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WORLD HEALTH ORGANIZATION
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Environmental and Health Monitoring in Occupational Health

Report of a
WHO Expert Committee

This report contains the collective views of an international group of experts and does not necessarily represent the decisions or the stated policy of the World Health Organization.

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* * *

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WHO EXPERT COMMITTEE ON ENVIRONMENTAL AND HEALTH MONITORING IN OCCUPATIONAL HEALTH

Geneva, 31 July – 6 August 1973

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Professor R. S. F. Schilling, Director, TUC Centenary Institute of Occupational Health, London School of Hygiene and Tropical Medicine, London, England (*Rapporteur*)

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Professor L. Parmeggiani, Medical Director, FIAT Motor Company, Turin, Italy

Secretariat :

Dr M. A. El Batawi, Chief Medical Officer, Occupational Health, WHO, Geneva, Switzerland (*Secretary*)

Dr S. Forssman, WHO Regional Office for Europe, Copenhagen, Denmark

Professor T. F. Hatch, Professor Emeritus of Industrial Hygiene, University of Pittsburgh, Pa., USA (*Temporary Adviser*)

Dr A. J. Tuyns, Unit of Epidemiology and Biostatistics, International Agency for Research on Cancer, Lyon, France

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* Unable to attend : Dr J. H. Gesa, Minister of Health, Entebbe, Uganda.

ENVIRONMENTAL AND HEALTH MONITORING IN OCCUPATIONAL HEALTH

Report of a WHO Expert Committee

A WHO Expert Committee on Environmental and Health Monitoring in Occupational Health met in Geneva from 31 July to 6 August 1973. Dr B. H. Dieterich, Director, Division of Environmental Health, opened the meeting on behalf of the Director-General. He called attention to the purpose of the meeting, which was to review measures used in monitoring the work environment and workers' health and to make recommendations to governments and to WHO on environmental and health monitoring in preventive occupational health practice. He commented that WHO was paying special attention to the development of occupational health programmes. The Twenty-fourth and Twenty-fifth World Health Assemblies had emphasized the growing importance of developing comprehensive preventive health care for the working populations in all occupational sectors. The Twenty-sixth World Health Assembly, in 1973, had resolved to promote international work in monitoring and control of environmental hazards, including those in the work environment.[1]

1. INTRODUCTION

1.1 Objectives of an occupational health programme

An occupational health programme aims to promote and maintain the highest possible level of health among the gainfully employed upon whom the economic welfare of a community depends. To meet these objectives it is necessary: (1) 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; (2) 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; (3) to provide effective measures to protect those who are especially vulnerable to adverse working conditions and also to raise their level of resistance; (4) 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

[1] *Off. Rec. Wld Hlth Org.*, 1973, No. 209 (Resolution WHA26.58).

level; (5) to educate management and workpeople to fulfil their responsibilities relevant to health protection and promotion; (6) 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.

1.2 Reduction or elimination of specific occupational risks

These statements of requirements to meet occupational health goals imply that dependable cause-and-effect relationships are known or can be established between conditions of work and state of health, from which logical preventive measures can be developed and applied to eliminate health risks in industry or to reduce them to acceptable levels. This is especially true of the specific occupational diseases for which a substantial body of scientific and technical knowledge has accumulated, mainly in industrialized countries. Out of this experience have come important data concerning the relationships between the nature, magnitude, and duration of contacts with the causative agents and work situations and the resulting kind and degree of response in man.

The development of this body of knowledge has come not only from laboratory experiments but, to a very considerable degree, from field studies and experience in industry, mining, agriculture, and other occupations. The systematic collection of measurements of actual exposures to the various hazardous agents and work situations and the parallel recording of medical observations on exposed workers has made it possible to demonstrate correlations between level of exposure and degree of health impairment that could be expressed in the form of quantitative dose/response relationships. From these have been derived permissible limits of exposure for a number of hazardous agents.

Systematic application of this knowledge has resulted in a substantial reduction in the occurrence of many occupational diseases. For example, miner's nystagmus has been eliminated where appropriate lighting was provided,[1] and the incidence of disabling pneumoconiosis has been substantially reduced by health surveillance and better dust control in many industries.[2]

The techniques used for measuring the characteristics of the work environment and for determining the biological response characteristics of man constitute the basis of the modern practice of occupational medicine and hygiene. Such practice includes the routine assessment of control measures to ensure that exposure levels are kept within prescribed limits for continued health maintenance or to provide early warning of impending ill health, this indicating the need for additional preventive action. The

[1] Schilling, R. S. F. (1963) *J. roy. Soc. Arts*, III, 933.

