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Identification and control of work-related diseases

Report of a
WHO Expert Committee

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CONTROL OF WORK-RELATED DISEASES**

Geneva, 28 November–2 December 1983

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IDENTIFICATION AND CONTROL OF WORK-RELATED DISEASES

Report of a WHO Expert Committee

A WHO Expert Committee on Identification and Control of Work-Related Diseases met in Geneva from 28 November to 2 December 1983. Dr Lu Rushan, Assistant Director-General, opened the meeting on behalf of the Director-General. He pointed out that, although extensive information is available on the principal causative factors in occupational diseases, and on the health effects in man corresponding to different levels of exposure to these factors, much less is known about a number of other health problems affecting working populations. These other problems, referred to in this report as work-related, are associated with certain exposures at work, including physical and mental work-load, adverse psychosocial factors, workers' habits and life-style, individual susceptibility and, in some instances, combined occupational and general environmental exposures. Diseases of multiple etiology, such as those affecting the circulatory, locomotor, and respiratory systems, and a number of behavioural disorders were cited as examples. There is a need for additional epidemiological studies of the degree of work-relatedness of these diseases and for guidelines to be developed for workers' health care programmes aimed at the prevention and control of these diseases.

1. INTRODUCTION

The purpose of occupational health programmes is to protect and promote the health of all employed persons. With industrialization in developing countries, mechanization of agricultural work, and automation of industry in industrialized countries, new types of health problem are appearing. Primary health care is the approach chosen by the Member States of WHO to achieve health for all by the year 2000, an approach which emphasizes equity, self-reliance, and people's involvement in health programmes and is comprehensive in character.

The Director-General, in a number of reports to the World Health Assembly, has pointed out that occupational health is not limited in scope only to preventing and controlling specific occupational diseases. Workers' health programmes should deal with the full relationship between work and the total health of man. The WHO Expert Committee on Environmental and Health Monitoring in Occupational Health (147) stated that occupational health programmes should aim:

(a) "to identify and bring under control at the workplace all chemical, physical, mechanical, biological, and psychosocial agents that are known to be or suspected of being hazardous;

(b) "to ensure that the physical and mental demands imposed on people at work by their respective jobs are properly matched with their individual anatomical, physiological, and psychological capabilities, needs, and limitations;

(c) "to provide effective measures to protect those who are especially vulnerable to adverse working conditions and also to raise their level of resistance;

(d) "to discover and improve work situations that may contribute to the overall ill health of workers in order to ensure that the burden of general illness in different occupational groups is not increased over the community level;

(e) "to educate management and workpeople to fulfil their responsibilities relevant to health protection and promotion;

(f) "to carry out comprehensive in-plant health programmes dealing with man's total health, which will assist public health authorities to raise the level of community health."

The above goals are in line with WHO's policies in this field.

1.1 Work-relatedness of health and disease

In general, work and health interact with one another as follows:

(a) When work is fully adapted to human goals, capacities and limitations, and occupational health hazards are under control, work often plays a role in promoting both physical and mental health: physical work is usually associated with an improvement in physical capacity, while goal achievement and self-realization in work are a source of satisfaction and enhanced self-esteem.

(b) Physical, chemical, and biological occupational hazards, if they exceed tolerable limits, are recognized causative factors of occupational diseases.

(c) The work environment and its characteristics can play a role, together with other risk factors, in the development of diseases having a complex, multiple etiology. Epidemiological investigations have shown that an increased prevalence or risk of "multifactorial diseases", such as hypertension, disorders of the locomotor system, chronic non-specific respiratory diseases, gastric and duodenal ulcers, and a number of behavioural disorders, may be found among certain segments of the working population. Such diseases can therefore appropriately be called work-related. Among the groups concerned, adverse psychosocial factors at work, lack of proper attention to ergonomics in the design of equipment leading, for example, to postural problems during work, mental over- and underload, and a number of other environmental hazards and conditions are increasingly recognized as risk factors. Individual susceptibility related to familial factors, personal health characteristics and habits, also plays an important role in these disorders.

(d) It is also known that general diseases affecting working populations, e.g., communicable diseases, parasitic diseases, and malnutrition in developing countries, may be aggravated by occupational hazards to health.

Thus, in occupational diseases, there is a direct cause-and-effect relationship between hazard and disease. In work-related diseases, in contrast, the work environment and the performance of work contribute significantly, but as one of a number of factors, to the causation of a multifactorial disease. Occupational diseases therefore stand at one end of the spectrum of work-relatedness, where the relationship to specific causative factors at work has been fully established and the factors concerned can be identified, measured, and eventually controlled. At the other end, diseases may have a weak, inconsistent, unclear relationship to working conditions; in the middle of the spectrum there is a possible causal relationship but the strength and magnitude of it may vary.

Preventive interventions and approaches in the work setting have been found, in many instances, to be effective in preventing the occurrence of these diseases or in mitigating their serious pathological consequences.

1.2 Characteristics of occupational and other "work-related" diseases

As far as the difference between occupational and other "work-related" diseases is concerned, the Committee noted that:

(a) Factors in the work environment are predominant and essential in the causation of occupational diseases, e.g., silica dust and silicosis, lead fumes and lead poisoning, but other factors may nevertheless play a varying role in their occurrence. For example, individual susceptibility and age play a role in noise-induced hearing loss. Likewise, the presence of pulmonary tuberculosis among workers exposed to silica dust increases the extent and severity of silicosis.

(b) Occupational diseases, by definition, exclusively affect working people exposed to the specific hazards in question. In some instances, however, manifestations of such diseases may also prevail elsewhere in the community. For example, in the case of endemic byssinosis in an Egyptian village, workers processed flax in their homes and the resulting dust exposure affected their wives and children (38).

(c) "Multifactorial diseases", which may frequently be work-related, also occur among the general population, and working conditions and exposures need not be risk factors in each case of any one disease. However, when such diseases affect the worker, they may be work-related in a number of ways: they may be partially caused by adverse working conditions; they may be aggravated, accelerated or exacerbated by workplace exposures; and they may impair working capacity. It is important to remember that personal characteristics, other environmental and sociocultural factors usually play a role as risk factors for these diseases.

(d) On the other hand, work has beneficial rehabilitative effects on certain pathological conditions, for example in hypertension that is already established and in ischaemic heart disease, provided that the workers concerned are properly placed in jobs suited to their capacities and limitations and that they are encouraged to adopt a healthy life-style.

(e) Finally, multifactorial "work-related" diseases are often more common than occupational diseases and therefore deserve adequate attention by the health service infrastructure, which incorporates the occupational health services. This new concept of work-relatedness is of substantial importance to health care workers in protecting and promoting the health of workers in many occupations.

1.3 Aims of the report

This report considers a wide variety of health problems affecting workers, including diseases that may partly be caused by factors in the work environment and work performance, and aims to provide guidance on the action that can be taken to deal with them and thereby protect workers' health. It also aims to stimulate research in the identification of risk factors in the work environment that have a potential role in the etiology of "multifactorial diseases"; these appear to be recognized among working people more widely now than was the case in the past.

This report does not deal, however, with specific occupational diseases, which have been extensively discussed in the literature, nor does it deal in detail with the aggravation of diseases by adverse working conditions or with the effect of work-related diseases in decreasing productivity. Furthermore, the problems that arise when partial causal relationships between work and disease are considered in workers' compensation proceedings are also outside the scope of the report; only the general role of workers' health programmes in providing information for such proceedings is discussed. Limited information is available on the quantitative partial responsibility of working conditions in the causation of various non-occupational diseases. This question is also more a legal one than one of preventive medicine and should more appropriately be dealt with at a later stage by disciplines other than those represented in this Committee.

The examples cited in this report have been selected by the Committee to illustrate a variety of work-related diseases and widely different types of workplace risk factor. The disorders of public health significance selected by the Committee are as follows: behavioural responses and psychosomatic illness, hypertension, ischaemic heart disease, chronic non-specific respiratory disease, and certain locomotor disorders. The International Agency for Research on Cancer has dealt extensively with the work-relatedness of a number of malignant diseases, and the Committee recommends the IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, and especially Supplement 4 (22), as additional useful sources of information on the relatedness of cancer to various occupational health hazards.

Guidance is provided on epidemiological methods for investigating multifactorial work-related diseases which should be of

value to health personnel undertaking such investigations. The report also describes the role of workers' health programmes in controlling these diseases; greater efforts and probably also different approaches are required, as compared with the classical methods of controlling specific occupational diseases.

2. SOME WORK-RELATED DISEASES OF PUBLIC HEALTH SIGNIFICANCE

2.1 Behavioural responses and psychosomatic illness

2.1.1 Magnitude of the problem

In developing as well as developed countries, both the work and home environments can be major sources of adverse psychosocial factors. The relative importance of such factors in disease causation may vary widely in different population groups, including working populations. Adverse occupational psychosocial factors, however, have become increasingly important. They have been defined as those characteristics of the work environment which pose a threat to the individual (21).

Although a large proportion of workers are known to suffer from the effects of adverse psychosocial factors, individuals differ widely in their responses. Factors predisposing to behavioural responses and psychosomatic illness, as well as others having the opposite effect, can be found in physiological (biological), psychological, and interpersonal characteristics and in the sociocultural environment of individuals. The level of education and presence of social supports are known to play a role. Information is also accumulating on the impact of cognitive and other coping mechanisms (82) and behavioural patterns, e.g., Type A behaviour (49).

A review of studies on occupational stressors and related psychological, physiological and behavioural disorders reveals that serious problems are found among roughly 5-10% of the working population, being higher among the older age groups (54). Moderate stress problems are reported by up to half of the workers in occupations characterized by a large number of "stressors" (23). Diversity in methodology and in the type of population studied makes comparisons extremely difficult.

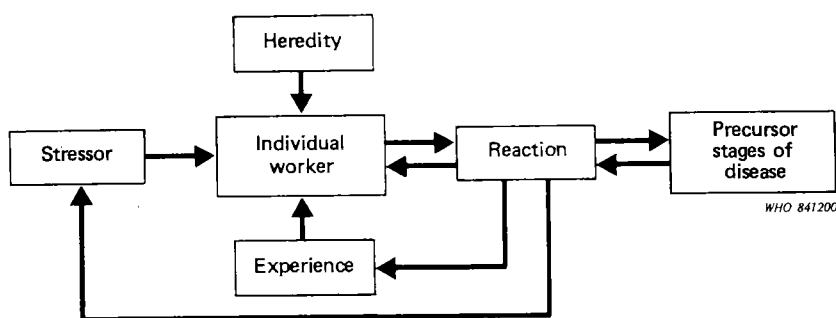
Risk factors involved in the causation of mental disorders and psychosomatic illness include those in the work environment and human characteristics, habits and reactions.

2.1.2 Risk factors for behavioural and psychosomatic disorders

Research in many countries during the past 20 years has produced ample evidence that a relation exists between certain types of working condition and behavioural and psychosomatic disorders among workers, even though the exact sequence of events and all the other contributing factors leading to the development and progression of such disorders have not as yet been fully defined. Factors that seem to predispose groups of workers or individuals to a particular disorder, a class of disorders, or to their clinical manifestations are called risk factors or risk indicators. Causal relationships between risk factors and disease are not always clearly or completely defined, even though it has been shown in some disorders that control of suspected risk factors reduces the risk of disease.

In considering risk factors in behavioural and psychosomatic disease, the Committee found it helpful to modify and apply a model which takes into account the interplay between the psychosocial stressors, the individual and his/her experiences (see Fig. 1).

Fig. 1. Model for conceptualizing impact of psychosocial factors



Environmental psychosocial factors may act directly on one or more body organs or systems or, more commonly, their effects are mediated through psychological processes. The resulting

behavioural reactions may themselves serve to alter the psychosocial environment or, through experience, the individual's response to psychosocial stressors. Reactions to psychosocial stress may also play a role in initiating or promoting the precursor stages of disease, either directly through altering the internal milieu, or indirectly through such behavioural responses as alcohol abuse and cigarette smoking. It should be pointed out that environmental and psychosocial factors can be stress-relieving as well. The individual with good social support who is performing meaningful, manageable and comprehensible work may well react in ways that promote health and ameliorate or delay the precursor stages of disease.

