risk, and if further control measures are needed.

The assessment of psychosocial factors at work is more complex. It may include the evaluation of organizational dysfunction, work conditions, as well as a study of indicators such as sickness absence, staff turnover, and measurement of stress-related illness among employees. The identification of work stressors should review design of tasks, management style, interpersonal relationships, work roles, career concerns, and environmental conditions. Questionnaires to staff can be carried out using validated instruments—e.g. the Finnish Occupational Stress Questionnaire.

Environmental monitoring

Environmental or ambient monitoring in the workplace is undertaken to measure external exposure to harmful agents. The monitoring is to ensure that exposure is kept within 'permissible levels' so as to prevent the occurrence of disease.

Permissible levels or occupational exposure limits (OELs)

Permissible levels, or OELs, are standards that are available for many of the common hazards found in workplaces. Standards are available for the commonly encountered physical as well as chemical hazards. Standards can also be found for some substances of biological origin, including cellulose, some wood, cotton and grain dusts, proteolytic enzymes, and vegetable oil mists.

Permissible levels are based on the following considerations: (i) the physical and chemical properties of substance, including the nature and amount of impurities; (ii) toxicological studies; and (iii) available human data. The concept of permissible levels assumes that for each substance there is a level of exposure at or below which the exposed worker does not suffer any health impairment.

Permissible levels have their limitations. As such every effort must be made to keep exposure levels as low as reasonably practicable and the permissible level is a level above which exposure should not occur. This level could also be mandated by legislation. However, such levels may be based on incomplete information. Previously unsuspected health risks have arisen from substances assumed to be comparatively safe, for example, glycol ethers in the electronic industry and the risk of spontaneous abortions. The use of exposure standards for working conditions depends on good professional judgement, and hence should be used and interpreted only by trained persons.

Different countries have different exposure limits. The process of standard setting, nomenclature, and applicability would necessarily differ. For example, different approaches were taken in setting standards in the USSR and the United States in the 1970s (Levy 1999). The USSR standards, which were lower than those set in the United States at that time, were maximum allowable concentrations based on an absence of development of any disease or deviation from normal. In contrast, the US approach allowed for minor physiological adaptive changes. In addition, the principle in the USSR was that standards should be based entirely on health and not on technological and economic feasibility. In the United States, economic and technological feasibility were important considerations in the development of the standards.

Another consideration would be to take into account the situation for which the standards were set. For example, standards that are set for an 8-h working day would not be applicable for a 12-h working day. Furthermore, exposure to several hazards simultaneously may occur. In such situations, there may be interactions, with possible synergistic or additive effects. This would then require more stringent control of each individual hazard.

The method of environmental monitoring is also important. The choice of the correct collecting devices, sampling strategy, and analysis of the collected samples in accredited laboratories with proper quality control are important considerations that have to be addressed.

The type of persons exposed should also be considered. These include variations in age, gender, pre-existing disease, genetic make-up, and social habits (e.g. smoking) influence individual susceptibility. Some permissible limits, such as the threshold limit values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH), are derived to protect the majority of, but not all exposed persons. Susceptible individuals may still suffer health effects even at levels below the recommended TLV.

In spite of these limitations, sensible use of environmental standards can often result in practical control of many common workplace hazards so that the majority of workers are protected. Supplementary measures, such as biological monitoring, will ensure a safety net to identify workers with excessive body burdens or who have early health impairments.

The proprietary TLV developed by the ACGIH is one of the best known and widely used of the OELs. The TLVs are updated and published annually. They are derived from information from industrial experience, as well as studies in both animal and human populations. The TLVs of some chemicals, with their accompanying notations, are listed in Table 8.5.3.

Table 8.5.3 Threshold limit values of selected agents (ACGIH 2007)

Substance	TWA[a]	STEL/C[b]	TLV basis—critical effects
Acetylene	-	-	Asphyxiation
Acetylene tetrabromide	1 ppm	-	Irritation, liver
Acrylamide	0.03 mg/m^3	-	CNS, dermatitis
Asbestos (all forms)	0.1 f/cc	-	Asbestosis, cancer
n-butyl acrylate	2 ppm	-	Irritation, reproductive
Chlorine	0.5 ppm	1 ppm	Irritation
Chloroacetone	-	1 ppm	Irritation
Lead chromate			
as Pb	0.05 mg/m^3	-	Cancer, CVS, reproductive
as Cr	0.012 mg/m^3	-	
Mercury			
Alkyl compounds	0.01 mg/m^3	0.03 mg/m^3	CNS
Aryl compounds	0.1 mg/m^3	-	CNS, neuropathy, vision, kidney
Inorganic forms, including metallic Hg	0.025 mg/m^3	-	CNS, kidney, neuropathy, vision, reproductive, GI
Welding fumes	5 mg/m^3	-	Metal fume fever, irritation
Wood dust			
All species except Western red cedar	1 mg/m^3	-	Cancer, irritation, mucostasis, dermatitis
Western red cedar	5 mg/m^3	10 mg/m^3	Irritation, dermatitis, asthma

[a] TWA—time-weighted average

[b] STEL/C—short-term exposure limit ceiling

Exposure limits for combined exposures

The toxicity of substances of variable composition, for example, welding fumes, is dependent on factors such as the welding process and electrodes used, and the particular alloy that is welded. The TLV given, which is based on total particulate concentration, would be adequate only if no toxic elements are present in the welding rod, metal or its coating, and the welding conditions are not conducive to the formation of toxic gases.