[2] Hatch, T. F. (1951) *Amer. industr. Hyg. Ass. Quart.*, 12, 46.

experience gained so far demonstrates the need for the continuing monitoring of health and the environment in workplaces.

While one of the aims of this report is to provide guidance in the planning and conduct of monitoring schemes and to make recommendations for their implementation in respect of specific occupational health risks, it will also emphasize the need to take account of other health problems of workers, such as the development of ergonomic criteria in matching demand to human capabilities to ensure optimal health and performance. Similarly, the psychosocial characteristics of the work situation must be considered as important determinants of man's function and wellbeing.

2. MONITORING

2.1 Definition and scope

Monitoring has two distinct functions: first, the making of routine measurements on health and environmental indices and the recording and transmission of these data and, second, the collation and interpretation of such data with a view to detecting changes in the health status of populations and their environment. The distinction is important because these functions involve different types of skill. The first requires careful planning and the use of standardized techniques and methods of data collection. The second requires analysis and evaluation, which lead to recommendations for preventive action. It will be possible to broaden the coverage of health surveillance of working populations by making fuller use of technicians and, where available, automated procedures for monitoring. One of the most important aims in current practice is to raise the efficiency of monitoring and to ensure comparability of data from different groups of research workers (and within the same group over a period of time) by standardization of techniques.

An essential part of an occupational health programme is a plan for the continuing hygienic assessment and evaluation of work processes and associated environmental conditions, concurrent with continual health surveillance of the workers. The results must be recorded in a manner that will permit a proper matching and joint analysis of the two sets of data at regular intervals so as to reveal any significant relations that develop between the stresses of work and the health of the worker. In particular, an early warning of health impairment is needed so that appropriate additional protective action can be taken before illness develops.

2.2 Purpose

Monitoring is carried out for the following reasons:

(1) To assess recognized occupational health risks and evaluate their control by (*a*) providing the necessary data to ensure that environmental

protective action is initially taken against health risks and to ensure that workers are placed in jobs suiting their capacities ; (*b*) providing continuing evaluation to ensure that adequate protection is maintained ; (*c*) obtaining an accumulating body of data for epidemiological use to show the comparative effectiveness of the engineering and medical aspects of preventive programmes and, where appropriate, to permit the redefinition of permissible levels of exposure.

(2) To identify occupational health risks not previously recognized so that steps can be taken to control them—for example, by establishing permissible levels of exposure.

(3) To reveal other sources of health risk, especially those associated with stresses that do not cause occupational disease but increase psychobiological vulnerability and possibly contribute to general ill health.

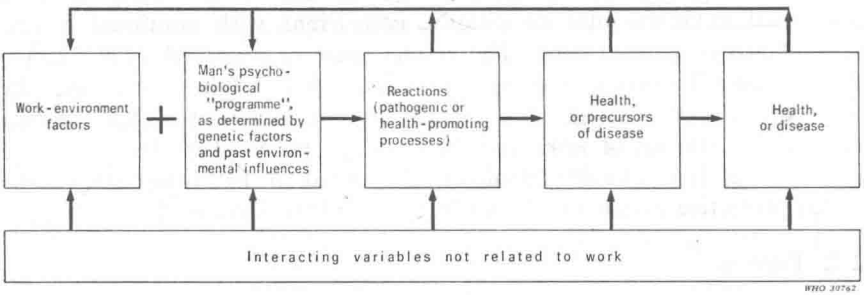
(4) To identify and promote work factors that are beneficial to health.

(5) To provide information on community health problems (not primarily caused by work) through the observation of the gainfully employed, who form a significant part of the general population.

The various levels at which monitoring can take place are shown in Fig. 1 in which the interrelations between occupational environmental factors and man are demonstrated.