Environmental psychosocial risk factors

(a) *Overload.* Work overload is characterized as being either excessive in quantity (i.e., there is too much to do) or in quality (i.e., the work is too difficult). Various types of behavioural malfunction and perceived symptoms have been associated with work overload (29, 30, 70). A relationship between quantitative overload and cigarette smoking has been suggested. It has been found (48, 92) that overload is associated with such stress-related symptoms as lowered self-esteem, low work motivation and "escapist" alcohol consumption.

(b) *Underload.* Repetitive, routine and insufficiently stimulating work typical of mass production assembly lines and some clerical tasks has been associated with various types of health complaint, physiological disturbance and ill-health (31), and increased absenteeism due to medical causes (51). The effects of underload are often aggravated by a lack of control over the work situation (51). Underload may also be a problem related to the application of modern technologies. The operators in nuclear power plants have been shown to devote most of their time to endless vigilance with high responsibility, rather than to stimulating tasks. Boredom and lack of interest in the job may reduce their effectiveness in emergency situations.

(c) *Shift work.* Shift work is a common occupational stressor which affects biological rhythms, such as body temperature, metabolic rate, blood sugar levels, and mental efficiency and work motivation (117). The principal psychosocial risk to night-shift workers results from the differences in the pattern of time-indicators, such as social contacts and knowledge of time, as compared with normal working hours (118). Disorders resulting from night-shift

work include sleep disturbances, disturbances of appetite and of the gastrointestinal tract, and eventually peptic ulcers (117). However, such disturbances and diseases occur only when night-shift work is combined with factors of personal predisposition and/or additional stressors from other parts of the social environment (117). It is, however, a common complaint among shift workers that opportunities for full social participation are limited.

It should also be recognized, however, that shift work can be organized in such a way as to minimize health risks, and that individuals may be able to adapt to it and tend to select or to abandon long-term shift work spontaneously.

(d) *Migration.* Migration often poses health risks to the migrant worker because of the potential hazards associated with uprooting. Some migrant workers may suffer from malnutrition because they deprive themselves of essential food to save as much as possible of their wages to send to their families in their native countries. Differences in food habits and in religion in new types of working environment are other sociocultural stressors. Migrant workers may also have to adjust to a climate different from that of their countries of origin. Other stressful psychosocial factors among migrants include language barriers, lack of contact with family and fellow countrymen, and sometimes discriminatory employment policies.

(e) *Role in the organization.* Managerial, clerical and professional occupations may be especially prone to occupational stress related to role conflict. A person's role at work has been shown to be a major source of occupational stress when it involves role ambiguity (a lack of clarity about the tasks to be performed) and role conflict, i.e., conflicting job demands (66) and conflicts stemming from organizational boundaries (29). It has been suggested that organizational stressors stemming from role ambiguity and conflict may be associated with a risk of cardiovascular disorders (12, 48, 126).

Correlations between role conflict, ambiguity and job satisfaction are strong, while correlations with mental health measures tend to be weak (70). Personality differences are an important determinant of how an individual reacts to role conflict. Job-related tension is greater among introverts than extroverts (11). Flexible people suffer from a higher level of psychological tension under conditions of conflict than do rigid individuals (48).

Responsibility for people and their safety may constitute an adverse occupational psychosocial factor, e.g., among nuclear power

plant operators, particularly when faced with abnormal situations. Responsibility for people is a potential stressor in policing (79) and among prison personnel (67). Responsibility for people's safety and lives was found to be a major occupational stressor for air-traffic controllers (34), among whom another study (25) found four times the prevalence of hypertension and also more cases of diabetes and peptic ulcer than among control groups composed of second-class airmen.

(f) *Career development.* Stress related to career development is associated with overpromotion, underpromotion, status incongruence, and lack of job security (29). Status congruency, or the degree to which there is job advancement (including pay grade advancement), was found in a large sample of United States Navy employees to be positively related to military effectiveness and negatively related to the incidence of psychiatric disorders (39).

Individual psychosocial risk factors

(a) *Interindividual relationships.* Relationships at work, which include the nature of relationships with, and social support from, colleagues, supervisors and subordinates, have often been shown to be related to job stress (108). Poor relations with members of an organization may be associated with various external factors, e.g., role ambiguity, which in turn produces psychological strain (48). Such strain also occurs among those working in jobs entailing long periods of isolation. On the other hand, it has been found that social support from peers relieved job strain and also conditioned the effects of job stress on cortisone and glucose concentrations in blood, blood pressure, and the number of cigarettes smoked per unit time (21).

(b) *Habits.* Stress is known to cause behavioural changes, which themselves may be contributing factors in causing illness. The use of, and dependence on alcohol, nicotine, and drugs are examples of typical reactions which represent efforts to escape from situations provoking anxiety or other negative psychological effects (86). These "escape" efforts are often preceded by complaints and problems in the social setting, both at work and outside it (51).

2.1.3 *Adverse health effects*

The development of mental and psychosomatic illnesses is preceded by a state characterized by subjective and objective changes

in the individual's mental state and by the malfunction of physiological systems without definite disability or structural damage, e.g., mild anxiety or depressive reactions and mild hypertension or elevation of the cholesterol concentration in the blood. At the social level, it may manifest itself, for example, as a diminution of interest in social activities and problems in interpersonal relations.

Many of these malfunctions improve spontaneously, but if they last long enough or are frequently repeated without adequate recovery periods, the risk of more severe manifestations, e.g., mental disorders, hypertension, peptic ulcer, smoking, over-eating and alcohol abuse, which in themselves can have serious effects on health, may increase. For example, the somatic, psychological, and sociological disorders attributed to migration, which imposes some of the most severe types of stress, include duodenal ulcer, reactive depression, neurotic reactions, personality disturbances and, in extreme cases, psychotic illness.

Mental disorders and mass psychogenic illness. It has been commonly believed that workers of low socioeconomic status and with little education may be prone to psychiatric illness (69). Two large-scale studies on stress and work found that the incidence of ill health was greater among blue-collar workers than white-collar workers (21, 23). Among white-collar professional workers, however, a higher proportion was reported to show nervous strain at work than among skilled, semi-skilled, and unskilled manual workers (23).

Psychogenic disorders are sometimes observed on a wide scale among workers in industrial organizations. The symptoms include, for example, headache, persistent general fatigue, and dizziness and are seen in workers in whom no identifiable pathogen can be found that might directly cause these symptoms. Although individual characteristics may play a role in causation, occupational factors are often thought to be the indirect causes of such abnormal symptoms. Such factors as boredom, physical overload, interpersonal conflicts and production pressures have been suggested (27).

Several "epidemics" of hysteria among workers have been reported, especially from developing countries, in recent years; outbreaks have occurred in Singapore, Thailand, and Malaysia, as well as in other countries (110). The manifestations included violent seizures and states of disturbed consciousness, several workers being

involved in the factories affected. Most of the victims were young female workers (24). A psychological evaluation performed on 25 cases of hysteria showed that the majority came from the lower socioeconomic classes who were living in a rural setting. More than half had timid personalities (75). No physical or chemical causes have been found in these outbreaks, and several theories have been put forward in order to explain them. In general, a build-up of emotional tension was found against a background of poor wages, low job morale, and poor socioeconomic circumstances (111).

Smoking. The smoking of tobacco and smoking-related diseases have spread from country to country and population group to population group as a twentieth century epidemic (149). In both developed and developing countries, about half the adult males are dependent on some form of tobacco use, cigarette smoking being the preferred habit. The frequency of cigarette smoking among adult females has increased during recent years in most industrialized countries. Patterns of cigarette usage among adult females in developing countries are quite variable, but frequency of use has been increasing recently in some of them (152).

Smoking has been shown to be associated with tension and anxiety (94) and to be most frequent among employees who perceive occupational stress (124). In addition, a survey of 200 male administrators, engineers, and scientists showed that an inability to stop smoking was associated with job stress and high levels of quantitative workload (21). Giving up smoking seems to be difficult for those working in stressful environments in which a cigarette may provide a relief from tension (62). In a longitudinal study, occupational stress, habitual cigarette smoking, and coffee drinking were also found to be positively related (28).

The higher morbidity among smokers than among non-smokers may be still further increased by occupation. The combined effect of smoking and other environmental hazards, mainly occupational in nature, has been extensively studied during the past few years. In a large number of studies on occupational morbidity, very significant differences between smokers and non-smokers have been discovered, with occupation and smoking interacting to increase the risk of chronic non-specific respiratory disease, lung cancer, bladder cancer, accidents and absence because of sickness (149).

Alcohol abuse. The alcohol dependence syndrome and alcohol-related problems constitute both a great challenge and an opportunity for the staff of occupational health services in many countries of the world. The alcohol dependence syndrome, commonly referred to as "alcoholism", manifests itself by alterations at the behavioural, subjective, and psychological levels, with an impaired control over the intake of ethanol as a leading symptom. More severe manifestations include impairment of physical, mental, or social functioning, which can result in an alcohol-related disability. Alcohol-related problems may involve the individual drinker, his family, the workplace, and other sections of the community. Alcohol-related health effects include excess mortality, cirrhosis of the liver, certain cancers (especially those of the liver, mouth and oesophagus), cardiovascular disorders (such as hypertension, stroke, and cardiomyopathy), nutritional deficiencies, alcoholic psychosis, damage to the central and peripheral nervous system, accidental injuries, psychopathology in the family, fetal defects and growth abnormalities.

A problem drinker at the workplace is an individual whose consumption of alcohol has reached the point where it interferes with performance and other work-role demands. The impact of alcohol abuse on work performance will vary widely depending on the frequency, the setting, and the level of ethanol ingestion. It is generally accepted that the health and social problems of problem drinkers may be greater in their work than in their daily lives. Alcohol abuse increases illness, diminishes productivity, and increases worksite interpersonal conflicts, leading to poor morale. It has been estimated that in one large industrialized country more than 5% of the labour force suffered from alcoholism, which lowered their productivity by about 25%. Alcoholic employees may have a considerably greater number of days off work for sickness and accidents than controls (10).

Information is limited on the extent of alcohol-related problems in various occupations and on whether persons prone to alcoholism select specific types of work. According to a WHO survey prepared for the Technical Discussions at the Thirty-fifth World Health Assembly, certain occupations, such as those related to the production and sale of alcoholic beverages, and those involving prolonged separation from normal social relationships, (e.g., seamen, the armed forces) seem to be associated with high rates of drinking and alcoholism.

In a study in which over 1500 workers in the United States of America in different occupations were interviewed, a positive relationship was found between escapist drinking and a number of job stressors (92). Those experiencing high job stress drank more than those in occupations where such stress was lower. Investigation of stress in the police force indicated that high levels of stress associated with work can accentuate the tendency of some individuals to turn to heavy drinking as a stress-coping technique (36). Similarly, unemployment was found to be associated with alcoholism and psychosomatic problems in industrial workers (43).

Eating habits. Changes in eating habits, and especially overeating, are commonly observed as a reaction pattern during periods of perceived anxiety. More research would be needed to find out to what extent obesity, which is considered to be a "known biological risk factor" in hypertension and in coronary heart disease, is caused or exacerbated by psychosocial pressures originating in the workplace. Known determinants of obesity include age, sex, socioeconomic status, cultural heritage, and ethnic group (42).

2.1.4 *Psychosocial stress and the immune response*

It is well known that stress reactions can influence the body's homeostatic mechanisms and its resistance to various environmental pathogens. Such reactions can play both causative and aggravating roles of great importance in the etiopathogenesis of work-related diseases. The immune system is an important target system of stress reactions (2, 133). Since the concept of stress was established, corticosteroids have been shown to have profound and complex effects on the human immune system (33). A remarkable similarity has been found between the effects of stress on neurochemical, hormonal, and immunological functions (immunosuppression) (128). However, the precise mechanisms of such interactions have not been determined. Further opportunities to investigate this problem in depth are now available in the light of recent research on neuropeptides, as well as on certain other mediators, including prostaglandins, cyclic nucleotides, etc. (2, 18, 53, 114). Neuroendocrine-immune system interactions can also help in understanding the mechanisms of the immune system's involvement in stress reactions. Up to the present, however, there is a great lack of knowledge in this particular field, and further

investigations should therefore be made into the mechanisms of occupational stress and its influence on the immune response. Further multidisciplinary research, involving occupational health specialists, immunologists, physiologists, and neuro-endocrinologists, will help in solving this problem.

Since the workplace environment may contain various factors (physical, chemical, biological, etc.) that influence the immune system, further research on the immune mechanisms and pathogenesis of work-related diseases is needed.