Threshold limit values for chemical mixtures can be computed if components in the mixture have either similar toxic effects or independent toxic effects, using the appropriate correction formulae. Exposures to a combination of factors, such as physical and chemical agents, may result in interaction of these agents, and place added stress on the exposed person. For example, among exposed workers, interactions between physical and psychosocial risk factors can increase the risk of developing work-related musculoskeletal disorders (Devereux *et al.* 1999).

Managing the risk of work

Prevention of occupational disease can take place at various levels, such as at the national level, or at the level of the workplace itself. The aim is to reduce the occurrence of occupational disease by eliminating the cause or by controlling exposure to safe levels in order to prevent damage to the health of workers. Customarily several levels of prevention are recognized.

Primary prevention aims to reduce the occurrence of disease by eliminating the cause of disease or reducing exposure to safe levels that prevent it from causing damage, for example, banning the use of asbestos or reduction of noise at its source to levels that do not cause noise-induced deafness. Primary prevention with regard to chemicals requires either (i) elimination of toxic materials and their replacement by less hazardous substitutes or (ii) use of tight processes and controls, such as complete enclosure or ventilation at the source of aerosol generation.

Secondary prevention aims to detect situations of early effects of disease before they manifest as clinical symptoms and signs in

order to take corrective action, for example, regular monitoring of blood lead (BPb) levels among exposed workers or regular audiograms among noise-exposed workers. Successful secondary prevention depends on the ability to identify work-related illness efficiently and effectively through screening workers at high risk for occupational disease.

Tertiary prevention aims to minimize the consequences in persons who already have disease. This activity is largely a curative and rehabilitative procedure and depends on proper and appropriate treatment. Tertiary prevention depends on the development and wide application of appropriate diagnostic techniques for identification of persons with already established occupational illness.

Prevention on all three levels requires information on the potential effects of specific occupational exposures, as well as data on the industries, occupations, and geographical areas in which hazardous substances are used. The hierarchy of strategies for preventing occupational diseases is as follows:

- A. Primary prevention
  - Elimination of the hazard
  - Substitution with a safer alternative
  - Engineering controls
  - Redesign of the work station or process
  - Administrative controls
  - Education of workers
  - Improved and safer work practice
  - Use of personal protective equipment
  - Personal hygiene
  - Pre-employment or Pre-placement examinations
- B. Secondary prevention
  - Periodic health monitoring
  - Detection of evidence of excessive exposure
    - Biological tests of excessive exposure
    - Biological tests of early effect
- C. Tertiary prevention
  - Planning for emergency response
  - Rehabilitation and return to work
  - Workers compensation

Primary prevention

The most important prevention strategy is the primary prevention of exposure to toxic chemical, physical, biological, or psychosocial hazards. Reductions in exposure can be accomplished by using the techniques listed below, in descending order of preference.

Control of new hazards

Animal toxicity studies of chemicals to be used in industry are a reasonable predictor of potential health hazards to humans. On the basis of such studies, legislation in manufacturing nations would control the usage of such chemicals in industrial processes. One limitation is that such controls apply only to the new chemicals that are to be introduced into the market. For instance, it is estimated that only 10 per cent of pesticides in current usage have undergone such toxicological evaluation (Koh *et al.* 2001).

Control of known hazards

Several countries have legislation to ban the use of substances known to be harmful to human health. The UN has compiled a consolidated list of products whose consumption and sale have been banned, withdrawn, severely restricted, or not approved by governments. This publication constitutes a tool that helps governments keep up-to-date with regulatory decisions taken by other governments and assists them in considering the scope for eventual regulatory action. The United Nations Environment Program (UNEP) in 1989 has evolved a procedural mechanism of Prior Informed Consent (PIC) to inform government of banned agents such that these governments could take appropriate action for their control. By such means, the UN system attempts to prevent importing countries from unknowingly using substances banned in countries for health reasons.

At the national level, there may be rules that regulate the import, storage, sale, and transport of legislated substances through a licensing system, for example, for pesticides. Some substances may be subjected to import controls.

Control of hazards at the workplace

Total elimination of the hazard

This method eliminates the health risk completely, and has been used for substances that are carcinogenic (e.g. asbestos, benzene), or those that can cause serious health effects (e.g. cadmium). In the United Kingdom, the HSE had regulated in the mid-1980s that solder should be substituted with solder low in, or without, cadmium (Mason *et al.* 1999).