While the general aim should be to provide comprehensive routine monitoring of workpeople and their environment, such an ideal may at the present time be beyond the resources of many countries or industries. It should nevertheless be possible to adopt two other approaches—(i) the clinical observation by health personnel of individual workers presenting illnesses found, on inquiry, to be related to specific exposures at work, and (ii) the statistical monitoring of populations, using national and local records of mortality and morbidity to identify hazards in particular

FIG. 1. MODEL OF MAN/WORK INTERRELATIONSHIPS



Monitoring can take place at any or all of the six levels indicated. The combined effect of factors in the work environment and man's psychobiological "programme" determines pathogenic or health-promoting reactions, which may lead either to health or to precursors of disease and ultimately to disease itself. This sequence of events can be promoted or counteracted by interacting variables not related to work.

occupations or groups. Clinical observation and statistical monitoring are useful additional methods of identifying hazards in groups already subjected to fully developed monitoring systems. In many instances, the existing methods of environmental assessment and health examination can be simplified so that monitoring can be carried out at a much lower cost. Information on simple techniques of monitoring should be made available, and further research in the simplification of techniques should be stimulated. A number of occupational health institutions in developing countries have used such techniques for epidemiological investigations of environmental and health conditions at work and have later continued to use them in routine monitoring practice.

3. PRESENT LIMITATIONS IN OCCUPATIONAL HEALTH PRACTICE

Current practices in occupational health, even in the most highly industrialized countries, seldom meet the goals set forth above. In many instances the major emphasis is on the finding of cases of illness and providing the necessary medical care, and true preventive medicine plays only a minor role, if any, in day to day operations. Indeed, it is the practice of general medicine in industry and not the practice of industrial medicine *per se* that characterizes today's efforts.

Medical records, for example, usually provide only separate medical histories on individuals to be referred to when these individuals come as patients. Conceptually, therefore, they do not differ from the records in the office of a physician practising in the community and include little information of the kind that is essential to the practice of occupational health, which must be based on the systematic gathering of parallel data on the conditions of work and the health of the worker.

Thus, the true objectives of systematic monitoring are not often achieved, and when a routine monitoring scheme is adopted it is usually of limited scope—that is to say, it is usually designed to control only a limited number of occupational diseases and often only one. In developing countries, and even in some enterprises in highly industrialized countries, occupational medical services may be absent, especially in small establishments, and the systematic approach of occupational hygiene is usually unknown. As the team approach by physicians and hygienists is rarely practised, it is difficult to relate the conditions of ill health to environmental factors at work. Thus it is not possible to evaluate the effectiveness of environmental control measures. The main causes of these serious limitations are lack of awareness by health planners of the need for occupational health practice and a shortage of trained occupational health personnel. In addition, today's practice rarely includes a systematic consideration of ergonomic and psychosocial factors.

The conditions of health of workers in different parts of the world vary widely, depending *inter alia* on the type of employment and the pattern of disease in the area. A small proportion may enjoy better health than other sectors of the community, but in the world as a whole the majority work under unfavourable conditions. In developing countries the prevalence of communicable diseases is sometimes higher among occupational groups than in the general population.

Although reporting is generally inadequate, field investigations in developing countries often show a high prevalence of occupational diseases. For example, fibrotic pneumoconiosis is as high as 23% in miners and stone cutters in some countries. In others, where large numbers of workers are exposed to vegetable dust in processing hemp, flax, and cotton, a prevalence of 60% of byssinosis and other respiratory diseases has been reported. Poisoning by carbon monoxide has been observed in up to 15% of workers employed in coke production and gas plants. Excessive lead absorption has been found in almost 40% of workers in smelting and battery manufacture. In certain countries occupational dermatoses have been found to affect as many as one third of workers in contact with mineral oils, cement, and other substances. Even in highly industrialized countries the occurrence of occupational diseases is still too high, and additional health problems affecting the gainfully employed include chronic noncommunicable diseases, mental disorders, alcoholism, and drug abuse.[1]

4. CURRENT MONITORING SCHEMES IN THE PREVENTION OF OCCUPATIONAL DISEASE

Monitoring systems are mainly directed towards the prevention of recognized occupational diseases, for each of which a specific causative agent is found in the work environment, usually associated with a particular process or occupation.

Historically there is a reason for this emphasis on specific occupational diseases, since it was their occurrence in almost epidemic proportions that called attention to the greater need for effective preventive action. Because of this overwhelming experience immediate attention had to be given to their control. This explains why the preventive aspects of occupational health have remained so limited in scope. But the successes in this limited field encourage the visualization of a much broader set of objectives for occupational health services and for monitoring.