2.2 Hypertension

2.2.1 Magnitude of the problem

Hypertension is an important disease in both developed and developing countries and a major cause of pathology in vital organ systems such as the heart, brain, and kidneys. It is one of the principal risk factors for the two most important causes of mortality among adults: cardiovascular disease in the form of coronary heart disease and congestive heart failure, and cerebrovascular disease leading to stroke. In the United States of America during a recent year, the incidence of cardiovascular disease in males aged 55–61 years was 161 per 10 000 for those with normal blood pressure and 458 per 10 000 for those with definite hypertension (105).

The National Heart, Lung and Blood Institute of the United States National Institutes of Health estimates, on the basis of a survey conducted in 1971–1974, that 19.5% of employed white males have definite hypertension, defined as a systolic pressure equal to or greater than 160 mmHg (21.3 kPa) and/or a diastolic pressure (fifth phase) equal to or greater than 95 mmHg (12.7 kPa) (105). The age-specific prevalence ranged from 5.8% in the age group 18–24 to 41.8% in men of 65 years and older. The comparable prevalence in employed white females was 13.5%, in employed non-white males 32.4%, and in non-white females 29.8%. Few cases of hypertension can be attributed to endocrine problems, such as adrenal tumour, vascular disease, such as renal artery stenosis, or other specific defects. Most cases are therefore considered “essential”, in that the exact etiological factors and events responsible are not known. There is therefore a need to develop a better understanding of the risk factors for essential hypertension.

2.2.2 Risk factors

The risk factors for essential hypertension have recently been reviewed by a WHO Scientific Group (150) and include increased body weight, high salt intake, and perhaps other dietary factors, high alcohol consumption, physical inactivity, and psychological influences including stress. The evidence for the existence of a relationship between these factors and hypertension varies considerably. The Scientific Group concluded that: (a) genetic factors are important, but specific genetic markers for hypertension have not been firmly established; (b) while it could be expected that avoidance of weight gain may prevent, diminish, or postpone the rise of blood pressure, a mechanism to explain the association between obesity and hypertension should be sought to provide plausible evidence that the association is causal; (c) although questions concerning the association between salt intake and hypertension remain, it appears prudent to reduce salt intake; (d) there is no scientific evidence that low to moderate consumption of alcohol causes sustained blood pressure elevation; (e) more study is needed to confirm the possible long-term pressure-reducing effects of physical training; (f) modification of psychological influences may be important as an approach to the prevention of essential hypertension, although more research is needed to determine whether the psychosocial characteristics of hypertensives do, in fact, play a role (see below). In addition, it was concluded by the Scientific Group that other environmental factors, such as noise, should be given further consideration (9). Other physical or chemical agents, such as vibration (17) and temperature and humidity (74), also require further investigation.

There are a number of methodological problems in documenting an association between hypertension and risk factors, e.g., in the measurement of both the cause and the effect. Blood pressure measurements fluctuate; repeated measurements may be necessary to ensure validity. Psychosocial risk factors, including stress and personality subtype, are sometimes difficult to characterize and to quantify. In addition, other risk factors, such as the demographic characteristics of age, race and sex, and personal habits (e.g., diet and physical activity), as well as the effect of employment policies (e.g., a refusal to employ hypertensives), must be either controlled in the selection of participants and the comparison population or considered in the analysis in the hope of achieving a reasonable

understanding of the strength of any association between hypertension and the particular risk factor concerned. While there are other study design considerations, the final one to be considered here is the "power" of the study, i.e., its ability to detect the association of interest and to show that it really exists. Because the statistical concept of power is largely dependent on sample size, large studies are more powerful. The study of hypertension may be difficult because the researcher is usually attempting to find a modest excess of a disease that is already very prevalent. Except in large studies, the etiological agent must be very strong to increase this excess to a level that is readily detectable.

Although there are methodological difficulties in studying hypertension, it is generally felt that substantial benefit would be derived if the risk factors could be controlled. Primary prevention is preferred because of the problems involved in the treatment of established hypertension, such as the failure, complications, and cost of therapy (150).

2.2.3 Evidence for work-relatedness of psychosocial factors

As far as the evidence for the work-relatedness of psychosocial factors in hypertension is concerned, some investigators have reported that psychosocial stressors can result in increased blood concentrations of adrenaline and noradrenaline (85) as well as cortisol (93), which accentuate the hypertensive effect of excessive salt intake (13).

It is accepted that acute stress causes increases in catecholamines and a transient increase in blood pressure. Whether repeated stress causes sustained hypertension remains a most important question. Some evidence suggests that an association between them does exist. Thus an association between stress and hypertension was demonstrated in a study of air traffic controllers (25). From the data obtained in the course of the mandatory periodic medical examinations for the issue of licences, the point prevalence and incidence of hypertension were determined retrospectively, second-class airmen being used as controls. Both prevalence and incidence were higher among the air traffic controllers, the latter being 5.6 times as great. Moreover, air traffic controllers working in high-traffic-density towers had a prevalence 1.6 times higher than those in low-traffic-density towers. Suggestive excesses were also found for

peptic ulcers and diabetes. These findings were subsequently confirmed by another investigator (47).

The relationship between psychosocial stress and hypertension deserves further investigation in order to discover the particular psychological or physiological factors that place the worker at excess risk and may possibly offer a means of early detection or intervention.

It is particularly important to determine whether short-term stress that causes transient elevation of blood pressure, when repeated chronically, results in sustained hypertension. The Committee agreed that it is possible that occupational psychosocial factors may be an important cause of hypertension but did not feel that the particular circumstances under which causal associations occur, their strength, and the postulated beneficial effects of intervention have been adequately documented.

2.3 Ischaemic heart disease

Major non-hereditary risk factors for ischaemic heart disease include hypertension, smoking and diet. As already mentioned, some data point to a link between psychosocial factors and smoking and obesity. While there is a suspicion that psychosocial factors may also be etiologically related to ischaemic heart disease, the association requires further attention. Some of the studies linking psychosocial factors and ischaemic heart disease are summarized below.

An early study (115) drew attention to the frequent history of holding two jobs or of working overtime for long periods immediately preceding the onset of an acute coronary event in young patients; the association was stronger than with other risk factors.

A twofold difference has been observed in comparing the incidence of ischaemic heart disease among the male personnel of two banks in the same city (72); after a multiple logistic analysis of the "physical" risk factors, the authors were left with the impression that the staff members of the bank with the higher incidence had a tighter daily programme, were in a hurry, and worried.

A two-year follow-up of a questionnaire study of construction workers (134) showed that an index of workload can significantly predict myocardial infarction.

Where the association between ischaemic heart disease and psychosocial factors is suggestive, further research is necessary to clarify this association and identify the mechanisms.

2.4 Chronic non-specific respiratory disease

2.4.1 Background

Chronic non-specific respiratory disease (CNRD) is a general term used to describe the group of conditions in which there is chronic sputum production and/or shortness of breath at rest and/or during exercise. These conditions include chronic bronchitis, emphysema, and bronchial asthma. All of these diseases may be acutely or chronically exacerbated and complicated by respiratory infections. Immunological mechanisms may be involved in some of them. They are undoubtedly diseases of multiple etiology and represent a classic example of disorders that may mainly be occupational in origin or partly work-related, as well as related to the social phenomena of urbanization and industrialization.

In selecting CNRD as an example in this report, the Committee realized that when the risk for these disorders is strongly related to specific occupational exposures, such as dusts and irritants, they may easily be thought of as essentially occupational diseases in workers who are heavily exposed. However, the Committee felt at the same time that this group of diseases may often be only partly causally related to such occupational factors. It is well known that the various conditions designated as CNRD are diseases of multiple etiology, in the causation of which smoking, level of air pollution in the community, individual susceptibility, and repeated respiratory infection all play major roles. When workers are exposed to any of the above risk factors in addition to particulate matter or respiratory irritants at work, even when the workroom air concentrations of such agents are below permissible exposure limits, the prevalence of CNRD may be increased. CNRD may therefore be work-related when the known causal agents in the work environment are not sufficient when acting alone to induce the disorder or to cause the increased prevalence observed, and for this reason has been included among the examples of work-related diseases.

A problem arises in differentiating between occupational diseases caused by workplace dusts (e.g., byssinosis) and CNRD caused by

the same dust. Similarly, chlorine and sulfur dioxide, which in low concentrations may increase CNRD, can in high concentrations cause acute irritation of the upper and lower respiratory tracts, which is then considered to be an occupational disease.

This report is concerned, not with occupational diseases of the lung, but with CNRD when it is related to work exposures. It then differs from well-recognized occupational respiratory diseases in that:

(1) exposure levels may be too low to cause occupational disease consistently, but may still, in combination with other factors, contribute to CNRD;

(2) the part played by individual susceptibility, infections and—mainly—smoking can be so important that the role of dust exposure may be minimal in cases of work-related CNRD; and

(3) in the development of occupational diseases, workplace factors play the decisive role in causation, which may not be the case with CNRD.

2.4.2 *Magnitude of the problem*

It is difficult to estimate the impact of CNRD morbidity and mortality because of intercountry differences in medical traditions, the use of diagnostic facilities, the organization of health services, and diagnostic terminology. In the *Sixth report on the world health situation* (145), it was reported that 2.9% of all deaths reported from 88 countries were due to CNRD.

In the United States of America, these disorders are a primary or contributing cause in about 5% of deaths. Prevalence surveys report that between 12% and 50% of various population groups are affected, depending on age, sex, and definition of the disorder used. A total of 1–1.5 million new cases are diagnosed each year, of whom roughly 35 000 become completely disabled. It has been estimated that over one million men who would otherwise be in the mature segment of the workforce (age 40–60 years) are permanently disabled as a result of CNRD (59).

High morbidity and mortality rates are not confined to developed countries, such as the United Kingdom and the United States of America, comparable rates having been reported from Papua New Guinea, Egypt, and Malaysia. In most countries, age-adjusted and

age-specific mortality rates are higher for men than for women, and death rates increase with age in both sexes. The rate of increase with aging is generally greater among men than in women (59).

2.4.3 *Risk factors*

Air pollution, weather and climate, smoking, socioeconomic status, familial and genetic factors, atopic predisposition (for asthma), bronchial reactivity, childhood respiratory disease, and occupation are among the factors which are important in the etiology and pathogenesis of CNRD. Some of these factors, e.g., climate, weather, and occupation, are responsible for the chronic course of the disease or the aggravation of pre-existing mild disease. Because of the number of factors involved, it is not easy to assess the role of any particular one in the causation of the disease. However, present knowledge indicates that occupational exposures are a factor in certain cases.

The complexity of the problems involved was recognized by the WHO Working Group on Early Detection of Chronic Lung Diseases (37), which concluded that the contribution of general and occupational air pollution to the etiology of CNRD is probably not large in comparison with that of smoking. The Group felt that there was a need for further studies of the frequency and severity of these disorders in occupationally exposed populations. A WHO publication on sulfur oxides and suspended particulate matter (146) gives examples of studies on occupationally exposed groups with respect to the effects of exposure on the respiratory system and concludes that:

“In many of these studies, only the currently employed workers were examined and a serious effort was not made to locate subjects who had left the industry and who may have suffered more from the disease or could have been more sensitive to the materials.”

In view of the above-mentioned difficulties, it is not surprising that various studies have come to different conclusions as to the degree of work-relatedness of CNRD.

2.4.4 *Evidence for work-relatedness*

In 1966, in the United Kingdom, the Medical Research Council (MRC) published a report on the role of occupation in the etiology

of chronic bronchitis with particular reference to coal mining (19). The conclusion reached in the report was that, on the evidence then available, the intensity of dust exposure did not appear to be a very significant factor in determining the prevalence of bronchitis in this group of workers.

Subsequent to the MRC report, a number of studies of coal miners have suggested that chronic bronchitis is more prevalent among dust-exposed workers than in non-exposed groups and may be regarded, at least in part, as a consequence of occupational exposure. Support for this conclusion has been provided by the data published in the United Kingdom by the National Coal Board (103): lifetime dust exposures of 4122 coal-face workers were calculated and the prevalence of bronchitis was found to be associated significantly with increasing exposure to airborne dust in the 25-34 and the 35-44 years age groups. In all age groups, both smoking and the presence of pneumoconiosis were associated with an increased prevalence of bronchitis.

Among former coal miners working in the steel industry, it was found that the age-standardized prevalence of bronchitis for smokers in the 55-64 years age group was about four times higher than for non-smokers who had never worked in coal mines (91).