Substitution of the hazard

Substitution of the hazard with a less toxic alternative is another feasible option. In the case of processes which use solvents, such as degreasing operations, a less toxic solvent such as 1,1,1 trichloroethane can be used, instead of the more toxic trichloroethylene or tetrachloroethane.

Another method could be the substitution of the hazard to a form that reduces risk of exposure for example changing the particle size or other physical characteristic of a toxic chemical so that it is less easily inhaled or absorbed.

Selection of a less hazardous process or equipment also represents a meaningful control strategy. For example, substitution of a continuous process for an intermittent process almost always results in a decrease of exposure. Where an entire process does not need to be changed to reduce hazards, equipment substitution may achieve the desired reduction in exposure. An example is use of a degreaser with a low-speed hoist in lieu of dipping parts by hand.

Engineering controls

Automation, enclosure, or segregation of a work process, the use of dampeners or mufflers to reduce vibration or noise, reducing the open surface area for the evaporation of volatile toxic agents have been some of the successful engineering control measures used.

Ventilation is one of the most effective and widely used control measures. Control of hazards by ventilation is usually further subdivided into two categories: Local exhaust ventilation and general exhaust ventilation. The approach for implementing ventilation controls is: (1) Conduct an engineering study to evaluate sources of exposure, (2) develop an engineering design, (3) install a system based on the design, and (4) evaluate the completed system to ensure that the air contaminant has been effectively controlled.

Isolation is defined as the interposing of a barrier between a hazard and workers who might be injured or made ill by the hazard. Isolation may refer to storage of materials, such as flammable liquids, enclosure or removal of equipment to another area (such as noisy generators), or isolation of processes or of the workers themselves (e.g. by enclosing a sawmill worker in a sound-proof ventilated booth to protect him from noise and wood dust). The petroleum industry, for example, uses automated remote processing in plants based on centralized computer control of process equipment. Workers are thus largely isolated from hazards except in maintenance operations and during process upsets.

Suppressing the substance by processes such as 'wetting' of dusty operations is another example of an engineering control. Alteration of work practices can help to reduce exposure to hazards. An example is vacuuming cotton lint off spinning machines rather than blowing it off with compressed air, a practice which creates airborne dust particles.

Redesign of the work station or process

Workstation redesign to reduce unnecessary and repetitive bending, or to prevent excessive stretching to the limit of the range of movement of the workers, can minimize ergonomic hazards. Among computer operators, use of adjustable equipment, positioning of the workstation to reduce glare, and appropriate work rest pauses can prevent the development of eyestrain and musculoskeletal complaints.

Administrative controls

Administrative controls may be a viable alternative or an additional measure to reduce worker exposure to occupational hazards. This could take the form of job enlargement or job rotation, restriction of hours of work at a hazardous operation, or temporary job reassignment.

With administrative controls, the level of exposure to the hazard is not diminished; instead, the duration of exposure is reduced and exposure is spread more widely among the work-force. For example, if the air standard for inorganic lead is 50 mg/m^3 based on an 8-h day, a worker could permissibly be exposed to 100 mg/m^3 for 4 h and then rotated to a job without lead exposure as an administrative control. A common use in industry of administrative controls is to reduce overall noise exposure through rotation. Given the typical demands of production and the potential for misuse, administrative methods of controls are not an optimal mode of control.

Education of workers

Training of workers to recognize work hazards, how to work safely, and what to do in the event of an emergency or when occupational diseases occur, is another important aspect of prevention. For example, metalworkers are often exposed to skin contact with coolants and soluble oils. Different workers performing the same job can have variable skin contact with coolants, ranging from almost negligible exposure to almost total constant skin contact with the coolants (Wassenius *et al.* 1998). This variation can be explained by differences in hazard awareness, attitude, and practice of safe working techniques in different workers.

- The 'right to know' concept refers to the mandatory sharing of information regarding workplace exposure to toxic substances between employers and workers, regulatory agencies, and in some cases communities near a workplace. The fundamental assumption in the right-to-know concept is that this transfer of information will prompt activity that will improve worker health. In fact, there have been several instances of workers themselves playing a direct role in the discovery of occupational health problems. Two examples are the discovery of lung cancer in workers exposed to bis(chloromethyl) ether (Figueroa *et al.* 1973) and sterility in workers exposed to dibromochloropropane (Whorton 1977).
- The right of workers to know about potential hazards necessarily implies a corresponding duty on employers to provide that information. Employers' duties can be considered in three ways. First, the duty to generate or retain information means that an employer would be required to perform environmental or medical monitoring and to retain the records pertaining to that monitoring for a specified period of time. This duty is specified under some of the Occupational Safety and Health Administration (OSHA) comprehensive standards, such as those for asbestos and lead. Second, the duty to disclose information on request means that an employer must provide copies of exposure or biological monitoring data to a worker or worker representative if that information is requested. For example, the OSHA Access to Employee Exposure and Medical Records Standard attempts to ensure that exposure, medical, and biological monitoring records are preserved and workers have access to them. Third, the duty to inform refers to an employer's or manufacturer's obligation to disclose information about potential toxic substances in the workplace. Under the OSHA Hazard Communication Standard, employers have a duty to inform workers of the identity of the substances with which they work through labelling the product containers and disclosing the source of supply through the use of Material Safety Data Sheets (MSDSs). The standard also requires that workers must be trained in methods to detect the presence of hazardous chemicals, the hazards of the chemicals, and protective measures.