Furthermore, it has been shown that bronchitis occurred significantly more often in cigarette-smoking gold miners than in cigarette-smoking non-miners from the same community in South Africa (129). This was not true for non-smokers. These findings led to the conclusion that underground exposure requires the co-factor of cigarette smoking to produce bronchitis.

When miners were compared with controls and with controls' and miners' wives, they were found to have an increased morbidity from non-specific pulmonary disease as compared with the other three groups (125). This correlated with the duration of work underground and with the degree of smoking. No difference was found between the wives of miners and those of controls.

In a study carried out in Czechoslovakia in which 3236 workers from 21 different occupations were examined clinically, radiologically, and by spirometry and forced expiratory spiograms, the important influence of the occupational environment in the causation of chronic bronchitis and emphysema was clearly demonstrated (139). The most dangerous situation in this respect was considered to be exposure to dust (whether inert or fibrogenic) combined with variations in thermal environmental factors,

followed by exposure to dust alone, and then by exposure to irritants. It was also concluded that in some instances age and smoking played a more important role.

In a study carried out in Norway, pulp mill workers were compared with paper mill workers, using a standard questionnaire on respiration and simple tests of pulmonary function. The smoking histories of the subjects were also studied. Levels of sulfur dioxide ranged from 6 to 100 mg/m³ (2–36 ppm), with peaks of 290 mg/m³ (100 ppm) when the digester was blown. The exposed group had more cough, sputum and dyspnoea than the unexposed group, but the vital capacities were similar in the two groups. The expiratory peak flows of the exposed men under 50 years of age were lower, however, than those in a comparable unexposed group (127).

Studies in a pulp and paper mill in the United States of America, however, did not support these findings (40) and, in a study of the same type of industry in Finland, it was noted that the effects of smoking were much more significant than exposures at work or the effects of climate (60).

The MRC questionnaire and a number of lung function tests have been used to study the prevalence of non-specific lung diseases among bakers (136). Although the mean airborne dust concentrations were not high, the prevalence of chronic bronchitis was significantly higher both among bakers who were cigarette smokers (45.7%) and among those who were non-smokers (24.2%) than in controls (smokers: 22.7%; non-smokers: 6.0%). Dyspnoea and chest wheezing were also more prevalent in bakers than in controls, irrespective of smoking habits. The ventilatory capacity was reduced significantly in bakers, with or without chronic bronchitis, as compared with controls.

One of the problems requiring field investigation in developing countries is the higher prevalence of chronic bronchitis in some sectors of the community, particularly among those who live in overcrowded homes or those exposed to smoke in baking operations using the different types of fuel available in the various localities. The prevalence of CNRD is likely to be higher among workers who are occupationally exposed to vegetable or other dusts if they live in certain sectors of the community, and the disease may also be aggravated, so that the pathological process is further developed.

It has been found (107) that exposure to domestic smoke pollution caused by wood, biomass fuels, and straw fires used for cooking and heating purposes in ill-ventilated houses in Nepal is

associated with a high prevalence of chronic bronchitis among smokers.

2.5 Locomotor disorders

From the wide variety of locomotor disorders, which are among the most common ailments of people in all age groups, the Committee selected two examples for which evidence of work-relatedness is available, namely "low back pain syndrome" and "shoulder/neck pain syndrome".

2.5.1 *Low back pain*

Magnitude of the problem. Low back pain is a complex symptom of common occurrence in the general population. It affects all age groups, males and females, but has been reported to be more common between the ages of 25 and 64 years than in younger or older age groups (142). Pain in the lumbosacral spine can result from inflammatory, degenerative, neoplastic, traumatic and other disorders. In some instances, it is claimed to be of psychogenic origin (97). The most common type of low back pain, however, is non-specific, of indeterminate pathology, and often associated with posture, the lifting of heavy objects, and injurious movements of occupational or non-occupational origin. Its associated risk factors include congenital back defects, weak musculature, rheumatic predisposition, and degenerative conditions of the spine or intervertebral discs. Low back pain is so common in working populations that it may almost be considered an occupational disease. However, in view of the fact that it is a multifactorial condition that can be associated with non-specific, non-identifiable factors in the general population, it is not always easy to establish its occupational specificity, for example in workmen's compensation claims, even though it is a disability for which compensation is payable in some countries. Low back pain is said to affect "over half of the working population sometime during their active working life" and it is "estimated that 2 to 5 percent of industrial workers experience low back pain each year in Western countries" (131). Although most back pain in workers in industry is non-specific, other cases are specified as: (a) lumbar fatigue with a feeling of a "tight band" across the back; (b) lumbago with sudden intense incapacitating low back pain; and (c) sciatica with pain radiating

from the back into either leg. In all these cases, there is a muscle spasm which may be a result, rather than the cause, of low back pain.

Work-relatedness. The work-relatedness of low back pain is usually associated with ergonomic factors and trauma. The risk of developing low back pain is higher in certain occupations, e.g., those involving heavy manual work, such as dockers or miners, material handlers, and workers with jobs requiring awkward postures or postures that must be sustained for prolonged periods of time, frequent bending and twisting, or exposure to whole-body vibrations. Whole-body vibration was found to result in increased low back pain in farmers driving agricultural machinery, train conductors and truck drivers (155). In comparative studies among heavy industrial workers and those doing sedentary work, 15% of total absenteeism in foundry workers, as compared to 4% in workers in commerce, was attributed to such causes (8).

Awkward postures are common in many industrial tasks, but also in nursing; this applies particularly to bending forwards and handling heavy objects. Postures that must be sustained for long periods of time have also been associated with low back pain. For example, a higher incidence of low back pain has been found in truck drivers and policemen who were required to sit and stand, respectively, for long periods of time than in those who were able to vary their posture repeatedly, even if only briefly (131).

In general, some 80% of cases of back pain clear up with rest and therapy in some 2–3 weeks, but of these, 10–15% may recur within one year (52).

Evidence in support of the multifactorial etiology of back pain continues to increase. Recent reviews of papers published in 1980–1983 show that a multitude of possible etiological factors are under study and that such factors are increasing in number. They include mechanical factors, such as trauma, heavy back load, and vibration, and inflammatory, congenital and psychological factors. Muscular factors, such as increased muscular tension caused by stressful life-styles and muscular imbalance caused by habitual posture defects, merit further attention in research (7).

There is a great need for prospective epidemiological studies and experimental data in order to identify the risk factors for back pain. Problems of job classification need to be resolved and criteria for load carrying developed, as well as improved objective measures for use in the selection of workers and methods of muscular training before and during employment.

2.5.2 *Shoulder and neck pains*

Magnitude of the problem. Shoulder and neck pains have multiple causes; some of these are predisposing factors, others are related to disease processes, and yet others are mainly work-related. As a result of the extreme mobility of the shoulder joint, the complex interactions between muscles and other structures make the shoulder highly vulnerable to disturbances caused by trauma and disease. Frequently, an initial injury will result in secondary reactions, thus making the clinical diagnosis difficult in relation to causative factors. Disorders associated with muscle weakness and general malaise, such as infections (50), may also result in an increased susceptibility to shoulder and neck complaints with loads on the shoulder at work that a worker would be able to tolerate in a normal state of health (15).

A variety of diseases may result in shoulder and neck pain, e.g., inflammatory reactions in the synovial membrane and bursa system and degenerative disorders of the cartilage, ligaments and tendons. In addition, muscular, vascular, and neurological disorders may result in shoulder pains, and there may be referred pain from the chest organs.

However, clinical, laboratory, as well as histopathological and electromyographical examinations do not currently provide a satisfactory basis for determining the cause of many disease states of structures in the shoulder and neck.

In studies of shoulder and neck complaints among industrial workers, undiagnosed inflammatory rheumatic diseases were found in 15% of workers with chronic complaints, and causes related to various other diseases in 35% of workers with acute shoulder complaints (14, 15). From the occupational health standpoint, however, individual predisposing factors, such as age, difficulties of organizing the work task, and inflammatory rheumatic predisposition, play a role in the causation of the disorders of shoulder and neck.

A number of studies have documented the high frequency of shoulder and neck complaints in the population (5) and among industrial workers, in whom figures of over 40% in some industries have been reported (16). The variation between industries in the frequency of shoulder and neck complaints among workers is evidence of the work-relatedness of shoulder and neck complaints.

Work-relatedness of shoulder and neck pain. It has been found that working with the hands above shoulder height was significantly

more frequent in workers with both acute and chronic shoulder and neck complaints and that they worked in this way for longer periods (15). Electromyographic (EMG) investigations of the trapezius and supraspinatus muscles during work showed a high median load and signs of muscle fatigue during work cycles in which the hands were used to perform tasks above shoulder height (16).

EMG signs of muscle fatigue can be demonstrated after only a few minutes when the arm is held at a right angle to the body. However, increased loads on shoulder and neck muscles can also be produced without lifting the arms above shoulder height (80), so that a careful evaluation of each specific working condition is necessary.

Studies of workers engaged in film packaging and loading during a complete working day showed that some had difficulties in distributing loads on the shoulder over time and in taking the short pauses needed to rest the shoulder muscles. These findings emphasize the importance of posture and of fine movements of the hands and forearms when work has to be carried out above shoulder level. Application of ergonomics to improve methods of work reduced shoulder and neck pains—a further proof of work-relatedness. No differences in terms of psychological factors were found in those with shoulder pain as compared with healthy referents (153). On the other hand, inflammatory rheumatic diseases were found in 15% of workers with chronic complaints of shoulder and neck pain (14).

Further investigation is required of the effects of certain occupational exposures in order to identify the precise risk factors involved in shoulder and neck pains.

3. EPIDEMIOLOGICAL STUDY OF MULTIFACTORIAL WORK-RELATED DISEASES

3.1 Introduction

Work-related diseases, because of their multifactorial etiology, constitute a challenging subject for epidemiological study. Although a great deal of effort has been devoted to them, much still remains to be done, and the need for an improvement in study design and measurement methodology is obvious. The creation of a cadre of well trained occupational epidemiologists is the first requirement for improving the quality of epidemiological studies. The active

participation of occupational health personnel can then provide the epidemiologist with pertinent data on work conditions, exposures, baseline health parameters, etc., not easily available otherwise.

The epidemiological study of work-related diseases can take the following forms:

(a) descriptive studies of morbidity patterns in different occupations, work areas or tasks;

(b) etiological investigations where the possible causal influences of work on the occurrence of disease are evaluated, and the occupational share in the multifactorial etiology is then quantified; such investigations also include intervention studies where the effects of preventive measures are evaluated.

Each of these approaches shares problems common to all epidemiological research; problems which stem from the fact that such research, by its very nature, cannot provide experimental evidence that a cause-and-effect relationship is responsible for an observed association between two phenomena. Since there is now an extensive literature on epidemiological research methodology (73, 87, 95, 122), and a new publication on occupational epidemiology is in preparation (68), only some aspects typical of the study of the non-specific manifestations of work-related morbidity will be highlighted here.

3.2 Descriptive studies

Descriptive studies relating morbidity to occupation, work area, task, or a specific exposure can be concerned with anything from "hard" indicators of illness, such as death, to very "soft" indicators, such as non-specific symptoms.

A descriptive mortality study is usually based on mortality registers. The occupational mortality statistics published in the United Kingdom by the Registrar General have been well known for more than 100 years. Such statistics are nowadays reviewed in relation to occupational information from the preceding decennial censuses (46). Direct effects of certain occupations are readily seen, e.g., various dust diseases among miners, foundrymen, potters, and cotton workers, while the influence of occupations on other, more non-specific diseases is less clear because factors outside work, such as social class and smoking habits, may also play a part. However, direct conclusions are usually difficult to draw from such register

studies, firstly because of frequent misclassifications of the occupation, secondly because occupational titles as such are illdefined and their meaning changes over time, and thirdly because only one occupation (the end-occupation) is usually recorded. In addition, the numerator (occupation-specific number of deaths) and the denominator (the working population at risk) are obtained from different sources of information. Hence, register-based mortality studies can only give very crude approximations of truly work-related mortality.

Descriptive studies of work-related diseases utilizing “softer” indicators of disease are usually of an *ad hoc* type, since morbidity registers exist only for certain severe diseases such as stroke, coronary infarction, and cancer.

They are usually carried out in the form of cross-sectional surveys of workers exposed to a certain substance or condition. In general, a reference group is also studied using the same methodology, so that the problems relating to inaccurate occupational classification discussed above are not so crucial in this setting. However, the cross-sectional design of a descriptive study creates other validity problems, the most serious being that those workers unable to tolerate the health effects of a particular type of work will leave it. The more distressing the subjective symptoms caused by the work in question, the greater will be such health-based selection, and this will result in an underestimate of the true prevalence of the disease indicators. The remaining workers can thus be said to represent a “survivor population”. For example, it is unlikely that workers with severe back problems will be found in jobs involving heavy manual work, whatever the reasons for their back pain. Descriptive, cross-sectional studies are therefore of limited value in the study of work-related disease, although they may suggest hypotheses for further study.

3.3 Etiological investigations

Etiological investigations address the question of causality, i.e., they ask the question: does some feature of work indeed cause a disease? Since classical occupational diseases are outside the scope of this report, the issue is whether work is one of the factors involved in the multifactorial causation of a non-specific illness. A second-order question is then that of quantifying the occupational

share of the etiology, or the etiological fraction, of the disease under study.

Self-evidently, the demonstration that the etiology of a multifactorial disease is partly occupational becomes more difficult, the smaller the etiological fraction. The value of the etiological fraction of an occupational exposure in the causation of a disease can be computed from the following formula (98):

$$EF = (RR - 1)/RR$$

where EF = etiological fraction and RR = rate ratio (or relative risk). For example, if there is a fourfold increase in bronchitis in a dusty job as compared with a non-dusty job, then:

$$EF = (4-1)/4 = 3/4 = 75\%$$

i.e., 75% of the bronchitis seen is caused by dust exposure.

In the application of this formula, of course, all other etiological fractions must be equally distributed between the groups, otherwise the rate ratio becomes confounded. However, even so, the etiological fraction can never be generalized; since it is a proportion, its magnitude is influenced by the magnitude of all other factors (98). It also varies from place to place, depending on the exposure intensity. Moreover, the sum of different etiological fractions is often more than 100%, because many causes may not be "sufficient causes", and their effect may thus become manifest only in the presence of other causes. The known synergistic carcinogenic interaction between asbestos exposure and cigarette smoking is a good example of this. Hence it can be said that the lower boundary for the sum of different etiological fractions is 100% whereas the upper boundary can be any figure in excess of 100% (26).

Etiological investigations can also focus on different degrees of morbidity, i.e., everything from mortality to slight symptoms. The selection of a morbidity indicator will, of course, depend on the problem under study. "Hard" indicators, such as death, are more reliable than "soft" indicators, such as subjective symptoms; on the other hand, they are crude and fail to reveal the work-relatedness of a number of diseases, such as low back pain, psychosocial disorders and to a great extent bronchitis. The optimal "hardness" of the indicator must be determined by the nature of the problem.

Occupational mortality is usually—although not ideally—studied, so that the mortality of an exposed cohort of workers is contrasted with that of the age-and-sex-standardized general population. Such studies usually suffer from severe systematic errors

arising from the invalidity of the comparison. The sum of these biases is commonly called "the healthy worker effect". This systematic error has been carefully analysed in several recent publications (58, 96, 141). It is sufficient to state here that its effect is almost invariably negative, because of the fact that being employable at all requires at least some degree of good health. How strong the healthy worker effect is and how it is made up depends on a number of factors, such as the age and sex distribution of the cohort, the length of follow-up, the disease under study, etc., whose strength may be very hard indeed to quantify in any single study. The interpretation of such studies on work-related mortality is difficult, therefore, unless the effect of interest is very marked. Because systematic errors of unknown strength are involved, tests of significance are of limited value and difficult to interpret because they measure random variation only.

Whenever possible, a better reference group than the general population should therefore be used (58, 144), i.e., a well selected reference population, sharing all the relevant aspects of the study group, with the exception of the exposure in question. Comparisons can then be made in a meaningful and valid way and the effects of the exposure of interest can be evaluated and tested statistically. However, it must be admitted that valid reference groups are not always available, or their use may increase the costs of the study to an unacceptable level. Other less ideal designs must then be adopted or the study abandoned.

If available, the mortality of the occupationally active population provides a better comparison than that of the entire general population. Local comparisons are better than national ones, especially where there are geographical differences in the incidence of the disease of interest. However, local reference populations are sometimes not "clean" enough (e.g., when the district is heavily industrialized and polluted), and any excess risk is then masked. If the study group is large, within-cohort comparisons between different exposure categories can improve the study. And should there, after all, be no other choice than the use of national reference data, the first 5 or 10 years of follow-up should preferably be disregarded because this is the period during which the healthy worker effect is most marked (96).

Studies addressing less severe manifestations of disease are usually better designed as far as validity of comparabilities is concerned in that they usually employ an *ad hoc* reference group. But

there are other problems. The selection bias hampering cross-sectional studies has already been mentioned and, in general, such studies must therefore be regarded as descriptive only. However, if the time between exposure and effect is short, etiological conclusions can sometimes also be drawn. For example, a clear relation between exposure to carbon monoxide, either from workroom air, cigarette smoking, or both combined, on the one hand, and symptoms of angina, on the other, has been demonstrated for foundry workers (77). The most plausible explanation is that of a causal, provocative connection. Hybrid studies, in which the exposure data are longitudinal and the effect data cross-sectional, can also sometimes give data that can be interpreted etiologically, but the effect of selection must always be considered. However, the most informative investigations for revealing the work-relatedness of a disease are well-designed longitudinal studies, either cohort studies or case-referent studies, their hybrids, or intervention studies, the last of these being used mainly to demonstrate efficacy of preventive measures. All types of design have been well described (73, 87, 95, 122). It will be sufficient here to stress the importance of securing accurate and detailed exposure data—a requirement that is sometimes neglected even in the best textbooks. Inclusion of an experienced hygienist in the research team whenever the exposure data are not straightforward, and especially in case-referent studies, is therefore recommended. In other respects, the main principles of the epidemiological study of work-related disease do not differ from those of epidemiological research in general, although specific features exist, of course, for each problem area. This review will therefore focus on a few features specifically related to the study of three of the model disease systems considered in section 2, namely behavioural responses, locomotor disorders and chronic non-specific respiratory disease. These disease categories have in common the fact that they influence mortality little, if at all, and hence indicators of effect “softer” than causes of death have to be employed.

3.4 Specific problems in the study of selected work-related diseases

3.4.1 Behavioural responses and psychosomatic illness

In principle, behavioural responses can be studied by means of the cross-sectional, longitudinal, or intervention approaches.

However, in practice, such studies have so far usually been cross-sectional and have relied mainly on the use of interviews and questionnaires, i.e., the “softest” of methods. These techniques yield valid results only in the hands of skilled and experienced researchers, but they appear to be so simple and uncomplicated that there is a danger that they will also be used by those without the necessary skills. Most situations giving rise to behavioural and psychosomatic symptomatology, such as overt aggressiveness, depression, insomnia, or psychosomatic diseases, such as hypertension or peptic ulcer, involve significant degrees of respondent bias and situational conflict, so that overt, rather than subtle manifestations of illness and adverse psychosocial stressors are the main sources of information. This has much to do with the need to assess the total situation of the individual, and to take both constitutional and environmental factors into consideration. In addition, certain adverse occupational psychosocial stressors, such as social interactions, are not objectively measurable at all. However, when objective measurement is possible, it should be combined with the questionnaire/interview approach. For example, factors such as work overload, understimulation, repetitive tasks, lack of control over the work situation, etc., can be measured, but the most pertinent information is that which shows how the subject perceives himself in relation to the work situation.

The choice of a valid reference group is difficult in all epidemiological research, but especially so in psychosocial epidemiology, where a very large number of background variables outside the work situation must be accounted for or controlled. Many unpredictable social changes in human life may affect the study and reference groups in different ways, and the changes may distort an initially sound comparison, especially in a longitudinal design. From a practical viewpoint it may be impossible to collect all the relevant background data before the groups are formed, so that controlling any intervening and confounding factors then becomes a problem for the data analysis stage, and detailed information is required on such factors.

Selection, which is likewise a common problem in ensuring epidemiological validity, is particularly difficult in psychosocial studies. Most people probably choose their occupation at least in part on psychological grounds, with factors such as motivation, personality, and initial intellectual or psychomotor capacity playing some role. These are likely to be far more important than

health-based selection into an occupation or job. In the same way selection out of a job often depends on psychological factors, although the importance of medical aspects is now likely to be greater. Finding a reference group in which the initial forces of selection into the job, the relevant job characteristics, and the forces determining selection out of it are all similar can often prove to be an impossible task.

The use of intra-individual comparisons overcomes some of these difficulties, but this approach requires a longitudinal follow-up design, with or without an intervention. However, restricting the comparison to a before-and-after evaluation introduces other biases, and a reference group is therefore usually required in addition. Longitudinal studies, although also affected by uncontrollable bias, certainly give more reliable data than cross-sectional ones, but the costs can easily become formidable because of the requirement for repeated measurements of a great number of variables, loss of material due to drop-out, etc. Cost therefore often restricts the use of such a design.

3.4.2 *Chronic non-specific respiratory disease*

Many occupational exposures affecting the respiratory system cause distinct subjective symptoms, whether allergic rhinitis, unproductive cough, chest tightness, or bronchitis. This leads to a marked health-based selection out of the job, the remaining workers representing a "survivor population", as already pointed out. That such selection occurs has been realized intuitively by practitioners for many years, and some scientific studies have recently demonstrated that it does indeed take place (77). Workers with allergic or chronic obstructive lung disease, in particular, tend to move out of jobs involving exposures to dusts or irritants, and some of them may even end up in the reference group of a study. Furthermore, factory physicians have for long restricted the recruitment of atopics or those with chronic obstructive lung disease for such jobs. Because of such problems, any cross-sectional study of work-related lung diseases tends to yield a marked underestimate of the true prevalence.

Such health-based selection is not a problem in cross-sectional studies alone; longitudinal studies suffer from the same bias. Preplacement examinations, if successful, result in a healthier-than-normal exposed group, and selective turnover out of the job leads

to reduced exposure times for those most readily affected by subjective symptoms. Many study protocols require a minimum exposure time in order to increase the effectiveness of the investigation, and early drop-outs will therefore not be classified as exposed. Later drop-outs, who have satisfied the minimum exposure requirement, pose another type of problem. It is true that they can be found if the tracing procedure is efficient, but they will have experienced less exposure than the "survivor population", and they may at least have partially recovered from the initial symptoms. This can severely distort the perceived exposure-response relationship.

The effect indicators used for the study of respiratory work-related diseases usually comprise symptom questionnaires (or interviews), lung function tests, X-ray examinations and in some instances immunological tests. All pose problems.

Questionnaires and interviews must be well validated and standardized to be reliable. Both their specificity and sensitivity must be known. One example of a validated method is the Epidemiology Standardization Project (41). Another is the MRC's bronchitis form, which has been widely used in epidemiological studies. However, few researchers realize that this form was originally validated as an interview, not as a self-administered questionnaire. It was also validated in a country with an exceptionally high prevalence of chronic bronchitis. Furthermore, the original form was in English, but has later been translated into several other languages. All these circumstances have changed the original situation so that it is highly questionable whether a translated version, used as a self-administered questionnaire in a country with little bronchitis, fulfils the criteria for validity any longer. In developing countries with a high illiteracy rate, questionnaires cannot be used at all; and whenever many languages are spoken, interviews are difficult.

Another unsolved problem is the extent to which other disorders e.g., farmer's lung or asthma, can be studied safely by means of questionnaires. A clinical diagnosis will always require additional information such as lung function tests and immunological examinations, so that the value of unvalidated questionnaires as the only source of information in prevalence studies of clinical entities is doubtful. Finally, some disorders overlap, as in the case of asthma, emphysema, and chronic bronchitis, which are grouped together as chronic non-specific respiratory disease.

Whenever lung function tests are used, it is extremely important to consider exactly what each specific test measures. Little useful

information can be gained from tests measuring obstruction in the greater airways (e.g., the forced expiratory volume in one second (FEV_{1.0}) and the forced vital capacity (FVC)) when the condition under study is mainly a restrictive lung disorder, e.g., fibrosis. In such instances, the emphasis should be on tests measuring diffusion, even though they may be more complicated in field use. Another problem is that the reference values generally used for lung function tests may be quite unsuitable for the group under study. Thus reference values rarely differentiate between smokers and non-smokers, although separate values for these groups are needed. The ideal approach is to use an *ad hoc* reference group, but this may not always be feasible since the costs of the study may then increase to such an extent that the resources available to the researcher are no longer adequate.