Use of personal protective devices

The use of personal protective equipment is often widely practised. It has its merits, a major one being its relative inexpense, and is especially useful for situations of short-term or occasional exposure to occupational hazards. Respirators, gloves, protective clothing, ear plugs, and muffs are all common forms of personal protective equipment in use throughout industry. They can play an important role, provided that carefully designed personal protective equipment programmes are in place and the equipment itself is frequently and regularly checked.

Protective devices have to be properly selected to be effective against specific hazards, e.g. the choice of an appropriate glove for use with a particular solvent. Workers have to be trained to use the equipment correctly and to ensure that it is working effectively, such as respirator fit testing in the use of respirators. Worker compliance in the use of these devices has to be high, or its protective effects may be less than desired. Compliance can be an issue, because of discomfort, especially for workers in hot and humid climates. Finally, protective devices have to be properly maintained and replaced when necessary.

It is important to recognize that programmes of personal protection never constitute as efficient a means of protection as engineering or process controls. Personal protective equipment is intended to reduce exposures to toxic substances which have already been dispersed in the workplace as the result of inadequate control at source. Unfortunately, programmes for personal protective

equipment, such as respirator programmes, often are ill defined, given inadequate attention, and used in lieu of engineering controls, with poor maintenance of the necessary equipment.

Personal hygiene

Programmes for encouraging personal hygiene constitute another approach to reducing exposure. In some instances, management may require showers and a change to clean clothes at the end of the working day. Several US OSHA standards, such as the occupational lead standard, require management to provide such facilities. A subtle but potentially important route of exposure is ingestion of toxic agents by eating, smoking, or applying cosmetics in the work place. To prevent such exposure, separate eating facilities outside production areas should be provided. Workers should be encouraged to wash their hands before eating or smoking.

Pre-employment or pre-placement examinations

Pre-placement or pre-employment medical examinations are undertaken to achieve proper job placement according to the mental and physical capabilities of the worker, and to prevent damage to susceptible workers. Such tests are also undertaken for other objectives—e.g. to protect other workers and the general public, for insurance purposes, and to obtain baseline information on fitness. Pre-placement examinations should not be used as a means to discriminate workers and deny employment.

Education of workers should be given during these assessments. Those who work have a right to know the potential hazards and risks in their work and workplaces. They should be educated on these matters and be given information on how to safeguard their health. Immunization against diseases that may possibly be contracted on the job, and for which an effective vaccine is available, should also be given. An example is the immunization of healthcare personnel exposed to the hepatitis B virus.

There are genetic disorders which can be identified and may make a worker more vulnerable to certain workplace exposures—e.g. people with red cell glucose-6-phosphate dehydrogenase deficiency are at risk for haemolytic anaemia and more susceptible to haemolytic agents. Persons with serum total α1-antitrypsin deficiency may be susceptible to respiratory irritants (Koh & Jeyaratnam 1998).

Similarly, evidence of other behaviours (e.g. smoking, alcohol consumption) and diseases (e.g. chronic bronchitis, liver, kidney disease), may increase the susceptibility of workers exposed to certain toxicants. Biological monitoring of the worker ideally begins at the pre-employment examination stage, as can be continued periodically (see below).

Secondary prevention

Secondary prevention aims to detect situations of early effects of disease before they manifest as clinical symptoms and signs. Upon early detection, corrective action can be taken, such as removal of the worker from further exposure. In most instances, early effects of disease can be reversed if corrective action is promptly taken.

Biological monitoring

Biological monitoring and environmental monitoring complement each other in the assessment of health risk in the exposed worker. It is a useful tool in the prevention and management of ill health among workers (Morgan 1997). One major feature of biological, as compared to environmental, monitoring is that for a particular individual, it takes into account exposure from all routes of absorption. For example, for workplace exposure to organic solvents, skin absorption may be a significant route of entry of the solvent into the body, and ambient environmental air monitoring might be less useful as an indicator of exposure than biological monitoring.

Furthermore, environmental monitoring at the workplace would not account for non-occupational or extra-occupational exposures. A person working in a noisy environment could be additionally exposed to noise in a second job, hobby, or non-occupational activity, e.g. reserve military service.

While some consider any procedure (e.g. periodic X-rays, blood tests, symptom enquiry, etc.) used to monitor exposed workers as biological monitoring, others make a distinction between biological monitoring and effects monitoring.