Successful measurements of lung function require simple, standardized, and repeatable tests. The cooperation of the subject is crucial in many of the tests usually employed. There is also great interobserver variability, so that it is recommended that the same technician should perform all the tests. If this is not possible (e.g., because the study is too large), the interobserver error must be measured and care must be taken to ensure that each of the technicians examines the same proportion of exposed and reference subjects, even of different subcategories of the exposed group, otherwise the observations will be subject to asymmetrical inaccuracy and may therefore be seriously biased.

The use of radiological examinations is also complicated by inter- and intraobserver errors. Without being perfect, the most recent ILO classification (64) is the best method available for assessing fibrosis, and should therefore be employed whenever possible. There should preferably be several different readers, who should be "blinded" both with regard to the exposure status of the subject and to the time sequence of serial radiographs. The inter- and intraobserver errors should be measured and reported.

Another difficult question is how to secure a valid baseline measurement for longitudinal studies. Researchers usually start with a cross-section of currently employed workers who represent a "survivor population", but who none the less probably already have some decrement of function as compared with their own (unknown) values before exposure was commenced. This is certainly not the ideal approach, although often the only practicable one. The ideal method would be to use a pre-employment examination as the

baseline. This examination would require better than usual standardization and quality control of the routine lung function test employed or an *ad hoc* programme. Serial examinations, combined with tracing of drop-outs (they should at least be asked why they left) would then give more reliable data than the commonly used approach just described. For example, much of the confusion regarding the effects of exposure to isocyanates (1, 20, 109) could probably have been avoided had the research strategy been better standardized and similar in all studies.

No study on occupational respiratory disorders can be valid if smoking is not accounted for. This requires first of all detailed data on past and current smoking habits. The next step is to consider how to secure great enough contrasts between subcategories. For example, it may be cost-efficient to focus on heavy smokers and non-smokers and to leave out moderate smokers and ex-smokers. Such a procedure, however, requires advance knowledge of smoking status. This information can sometimes be obtained from plant health records, but in other instances does not become available until the time of the examination. The requirement that an allowance must be made for smoking habits almost always makes the use of an *ad hoc* reference group necessary, since clinical reference values do not exist specifically for different smoking categories. Sometimes the most important information comes from comparisons between heavy smokers, because the exposure under study and smoking may act synergistically. In other instances it may be that the effect of smoking upon a particular parameter (e.g., the closing volume) is so overwhelming that the occupational etiological fraction cannot be determined. Comparisons of non-smokers then yield the best information. How ex-smokers should be classified is always a problem. They can sometimes be classified as non-smokers (provided that some time, e.g., a year or two, has elapsed since they stopped smoking), but in other cases the effect of smoking is less easily reversed. If the number of subjects in the study is sufficiently large, ex-smokers should perhaps be left out completely.

In general, more studies on work-related occupational respiratory diseases are needed. In contrast to some of the problems encountered in the study of certain other organ systems, especially the locomotor system, and psychosocial disorders, most of the difficulties characterizing the epidemiological study of respiratory disorders are not hopeless but can be overcome by refining and standardizing study design and measurement methods.

3.4.3 *Locomotor disorders*

The study of locomotor disorders, and especially of low back pain, is also associated with a number of difficult problems. Because low back pain is indeed painful, it causes a highly selective turnover in work that makes demands on the spine, such as heavy physical work, tasks involving bending and stooping or significant static loading, and exposure to whole-body vibration. Such selection invalidates most or all cross-sectional study designs, especially because less demanding tasks, often used for contrast, do not exert any such selective effects. Hence, in a cross-sectional study, mere selection (and the lack of it or selection in an opposite direction in the reference group engaged in light work) can lead to the total masking of work-related low back pain or even to an apparent absence of this effect. It is true that many authors, in spite of this, have indeed found an exceptionally high frequency of low back pain in demanding tasks, but such findings must reflect "endurable" disorders, not the more severe manifestations and especially not those leading to incapacity.

Selection is also a problem in longitudinal studies since it flattens the exposure-response curve in the sense that those with the worst manifestations often leave their jobs too early to be classified as "heavily" exposed or exposed for long periods. From a practical viewpoint, a high turnover also leads to difficulties in tracing all members of the study population. Furthermore, even if the tracing is successful, some of the low back pain patients improve when engaged in less demanding tasks, and therefore formerly exposed and ill subjects may not always be correctly classified. Finally, causation, on the one hand, and aggravation, on the other, are often very difficult or impossible to differentiate from each other, both in the general population and in the occupational setting.

Another type of problem arises from difficulties in assessing a life-long history of "exposure". In real life, the "exposure" of the back to various traumas, strains and stresses usually takes place over a very long period and is highly diversified. Standardized "exposure" ratings have not been developed and, even if they existed, the subjects' memory would probably not be accurate enough to provide a life history of "exposures". While some "exposures", such as trauma, may cause immediate effects (trauma can, of course, also initiate effects that develop later), others, such as whole-body vibration, may have effects occurring only after a long latency

period. With other "exposures", such as lifting, there may or may not be latency periods before chronic low back pain results. Often there are combinations of different "exposures" and, to complicate matters even more, occupational "exposures" are frequently confounded by leisure time "exposures", such as sports injuries and strain caused by gardening. In addition, both work and leisure, and especially the latter if it involves physical activity, can have beneficial effects. This complicated pattern renders assessment of occupational "exposure" a hard task.

The "effect" side also presents problems. Low back pain encompasses a variety of different disorders rather than a single entity (102). The etiology of a prolapsed lumbar disc may be quite different from that of other causes of low back pain, such as spondylosis, muscle spasms, or inflammatory processes. The diagnostic procedures necessary to identify each individual condition are complicated even in clinical examinations of single patients, not to speak of epidemiological series comprising hundreds or thousands of subjects. A further serious problem is the lack of good parameters for quantitatively measuring a condition. For example, in osteoarthritis mobility measurements, X-ray examination, and subjective symptoms are often not well correlated and may be in conflict to a surprising degree. This has been demonstrated in an experimental study on rabbits (138): while the X-ray findings showed steady deterioration, neither mobility nor the macroscopic anatomical findings always followed the same course. The back is even more difficult to assess than the limbs because its various disorders cannot be easily differentiated. For example, in one study (71) it was found impossible to classify more than 60% of a series of 404 patients with chronic back pain. Conditions associated with chronic pain are, furthermore, known to affect the psyche, which introduces more problems. Follow-up studies require simple and reliable tests, not only for discriminating between the various syndromes causing low back pain, but also for providing repeatable assessments of the back's condition. Such tests do not exist. Ethical considerations often prevent the use of certain examinations, e.g., X-ray examinations in the clinically symptomless subject. In case-referent studies, where the number of patients is far smaller, more elaborate examinations can be used, and ethical restrictions are less worrisome because "cases" are ill. On the other hand, in follow-up studies, it is usually not possible to devote more than 10–15 minutes to each subject, and all tests must be completely safe.

Finally, there are important constitutional differences between subjects, including: (a) macro-anatomical features, such as the size of the spinal canal and the differential length of the legs; (b) biochemical differences between the different collagens—there are about 120 different types of collagen; (c) great variation in natural motor skills between individuals; (d) variation in muscular strength (the effects of this variation may be either beneficial or harmful because very strong muscles may expose the lumbar column to excessive strain); and (e) variation in psychological factors, such as risk-taking and neuroticism. These factors, alone or together, often result in variations whose effect can be much greater than that of the occupational factors under study.

3.5 Analysis of data

The analysis of the data obtained from a study of work-related disease does not differ fundamentally from that used in other epidemiological studies and is discussed in, for instance, a publication being prepared by the WHO Regional Office for Europe (68). However, the use of many “soft” variables, especially in psychosocial epidemiology, and the requirement that a number of background variables must be included in order to control confounding almost always renders the use of multivariate analysis necessary. Several sophisticated methods exist, but it is important to remember that not even the most sophisticated analysis can eliminate errors or omissions caused by inadequacies in the collection of data. The collection of data that are unbiased and detailed enough on exposure, effects, and confoundees, must therefore be the foundation of epidemiological research both on work-related diseases and on other problems. The inclusion of an experienced statistician in the research team at the planning stage is essential.

4. ROLE OF WORKERS' HEALTH PROGRAMMES IN THE PREVENTION AND CONTROL OF WORK-RELATED DISEASES

4.1 Background

Because of the multifactorial origin of work-related diseases, their prevention and control must involve the multidisciplinary health

care delivery system as a whole. Nevertheless, workers' health programmes and public health services with a major responsibility in occupational health, have a central role to play in the control of such diseases. One group of tasks for the occupational health services involves making other parts of the health care delivery system fully aware of the interactions between work performance, the workplace environment, other environmental factors, and health. A second group of tasks relates to identifying the most appropriate activities for workers' health programmes in the prevention and control of work-related diseases and ensuring that such activities are coordinated with those of other parts of the health care infrastructure and multidisciplinary health care delivery system.

It is well recognized that the provision of an adequate workers' health programme for agriculture and for small-scale industries employing only small numbers of workers is, as yet, an unsolved problem in many countries. It is hoped that occupational health services can be successfully provided in such cases through the primary health care delivery system. Since many work-related diseases are also of major concern in the context of primary health care and since primary prevention is a major concern of both types of service, it would seem reasonable and appropriate that workers' health services delivered through the primary health care delivery mechanisms, e.g., health centres in rural and suburban areas, should have as their goal the prevention and control of both well recognized occupational diseases and other work-related diseases. Large-scale industries usually possess an organized health care unit capable of undertaking effective protection and promotion measures for workers' health. Experience gained in the workplace may also make important contributions to broad-based national programmes for the prevention and control of chronic diseases and other disorders which can be classified as work-related. Workplace-based efforts to prevent and control diseases need not be the responsibility solely of workers' health programmes. Occupational health services planning or conducting workplace-based prevention and control programmes for work-related diseases will, in most cases, find cooperation and coordination with other parts of the multidisciplinary health care delivery system both necessary and advantageous. Collaboration between workers' health programmes and other parts of the health care delivery system in the treatment and rehabilitation of recognized occupational diseases can be expanded to encompass

other work-related disorders. In such situations, it is desirable that all concerned should understand the concept of work-relatedness and its implications for prevention, control, treatment, rehabilitation, and compensation.

The more direct role of occupational health services in the prevention and control of work-related diseases encompasses familiar tasks and others that are not so familiar. Workers' health programmes need to identify and control, by means of engineering changes, improvements in work practices, and the use of personal protective equipment, the physical, chemical, and biological factors in the workplace environment which may causally contribute to work-related diseases. Occupational health professionals have a major responsibility in optimizing the psychosocial conditions under which work is carried out, and especially in helping to ensure cooperative, supportive, interpersonal human relationships at work because, as already pointed out in this report (see section 2.1), psychosocial factors are important in the development or progression of work-related diseases. Priority should be given to the planning of work as a positive force for the promotion of social, psychological, and physical well-being, with particular emphasis on the full involvement and participation of workers, together with management, in decision-making and, where necessary, in redesigning work systems. Workers' health services—for migrant workers, in particular—need to devote substantial attention to psychosocial factors. It is also important that greater consideration should be given to the ergonomic aspects of industrial hygiene practice in the prevention and control of work-related musculoskeletal disorders by redesigning tools and work stations and by improving methods of work. Workers' health programmes will also need to continue efforts directed towards protecting the community, including workers and their families, through appropriate programmes for immunization against communicable diseases and through the identification and control of discharges that are major contributors to air, water, and land pollution by chemical, physical, or biological contaminants.

In achieving and maintaining good health, it is essential for workers, management, and occupational health professionals to promote activities and attitudes that improve the capacity of the workforce, both as individuals and as a group, to cope successfully with ubiquitous workplace psychosocial stressors. While every effort should be made to eliminate such stressors through improved work

organization and work practices, such efforts will be only partially successful; as the demands and activities of the workplace change, whether predictably or otherwise, well developed coping skills will be needed by workers to protect their health. It should be recalled that success in meeting demanding work challenges can be a positive factor in mental health. Coping behaviour is promoted when work is meaningful, manageable, and comprehensible to the workforce. Coping capacity is enhanced when workers' health programmes help to improve the working environment. Giving workers the greatest possible influence over their own work situations and structuring an effective interchange of opinions and ideas among workers and management promotes coping capacities. Management programmes that assist employees and their families to resolve problems not related directly to work are thought to help to maintain the ability of the workforce to cope with worksite problems; this may also be true of physical fitness and relaxation programmes.