Biological monitoring

Biological monitoring refers to the measurement and assessment of workplace agents, their metabolites or effects either in tissues, secreta, excreta, expired air, or any combinations of these for the purpose of evaluating exposure and health risk (Meister 2007). The specific chemical, or its breakdown product, can be measured, to detect the total body burden of the substance. The method of measurement of these substances must be validated and there should be a means to interpret the results obtained in terms of the extent of exposure, and risk to health.

Biological effect monitoring

This refers to the measurement and assessment of early biological effects, of which the relationship to health impairment has not yet been established, in exposed workers to evaluate exposure and/or other health risk compared to an appropriate reference.

Some examples of include detection of alterations in enzyme levels (e.g. cholinesterase for workers exposed to organophosphorus or carbamate pesticides), or other biochemical changes such as delta aminolaevulinic acid in urine of workers exposed to inorganic lead, or beta 2 microglobulin in the urine of cadmium exposed workers.

In the early stages, these changes need not necessarily cause any direct pathological damage to the individual, but rather, reflect situations of excessive exposure. These changes are often reversible on removal of the worker from further exposure.

Health effects monitoring (health surveillance)

Health effects monitoring is 'the periodic physiological or clinical examination of exposed workers with the objective of protecting and preventing occupationally related diseases' (Aw 1995). These examinations detect early clinical effects in exposed workers. Examples include audiometry for noise exposed workers, clinical examination for skin lesions in workers exposed to polycyclic aromatic hydrocarbon compounds in tar, pitch, and bitumen, and chest X-rays for workers exposed to pneumoconiosis producing dusts. Figure 8.5.1 illustrates and summarizes the terminology and levels of prevention that are used in occupational health practice.

Biological exposure limit value

The measurement value obtained by biological monitoring is evaluated as a health risk by comparing it with the corresponding biological exposure limit value. A set of values have been developed by the ACGIH, which include results of biological monitoring as well as biological effects monitoring. The Biological Exposure Index (BEI) is described as in general representing the 'levels of determinants which are most likely to be observed in specimens collected from a healthy worker who has been exposed to chemicals in the same extent as a worker with inhalation exposure to the TLV'.

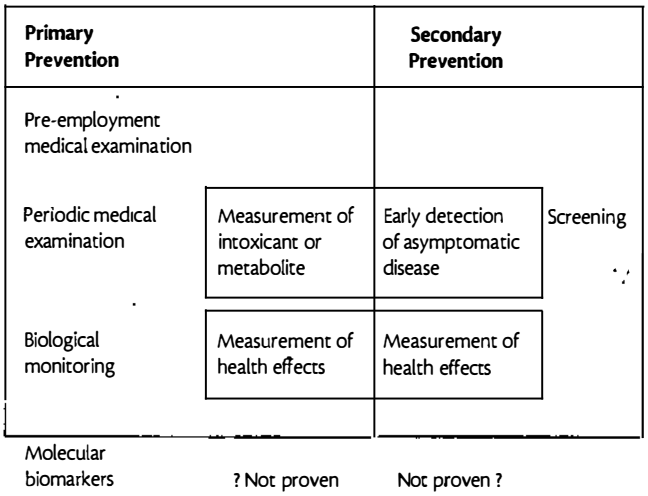

Fig. 8.5.1 Summary of terminology and levels of prevention in occupational disease.

Exceptions would be made for chemicals for which TLVs are based on non-systemic effects, for example, irritation; and for chemicals with significant routes of entry via additional routes of entry (usually percutaneous absorption).

The ACGIH cautions that 'BEIs do not indicate a sharp distinction between hazardous and non-hazardous exposures. Due to biological variability, it is possible for an individual's measurements to exceed the BEI without incurring an increased health risk'. It further states that BEIs are not intended for use as a measure of adverse effect or diagnosis of occupational disease. However, if measurements of the individual or group of workers persistently exceed the BEIs, the cause of the excessive values should be investigated, and measures should be taken to reduce the exposure. Biological exposure indices (as used by ACGIH) for some toxicants are shown in Table 8.5.4.

Technological advances in molecular biology over the last few decades have offered more sophisticated techniques that can be used to study the role of specific exogenous agents and host factors in causing ill-health. These advances have resulted in the development of newer molecular biomarkers of exposure, response, and genetic susceptibility. These include measurements for structural gene damage, gene variation, and gene products in cells and body fluids, e.g. oncogenes and tumour suppressor genes, DNA adducts, gene products, and genetic polymorphisms and metabolic phenotypes in environmentally exposed populations (Koh *et al.* 1999).