Occupational health services have for the most part recommended or established systems for promoting basic sanitation and good work practices, environmental monitoring in the workplace, preplacement health assessments, health surveillance (including medical examinations), and the reporting of early symptoms. The need for early detection of health impairment in occupational disease has already been emphasized (148). Health surveillance and environmental monitoring systems will have to be refined so as to provide the additional information needed for the prevention and control of work-related diseases. Maintenance of health and exposure records, now required in many countries for occupational disease control programmes, also provides an opportunity for research studies dealing with work-related diseases. Moreover, long-term maintenance of health and employment records provides an opportunity to assess the efficacy and cost effectiveness of workplace-based prevention and control programmes for work-related diseases.

4.2 Workers' compensation

The main objectives of workers' health services are the prevention and control of occupational and other work-related diseases. Control of psychosocial, chemical, physical, and biological hazards at the worksite, together with appropriate job structuring and worker placement, are directed towards minimizing the need for

workers' health programmes to concern themselves with questions of compensation. Nevertheless, work-related diseases remain a major consideration in workers' compensation systems.

The concept of work-relatedness may assume a different meaning when used by health professionals, who are primarily interested in prevention and control, from that assigned to it by the legal authorities, who may be more concerned with questions of compensation and liability. Work-relatedness is thus both a medical and a legal concept. The definition of work-relatedness employed in this report is not the same as that used by administrative bodies responsible for the compensation of workers who become ill or are injured. The definitions, regulations, and mechanisms utilized in connection with the compensation of sick or injured workers vary from country to country and at times from one administrative subdivision to another in a single country. It should be emphasized that workers' health programmes have a major role in the diagnosis of work-related diseases, the assessment of the degree of impairment and disability, and the appraisal of the evidence linking job conditions and exposure to effects on health and the course of disease. Even when health problems are clearly related to the workplace, the degree of causation attributable to work may be difficult to establish.

4.2.1 Medical evaluation of workers

Workers' health programmes and physicians with other responsibilities in the system designed to assess work-relatedness, disability, and impairment have several basic functions. It is important to make sure that a complete occupational history is available. This history should deal with all the jobs held by the patient during his working lifetime. Work organization and methods, exposures to physical, chemical, and biological agents, the availability and use of protective equipment, the use of technical methods to reduce exposure, and length of employment are all important considerations. A thorough family, personal, and medical history is also required, special attention being paid to recreational activities, personal habits, such as alcohol and tobacco usage, nutritional factors, the presence of chronic disease, and the use of medicines. A careful physical examination including appropriate functional testing, clinical procedures, and laboratory examinations

complete the examination of the patient. Functional testing and clinical laboratory examination procedures will vary according to the medical condition and the job history of the person concerned. Determination of specific functional capabilities, i.e., determination of impairment, is usually the primary function of the physician in disability evaluation. He is also usually involved in determining whether certain types of work can be performed by an individual who has specific functional capabilities, i.e., the determination of disability. Standards of impairment, such as the guides published by the American Medical Association (6) and standards of disability established by administrative bodies, such as social security organizations, facilitate administrative procedures for dealing with impairment and disability.

4.2.2 Establishing the role of workplace factors in disease causation

The occupational physician should blend clinical concepts and epidemiological approaches with prudence in examining the causation of diseases associated with workplace conditions. Clinically, most physicians learn to accept a great deal of medical knowledge that has not been subjected to careful scrutiny by the use of randomized clinical trials and other up-to-date scientific techniques. Many judgements are made on the basis of accepted medical practice and any available ancillary information regarding toxicity and exposure, since it is not possible or feasible to find an answer to every question by means of rigorous scientific study. Sometimes this knowledge is in the form of a consensus which can be applied to groups of workers. At other times similar clinical reasoning is applied to decisions regarding possible health risks relating to the job placement of an individual worker. Clusters of cases of a rare disorder related to occupational factors have most frequently been recognized by alert clinicians. When considering whether or not workplace factors not previously recognized as causing disease may in fact be responsible, the occupational physician often adopts an epidemiological approach. The contribution of occupational factors to the development and course of more commonly encountered diseases can usually be discerned only after epidemiological study. Even then, it is well recognized that occupational factors associated with disease need not be causal in themselves. In establishing cause, the design of the study, the

strength of the association, temporal relationships, exposure-response relationships, reversibility, consistency, biological plausibility and agreement with known facts should all be considered.

Occupational diseases are legally defined by governments for the purposes of worker's compensation. In general, an occupational disease is defined as a disorder arising out of, and in the course of employment, but there are many differences in such legal definitions. The ordinary diseases met with in daily life do not usually constitute grounds for compensation. Diseases which are peculiar to some type of work, or which arise as a consequence of a sudden unforeseen event, or as a complication of injury are usually classed as occupational. Some, but not all, countries depend heavily on a schedule of occupational diseases, such as that developed by the International Labour Organisation (63).

Questions relating to disease causality may be important in legal proceedings involving workers' compensation, negligence or product liability, depending on the administrative mechanisms that have been established to deal with these issues. The National Institute for Occupational Safety and Health (NIOSH) of the United States of America has suggested the following six-step approach to decision-making in determining the work-relatedness of diseases (79):

- consideration of evidence of disease;
- consideration of any available epidemiological data;
- consideration of evidence relating to exposure;
- evaluating validity of testimony made available;
- consideration of other relevant factors including other non-occupational causal and aggravating factors; and
- evaluation and conclusion.

Occupational health professionals have not always been satisfied with the way that the existing system deals with the work-relatedness of diseases. Among the problems identified are complexity, lack of consistency, and long delays before a determination of work-relatedness is made. Other major stumbling blocks impeding the development of a broad-based programme for the early identification and control of work-related diseases include the following:

- neither workers nor management are always aware of the presence of potentially hazardous materials or conditions in the workplace;

—existing health insurance plans may not pay for medical programmes intended to prevent, identify and control work-related diseases.

It would seem more reasonable for the emphasis to be placed, not on compensation, but rather on efforts aimed at the integration of early identification and control of work-related diseases into a lifelong personal health advancement programme, with a view to enhancing the health and productivity of workers, preventing or delaying the onset of common chronic disorders, and containing health care costs.

4.3 Control of work-related diseases

The workplace provides an opportunity to identify groups who are thought, on the basis of known risk factors, to be at increased risk for a number of work-related diseases, including major cardiovascular diseases, chronic respiratory conditions, alcohol abuse, and locomotor disorders.

4.3.1 Health education and workers' participation

The nature of health surveillance and worker education programmes carried out by workers' health services has in the past for the most part been determined by industrial policy, governmental regulation, or the special physical and mental requirements of particular jobs. In large industries, workplace-based health protection programmes and health education programmes directed towards the prevention and control of work-related diseases require full worker participation and have somewhat different purposes. In small industries and in agriculture, the health centres are responsible for workers' health education.

In a recently published report, the WHO Expert Committee on New Approaches to Health Education in Primary Health Care (151) emphasized the need for a change of attitude by health care providers towards the people they serve; instead of the old-fashioned "paternalistic" approach to health education, stress is now laid on the development of an effective partnership with the people. The report states that "the people need to understand the problems and to cooperate fully in finding a solution, together with the health care providers, in order for health care to have an impact on the health situation". In the context of occupational health, such an approach

will ensure full participation of workers in health care programmes aimed at them. Moreover, it will motivate them to take more interest in their own health care and to adopt more healthy life-styles. The Expert Committee also points out that the purpose of health education is not just to provide health knowledge, but also to seek political and social backing for health and health care programmes (151).

Health promotion and employee assistance programmes in the workplace need to be consistent with the approach described above. The purposes of such programmes include promoting workers' health and enhancing the quality of life for the worker. Advantages to the enterprise include increased productivity, reduced absenteeism, reduction of worker turnover and training costs, and of health care costs attributed to work-related disorders, as well as the prevention, early detection, and effective treatment of selected diseases, particularly chronic diseases and off-the-job accidents (55, 154).

4.3.2 *Health promotion programmes*

Health promotion programmes should be based upon a set of realistic, meaningful, and measurable objectives for a defined population, such as employees of an enterprise or groups of workers and their families. In the choice of preventive goals, the emphasis should be on work-related diseases selected according to criteria that take into account prevalence and severity, and the ability to prevent and detect disease and favourably and significantly to modify its course by treatment once it has been detected. Health promotion programmes may be thought of as including employee assistance services for dealing with mental health problems, home health-aid needs, alcohol and drug abuse problems, and family and marriage problems. Health promotion activities are also designed to achieve physical fitness through regular exercise, management of stress, cessation of smoking, home and driving safety measures, breast self-examination, cytological examination of cervical smears, and nutrition education. Health screening and examination activities in workplace-based health promotion programmes require full worker involvement in planning and execution. Such activities might include the taking of a medical and personal history, blood pressure measurement, vision and hearing testing, appropriate assessments of the cardiovascular, respiratory, and musculoskeletal systems, examination for evidence of excessive stress, alcohol abuse or

emotional illness, and appropriate laboratory examinations, such as tests for lipid abnormalities, hyperglycaemia, occult blood in the stool, anaemia, and endemic parasitic diseases of public health significance.

Health promotion programmes at the workplace should be seen as valuable by workers and families with different needs and problems. Effective individualized programmes need to take cognizance of the workplace situation, life goals, life-styles, and individual health problems and preferences. Such programmes should be flexible enough to accommodate the needs of individuals within groups of employees and be able to address different problems in different locations or in worker groups differing substantially in personal or worksite attributes. Prevention should begin with children and with young employees. For example, identification of a lung function abnormality or biochemical evidence of a lipid disorder at an early age can make it possible for risk factors for chronic disease to be modified many years before the first clinical manifestations might be expected to appear. Both the content of health promotion programmes and the periodicity of medical examinations will be influenced by available resources, health and disease patterns in the community, new knowledge, and the evolving practices of the health professions. Little information is as yet available on the development, implementation, evaluation, and cost-effectiveness of health promotion programmes. It appears, however, that once physical, chemical, and biological hazards in the workplace have been controlled, ergonomics and the proper matching of work and human capacities and limitations would play an important role in workers' health promotion.

4.3.3 *Smoking control and cessation of smoking*

The Committee reviewed the reports of the WHO Expert Committee on Smoking Control (149) and the WHO Expert Committee on Smoking Control Strategies in Developing Countries (152) and found overwhelming evidence of adverse health effects of smoking. Both reports stress the need to start anti-smoking campaigns throughout the world as a public health priority and confirm that smoking cessation has many beneficial effects.

The Committee was convinced that smoking cessation programmes should be established in all occupational health

services. In workplaces where smoking is widespread, rapid results would be achieved by concentrating on helping smokers to give up the habit, while long-term results would depend on successfully preventing workers from starting to smoke. In workplaces where smoking is not widespread, as is the case in some parts of certain developing countries, emphasis will have to be placed on primary prevention.

In cases where there are no occupational health services at the plant level, voluntary health organizations may be called on to help. Smoking cessation programmes could also be designed to be coordinated or run by the employees themselves. Key leaders in the workforce may be identified and trained to help their fellow workers in the cessation process. Programmes offering incentives to workers who continue to abstain from smoking may also prove useful at workplaces.

With regard to smoking cessation the report of the WHO Expert Committee on Smoking Control Strategies in Developing Countries (152) states:

“In recent decades much work has been published on different methods of smoking cessation, and much research still continues in this area. But as a general guide it is interesting to bear in mind that in all countries, well over 90% of those who give up smoking do so of their own volition, i.e., without use of any specific therapy. There are no miracle cures for individuals wishing to give up, and any methods cited should be regarded as examples. Appropriate methods of smoking cessation will vary from smoker to smoker, and their chances of success will vary according to circumstances such as individual smoking behaviour, nature and degree of tobacco dependence, reasons for smoking, time, cost, and type of social environment. While every assistance should be provided for those who really need it, most smokers should be able to give up the habit on their own. The major problem for most of them in attempting to do so lies less in taking the initial decision than in keeping to it and preventing relapse. Any means of strengthening resolve can be of value and further work should be undertaken on how this may best be done.”