Table 8.5.4 Biological exposure indices (BEIs) of some chemical toxicants (ACGIH 2007)

Intoxicant	BEI	Source	Sampling time
Carbon monoxide			
Carboxyhaemoglobin	3.5% of haemoglobin	Blood	End of shift
Carbon monodixe	20 ppm	Exhaled air	End of shift
Cadmium and inorganic compounds	5 µg/g creatinine	Urine	Not critical
	5 µg/L	Blood	Not critical
n-hexane			
2,5 hexanedione	5 µg/g creatinine	Urine	End of shift
Lead	30 µg/100 ml	Blood	Not critical
Mercury (inorganic)	35 µg/g creatinine	Urine	Pre-shift
	15 µg/l	Blood	End of shift/ week
Phenol	250 mg/g creatinine	Urine	End of shift

An understanding of biochemistry and genetics at the molecular level, specific knowledge on metabolism and mechanisms of action, and epidemiology is important. This is necessary in order to address the major question of validation and relevance of these molecular biomarkers. For example, the availability of genetic tests to identify susceptible workers raises issues of ethics, individual privacy, right to work, and the relevance of such tests. Several studies have presented data on the association of environmental measurements and various biomarkers for internal and biologically effective dose, genetic polymorphisms, and early response markers (Table 8.5.5). Given the limitations of individual molecular biomarkers in assessing health risk, and the multifactorial nature of environmental disease, it is likely that a combined approach which examines several of these biomarkers simultaneously will increase our understanding of the complex issue of disease mechanisms and further refine the process of risk assessment.

Periodic medical examinations

Periodic medical examinations may be required for some occupational groups in order to achieve primary, or failing that, secondary prevention of disease. In many countries, certain categories of employees must undergo statutory periodic medical examinations. These examinations are usually for workers exposed to known hazards such as noise, radiation, asbestos, silica, heavy metals, and specific toxic chemicals.

For some countries, only properly qualified health personnel, with additional postgraduate training in occupational health, are empowered to perform the examinations, and issue fitness to work certificates. The results of the examinations have to be kept for a specified period of time, and copies sent to the relevant government body.

The objective of statutory medical examinations is to prevent special groups of 'at risk' workers from developing serious occupational diseases. Regular health examinations, which are specific for the type of hazard the worker is exposed to, are conducted. Workers found to have signs of overexposure to any hazard; or with early signs of disease can be removed from further exposure. They can be given alternative work until they are fit to return to their former jobs. Furthermore, if signs of overexposure are detected, further control measures can be taken to reduce the exposure at source, and prevent other workers from being similarly affected.

Sometimes, special groups of workers are required to undergo periodic medical examinations for other reasons, such as to certify ongoing fitness to work in order to protect the health of the public, e.g. professional drivers and food handlers.

Post illness or injury evaluation

An evaluation of the health status of the employee returning to work after a prolonged absence from work due to illness or injury is important. This is to ensure that the worker has sufficiently recovered from the illness or injury, and is fit to return to work. Two issues to consider would be:

- Can the worker perform his/her duty without adverse health and safety risks to himself/herself or fellow workers?
- Should he/she return to full-time unrestricted duty, or should some modified, restricted or alternative duty be given?

Table 8.5.5 Examples of molecular biomarkers measured in occupational health studies

Molecular biomarkers	Application	Study population
Exposure marker		
PAH–DNA adduct	Workplace and community exposures and exposure to cigarette smoke, and risk of lung cancer	Foundry workers, coke oven workers, general community in industrial areas
Early effect markers		
p53 tumour suppressor gene or its protein product	Specific fingerprint mutation in certain gene codon and risk of liver, breast, lung, and oesophageal cancer	Radon-exposed miners, vinyl chloride monomer workers, general population with environmental exposure to AFB1
H-*ras* and K-*ras* gene or its protein product	Increased risk of various cancers, e.g. lung, liver, and bladder	Firefighters, hazardous waste workers, foundry workers, vinyl chloride monomer workers
Host susceptibility markers		
CYP1A1 polymorphism	Increased risk of lung cancer with exposure to Benzo pyrene	Foundry workers
NAT2 polymorphism	Increased risk of bladder cancer	Workers exposed to arylamine and hydrazine

Notification of occupational diseases

Most countries require the statutory notification of occupational diseases to the government. Notification should be done on the suspicion of occupational disease. The notified case is subsequently investigated and confirmed by the relevant government specialists. Either the employer or health practitioner who sees the worker can notify. In many countries, a list of notifiable occupational diseases is available.

Notification serves as an additional means of control of occupational diseases, undertaken by occupational health and safety professionals in the public sector. It initiates a chain of events, which often includes investigation and confirmation of the index case, and active case finding of other affected persons. Recommendations for specific preventive measures at the workplace are then prescribed. The authorities would follow up by ensuring that the recommendations have been implemented. If necessary, further evaluation of the effectiveness of the preventive measures can be made.

Figure 8.5.2 summarizes the continuum of various means of prevention in occupational health practice.

Tertiary prevention

Tertiary prevention activities are largely curative and rehabilitative procedures. Workers should be removed from further exposure, and the appropriate medical treatment given if indicated. Examples of appropriate treatment include the rendering of first aid promptly after an injury, chelation for severe cases heavy metal overexposure, and hyperbaric treatment for cases of compressed air illness.

Planning for emergency response

Occupational health personnel can also assist in planning for disasters in the workplace and community. In addition to consideration of first aid and acute healthcare, other aspects, such as the fire and emergency response services are essential in dealing with disasters at the workplace and that may spill over to affect the community. Planning and practice drills should be done jointly with the relevant local community agencies.

Rehabilitation

Rehabilitation of workers is another important aspect of occupational healthcare. Management, fellow workers, occupational health professionals, and the injured worker have to work together to ensure that suitable alternative duties are provided, and that any work restrictions or physical limitations are understood. There should be clear short- and long-term goals in rehabilitation, and alternative duties should be meaningful and contribute to production (ACOM and ACRM 1987). Sometimes, the use of external rehabilitation resources may be needed.

Workmen's compensation

In many countries, workers who are injured at work, or fall ill from hazardous work exposures are eligible for compensation. Employers who carry out economic activities through labour and machines create an environment that may be likely to cause ill health in the employees. Thus employers should be liable for payment of compensation to workers if they are injured or fall sick because of the work. Legislation concerning employment injury benefits is often called a *Workmen's Compensation Act*. Employers may be required to insure against their liability under the act.

Workers' compensation is a legal system designed to provide income support, medical payments, and rehabilitation payments to workers injured on the job, as well as to provide benefits to survivors of fatally injured workers. Essentially, all industrialized countries and many others have workers' compensation programmes. In some countries, certain categories of workers, e.g. domestic helpers, may be excluded. Other countries may have social insurance to give protection to employment injury victims. The principle of social insurance is that of sharing of risks and pooling financial resources. A social insurance scheme establishes a public channel through a government department or government supervised body, which oversees procedures of screening, determination of award and payment of benefits.

Benefits are payable for temporary incapacity or permanent incapacity, and survivors' benefits for those killed at work. Guidelines for assessment of disability are available in most countries.

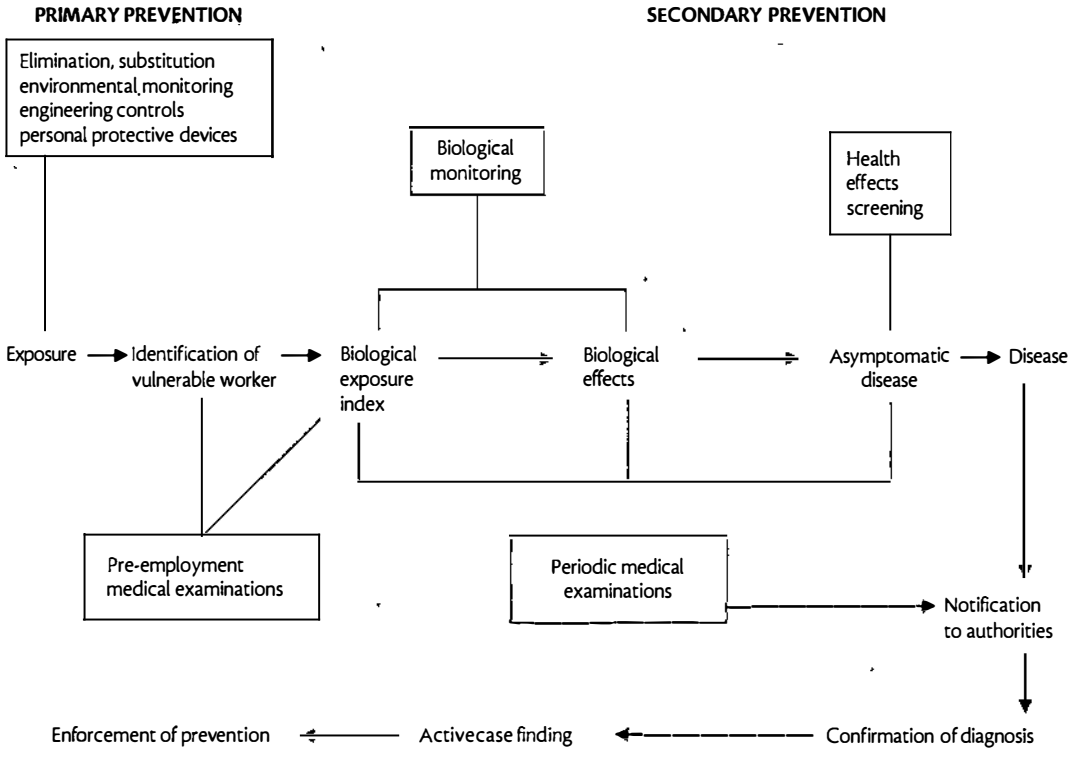

Fig. 8.5.2 Continuum of preventive actions in occupational health practice.