A wide range of smoking-cessation methods have been developed in recent years, and many have been applied in occupational settings. However, controlled experimental data on the efficacy of such worksite programmes are generally lacking. In non-occupational settings, 33–80% of participants are able to stop smoking with intensive clinical and educational assistance, but far fewer (e.g., 15–27%) stop when provided with information and brief instructions and encouragement (35). Of those who stop, the majority will relapse and resume smoking within 6–12 months, so that by the end of one year an average of 15–30%, but sometimes

as many as 50%, of those who originally entered the smoking cessation programme are still non-smokers (84).

For those smokers who do stop smoking, the smoking-related increased risk for a number of serious diseases declines. Postmyocardial infarction rehabilitation patients who discontinue smoking have a decreased risk of subsequent death from myocardial infarction and cardiovascular disease (120). For the average smoker, cessation reduces coronary heart disease mortality risk from 200% to 150% of that of non-smokers within one year, and within 5–10 years the mortality rate for ex-smokers is virtually equivalent to that of non-smokers (130). Lung cancer risks also decline after smoking cessation, although at a slower pace. Risk is reduced by approximately two-thirds after about the first five years and approaches that of a non-smoker by 10–15 years after cessation (120).

4.3.4 *Promotion of mental health and control of alcohol abuse*

Workplace-based programmes for the promotion of mental health and control of alcohol and drug abuse may take the form of employee assistance programmes. These programmes rely on health education as a primary prevention measure. One activity in such programmes is the dissemination of materials dealing with alcohol abuse, drug abuse, stress reduction, physical fitness, and commonly encountered family problems. Another is the early identification and treatment of mental health or substance abuse problems by promoting self-referral and early recognition of impaired job performance. Treatment, rehabilitation, and follow-up constitute other parts of the employee assistance programme. These latter activities usually involve occupational health services together with other parts of the health-care delivery system. Workplace-based alcohol abuse control programmes are more common than comprehensive employee assistance programmes.

When alcohol abuse control programmes are offered at the worksite, case-finding is enhanced, and the effectiveness of treatment and rehabilitation may also be enhanced (99). Early recognition of alcohol abuse is thought to facilitate treatment, and job-related considerations are thought to help to retain employees in treatment programmes. A wide variety of workplace-based treatment programmes have been developed, but such programmes are not yet generally available to workers in all countries where alcohol abuse

is an important public health problem. While programmes vary widely in organization and quality, most have three common clearly defined objectives: (a) early identification of the alcoholic employee or family member; (b) provision of appropriate therapy; and (c) a rapid return to work. Workplace-based alcohol abuse programmes have treatment efficacy rates of up to 80%—substantially better than those of hospital or community-based programmes. Prevention and control of alcohol abuse is thought to be cost-effective. Major benefits include improved job performance, reduced absenteeism, and reductions in on-the-job and off-the-job accidents and injuries. Successful alcohol abuse control programmes require the full participation and cooperation of both workers and management.

4.4 Prevention and control of selected work-related diseases

4.4.1 Hypertension

In the past, occupational health services themselves carried out or cooperated in screening programmes for hypertension. Research later showed that screening alone was not effective since many detected, hypertensive workers did not seek or follow the treatment needed to control their condition. The elements of a successful control programme include the following: detection, referral, diagnosis, follow-up, long-term maintenance and, throughout the process, education and evaluation.

The workplace provides an excellent opportunity for the detection, treatment and follow-up of individuals with high blood pressure. Workplace-based hypertension control programmes offer continuous access to a large number of hypertensives, including hard-to-reach adult males whose hypertension is poorly controlled (3, 61). Individuals may participate more frequently in health programmes offered at the worksite than in similar programmes in other settings. Convenience, low cost, and the presumed quality of such programmes may encourage the employees to use them. On-site occupational health professionals often have a close relationship with employees, giving them support and encouragement in controlling a symptom-free, lifelong disease such as high blood pressure (10). The social support system that exists in the occupational setting and the attitudes of co-workers are additional sources of encouragement (121, 135). Where companies have no on-site occupational health professionals, workers can take advantage

of a range of high blood pressure control services provided by the community. The worksite may also be the place from which to reach out to workers' families and dependants in order to educate, build family support for hypertensives, and reduce health-care costs of dependants. Finally, programmes in the workplace, especially those using nurses for follow-up, appear to be cost-effective (32, 44, 56, 57, 81, 89, 90, 116).

The most important benefit of a workplace-based high blood pressure control programme is its ability to reduce the risk of premature disability and death (134). Many programmes are highly successful in lowering employee blood pressure, and control rates of up to 80% have been achieved (4, 11, 32, 44, 88, 119, 123, 140). Three successful demonstration programmes in the United States of America dealing with hypertension control in the work setting involved the Ford Motor Company, the Westinghouse Electric Corporation, and the Maryland State government (104–106). These programmes provided data on the effectiveness of interventions that ranged from screening with minimal education and follow-up to screening with aggressive follow-up, including treatment. Results consistently showed that workplace-based high blood pressure control programmes improved control, offered potential cost savings, and reduced absenteeism among hypertensives (45).

Primary prevention of hypertension could involve the alteration of those psychosocial characteristics of the workplace that may contribute directly, or indirectly through overeating, obesity and alcohol abuse, to the development of hypertension. Other measures which may prove helpful in preventing hypertension include maintenance of normal weight, prudent limitation of sodium intake, ensuring adequate dietary potassium, and special attention to physical fitness, shift work, and heat stress. Unfortunately, there have as yet been no controlled randomized clinical trials directed towards primary prevention of hypertension at the workplace.

4.4.2 *Cardiovascular disease*

Every effort should be made to identify, monitor, and control any chemical agents, physical factors, or psychosocial characteristics of workplaces that may increase the risk for cardiovascular disease. There is also good reason to undertake prevention and control programmes directed towards attenuating the risks for affected or vulnerable groups of workers.

Workplace-based programmes for the prevention and control of cardiovascular diseases are most commonly directed towards the recognition and control of hypertension. More comprehensive programmes aimed at modifying a number of known risk factors for coronary heart disease are being attempted at a few worksites, and worksite programmes for the alteration of specific coronary heart disease risk factors other than hypertension have been described. These may deal with cessation of smoking, physical fitness, or weight reduction.

A substantial number of workers may have cardiovascular disease risk factors in addition to high blood pressure. However, the experience of health care providers and subjects involved in multiple risk factor reduction programmes shows that behavioural change and risk factor reduction can be difficult to achieve on an individual basis (106). It is thought that peer support, accessible health care through occupational health services, positive union and management support, intensive follow-up, adherence to a recommended medical regimen and, from the point of view of the industry concerned, economic or social incentives are important factors, as in hypertension and alcohol abuse control programmes. Dietary modification, physical fitness through regular exercise, and smoking cessation programmes may require close collaboration between worker health programmes, other parts of the health-care delivery system, and community resources.

Reducing the variables that confer risk has not in every case been shown to reduce risk. While smoking cessation and hypertension control do lower the risk, physical exercise has not yet been demonstrated prospectively to reduce the incidence of cardiovascular events. With respect to cardiovascular risk, the elimination of obesity will reduce risk if it causes a lowering of high blood pressure, and it may reduce risk if weight loss mediates a reduction in cholesterol. However, weight reduction will probably not substantially affect risk in a person with low cholesterol levels and blood pressure unless he/she was 25% or more overweight.

Few workplace-based studies on the control of multiple coronary heart disease risk factors have been completed (76, 112, 113). In the WHO multifactorial trial on the prevention of coronary heart disease, intervention consisted largely of health education aimed at promoting a cholesterol-lowering diet, smoking cessation, weight control, physical activity, and treatment of hypertension. The trial was conducted in factories in four European countries with the aims

of finding out whether risk factors in coronary heart disease can be reduced and of measuring the effects of any such reductions on the incidence of coronary heart disease (144). As part of this project, a randomized controlled trial was undertaken in 24 workplaces in the United Kingdom in collaboration with occupational physicians (113). Similar trials were conducted in Belgium, Italy, and Poland. The population studied in the four countries comprised nearly 50 000 men aged 40–59 years.

In each country the workplaces were paired for size, region, and nature of work. The members of each pair were then assigned at random to either:

- a group of “intervention” factories, where participants were screened and given advice on smoking, diet, and exercise and treated for any hypertension detected; or
- a group of “control” factories, where there was screening of a 10% sample of the workers, but no intervention.

In the intervention factories the following treatment or advice was given: cholesterol-lowering diet (all subjects); cessation of cigarette smoking (smokers); daily physical exercise (sedentary workers); weight reduction (men 15% or more overweight); and hypotensive drug therapy (men with raised systolic blood pressure above 160 mmHg (21.3 kPa)). There was also a general campaign by means of posters, letters, and group discussions aimed at modifying risk factors. Individual advice was also given, particularly to high-risk groups.

Taking into account changes in cholesterol levels, cigarette smoking, weight, and systolic blood pressure, the overall reduction in risk factors in the 5–6 years of the trial was small in the United Kingdom when compared with the results obtained in other countries. Belgium and Italy achieved the best results, with commensurate changes in the incidence of coronary heart disease. Poland did no better than the United Kingdom as far as risk-factor changes in the whole study population was concerned, but did exceptionally well in the high-risk group. There was a correlation between success in modifying people’s life-styles and the amount of time allocated to health education. For example, in Italy the net decrease in overall risk factors was 28% among 3131 men; six full-time staff were employed. In the United Kingdom the net fall was 4% among 9734 men, an equivalent of two full-time staff being employed. In the Belgian study, involving over 19 000 adult males

(76), mortality and the incidence of coronary heart disease were reduced in the intervention group as compared to an appropriate control group. The effort to reduce coronary heart disease in the United Kingdom was less successful in changing morbidity or mortality (113).

In the light of the foregoing, occupational health services have a major role to play in studies designed to identify the essential features of a practical, cost-effective workplace-based prevention and control programme for coronary heart disease.

4.4.3 *Locomotor disorders*

Prevention and control of many common, work-related locomotor disorders, including low back pain, shoulder pain, tendinitis, tenosynovitis, and carpal tunnel syndrome, can best be accomplished through improvements in work design, tools, equipment, and work methods. In other words, prevention of workplace-related locomotor disorders constitutes a major challenge to ergonomics. Occupational health specialists well trained in ergonomics can play a crucial role in the prevention and control of these disorders. Careful placement of workers so as to ensure that their physical capabilities are matched to job requirements and special training in materials handling may also prove of value. Despite such efforts, there are likely to be residual problems; some workers will still develop workplace-related locomotor disorders and it will not be possible in the immediate future to redesign all work tasks and methods in a way that would minimize such problems as back pain, shoulder pain, and tendinitis. Preplacement medical examinations and worker education programmes stressing appropriate practices, handling of materials, and use of tools are additional ways in which workers' health programmes should be involved in the control of locomotor disorders.

5. CONCLUSIONS AND RECOMMENDATIONS

The Committee concluded that the concept of the work-relatedness of diseases was a new and important dimension in the field of occupational health. There is therefore an immediate need to study in greater depth the problem posed by work-related diseases and to undertake appropriate intervention activities. The present

report should be viewed as a preliminary examination of the problem and, in view of this situation and the major gaps in the knowledge of this particular subject, the Committee recommends that:

1. WHO should examine ways of determining priorities for research on work-related diseases. This should be done as soon as possible, as the findings must be reflected in the implementation of the subsequent recommendations.

2. WHO should consider developing an international programme in the field of work-related diseases:

(a) To assess the magnitude of the problem of work-related diseases, and to establish the criteria for the selection of the diseases of this type to be studied, taking into account the needs of the different regions and countries, both developed and developing, and factors such as the introduction of new industrial technologies, the transfer of industrial processes from industrialized to developing nations, and occupational practices of special interest to particular regions or countries;

(b) To develop appropriate training programmes in the epidemiology of work-related diseases. In view of the immediate need for such training programmes, it is suggested that WHO should organize a training workshop for this purpose to be attended by participants from the various WHO Regions. In addition, WHO should encourage the development of appropriate epidemiological training programmes at both undergraduate and postgraduate levels to cover the problems of work-related diseases;

(c) To organize intervention programmes through the different WHO collaborating centres, as well as other centres, in order to assess the benefits of controlling the workplace components of certain work-related diseases. In the selection of work-related diseases for such intervention trials, account should be taken of their relevance and feasibility.

3. In order to throw more light on the problem of work-related diseases, collaboration with other on-going international health programmes, for example the WHO project on Monitoring Trends and Determinants in Cardiovascular Diseases (the MONICA project), the International Agency for Research on Cancer, etc., should be encouraged.

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