The final assessments for disability are made when the workers' medical condition has stabilized, and not likely to improve or deteriorate further. Besides Workmen's Compensation and social insurance schemes, injured workers can sue their employer through common law and claim benefits. This can be a long process, and the worker has to prove negligence on the part of the employer. In general, workers who have claimed benefits from Workmen's Compensation are not allowed further recourse through this action.

Health promotion at the workplace

Occupational health practitioners have long recognized health promotion to be an integral part of a comprehensive occupational healthcare system (ACOM 1983). However, the definition of what really constitutes 'health promotion' is sometimes unclear, as definitions of health promotion differ consequent to the continual evolution of the basic concept of health.

The WHO defines health promotion in its broadest sense as 'the process of enabling people to increase control over, and to improve their health'. Health promotion is seen as a continuum ranging from the treatment of disease, to the prevention of disease including protection against specific risks, to the promotion of optimal health (WHO 1988).

This definition appears somewhat vague but it does highlight the essence of health promotion. It involves the population as a whole, in the context of their everyday life, rather than focusing on people at risk for specific diseases. Health promotion is the social action dimension of health development, other dimensions being biomedical and technological interventions embodied in public health practice (WHO 1991).

It is a process of activating communities, policy-makers, professionals, and the public for health supportive policies, systems, and ways of living. It is manifested by promoting healthy lifestyles and community action for health, and by creating conditions that make it possible to live a healthy life.

From occupational health to environmental health

The recent growth in interest in environmental health has created a dilemma as to its identity as a speciality in the field of health. The public interest in environmental health was not matched by a well-developed speciality in the health field which could respond to its needs and concerns.

Increasingly, occupational health practice today has evolved to encompass environmental health issues as well. This is because of several reasons. First, many sources of pollution originate from the workplace. Second, in many other instances, the distinction between the work environment, the home environment, and the general environment may not be clearly defined—e.g. in agriculture and small-scale industries, often a clear demarcation does not exist between the workplace and home.

Furthermore, there are several areas of common ground between occupational and environmental health (Jeyaratnam 1994). A comparison of the factors in the work environment influencing the health of the working population (occupational health) and that of the general environment affecting the health of the community (environmental health), is shown in Table 8.5.6. It is evident that there exist several areas of similarity between the work environment and the general environment affecting health.

Occupational health practitioners have the necessary skills in clinical medicine, toxicology, hygiene, epidemiology, and preventive health to position themselves for the management of environmental health concerns.

Table 8.5.6 Comparison of occupational health and environmental health

Occupational health	Environmental health
Hazards in workplace environment	Hazards in community environment
Hazards largely in air	Hazards in air, soil, water, and food
Hazards are physical, chemical, biological, and psychosocial	Hazards are physical, chemical, biological, and psychosocial
Routes of exposure: Inhalation and dermal	Routes of exposure: Ingestion, inhalation, and dermal
Exposure period: 8 h/day for working life	Exposure period: Lifelong
Exposed population: Adults, usually healthy	Exposed population: Children, adults, elderly, and sick persons

Conclusion

Workers suffer a broad range of injuries and illnesses caused by hazards encountered in the workplace. This chapter has traced the history and development of occupational health and its related legislation. In the practice of occupational health, prevention of work-related and occupational disease is a key objective. The priority in prevention of occupational diseases should be to effect primary prevention. When this fails, secondary prevention activities are undertaken to contain damage. However, health protection is not the only occupational health concern. Health promotion in the working population is another important activity. The workplace is an ideal setting for health promotion activities, and appropriate lifestyle interventions can prevent many of the common causes of morbidity in society.

Despite the existence protective legislation in many countries, the burden of injury and illness on workers remains significant. It is essential for medical practitioners and public health programmes to recognize, prevent, and manage work-related injuries and illnesses. There is need for international co-ordination of occupational health protection for workers, given the increasing globalization of the world economy. Several approaches have been proposed to address this issue. For example, there should be harmonization of health, safety, and environmental standards in a way that does not unfairly impose a competitive disadvantage on the newly industrialized nations. Governments and multinational corporations should share the most advanced technologies and resources. Rather than allowing companies to manufacture products banned for use in their own country, governments in developed nations should provide financial incentives for their industries to develop and export safer products and technologies. At a minimum, international systems should be established to ensure complete notification of potential hazards, including labelling the contents of raw materials and products.

Finally, the practice of occupational health today has extended beyond the domain of the workplace, into the general environment. Hence, the term 'occupational and environmental health' might more accurately describe this important aspect of public health.

Key points

- 2.2 million work-related deaths, 270 million occupational accidents, and 170 million work-related illnesses occur annually.
- Workers, who constitute half the world's population, may suffer from occupational diseases, work-related diseases, and general diseases.
- The risks of work may be managed via primary, secondary, or tertiary prevention.
- Health promotion of the workforce is also important.
- Increasingly, occupational health practice has evolved to encompass environmental health issues.

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