Since extensive information is already available on the methods used in both occupational hygiene and medical monitoring, the Committee decided

[1] *WHO Chronicle*, 1972, **26**, 537.

to limit its discussions to the major principles on which the techniques of monitoring are based.

4.1 Environmental monitoring

Environmental monitoring (or occupational hygiene monitoring, as it is often known) makes use of an extensive battery of instruments to assess a variety of physical and chemical exposures at work.

The purpose of the procedures used for environmental assessment is to measure the dose of the hazardous agent absorbed by the worker at his place of work. This means that the assessment of the environment is not just an exercise in physical or chemical analysis but has its base in the biological characteristics of man, and the relevance of the results depends on the adequacy of the "biological calibration" of the analytical procedures.

One of the most important aspects of environmental monitoring is that concerned with sampling and measuring techniques. Accurate dose estimations depend on many factors, but particularly the selection of sampling or measuring points and the frequency and duration of sampling or measuring periods. Moreover, account must be taken of the type of hazard being monitored. There is, for example, considerable difference in approach between the assessment of exposures causing immediate illness and the assessment of exposures producing cumulative effects over a long period. In the former case, brief exposures to high concentrations may be the most important index of hazard; in the latter the level of exposure may best be expressed by time-weighted averages. Personal samplers (i.e., continuous sampling instruments that can be worn by individual workers as they move about) give a better estimate of dose in some instances than do static samplers at stationary sampling points. Particular care must be taken in the use of "spot sampling", which can lead to substantial errors in estimating exposures. Certain statistical procedures have been proposed for the selection of a proper sampling regimen.[1]

Instruments and analytical procedures are available to determine atmospheric concentrations of a large number of airborne gases, vapours, fumes, mists, and dust particles and to measure other important properties such as the aerodynamic characteristics of dust particles that govern lung deposition. Techniques are also available for the sampling and evaluation of bacteria and other biological agents. Other instruments permit the assessment of a variety of physical stresses such as exposure to excessive heat or cold, high noise levels, mechanical vibration, and inadequate illumination. For other types of contact (e.g., with the skin or by ingestion) different techniques are required. For example, in the control of ionizing radiation, it may be necessary to monitor work surfaces and clothing.

The instruments and techniques used in environmental monitoring range from the simple to the relatively sophisticated, depending on the

[1] Roach, S. A. (1966) *Amer. industr. Hyg. Ass. J.*, **27**, 1.

nature of the relationship between the hazardous agent and the resulting disease. They are selected to yield information on those characteristics of the environment that are known to have particular significance for health and for which dose/response relationships have already been established. Good descriptions of these instruments and techniques are given in several publications.[1]

In some countries there have been important developments in ergonomic practice, and attempts are also being made to describe, qualitatively and quantitatively, potentially harmful psychosocial aspects of the work environment.

4.2 Medical monitoring

Preplacement medical examinations serve the purpose of proper job placement according to the physical and mental capabilities of the worker. They also make it possible to identify persons likely to be vulnerable to certain exposures; for example, those with chronic obstructive pulmonary disease can be identified and excluded from work in dusty occupations. Another function is to provide baseline data that make it possible to measure early adverse effects of exposure in persons at risk. Since there are considerable variations in functional values (for instance, in lung function and blood tests) not only between individuals but in the same individual in the course of time, it may be possible to improve the chances of detecting early deviations from health by following the changes in values from levels established at preplacement examinations in exposed and unexposed groups.

Periodic medical examinations serve five main purposes: (1) to detect early impairment of health; (2) to evaluate the effectiveness of preventive measures; (3) to detect workers showing undue susceptibility to a particular environmental exposure, with a view to their replacement; (4) to reveal trends in the health status of groups of workers; (5) to indicate the need for medical treatment.

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[1] American Conference of Governmental Industrial Hygienists (1972) *Air sampling instruments*, Cincinnati, Ohio (P.O. Box 1937); American Conference of Government Industrial Hygienists (1973) *Manual of analytical methods*, Cicinnati, Ohio (P.O. Box 1937); Gadaskina, I. D. & Filov, V. A. (1971) [*Metabolism and determination of industrial organic poisons in the organism*], Leningrad, Medicina; Lawrence Berkeley Laboratory Report (1973) *Instrumentation for environmental monitoring*, Berkeley, Calif., University of California; Muraveva, S. I. (1969) [*Recent advances in the area of atmospheric chemistry in industry with reference to toxic products*], Moscow, Izdatel'stvo "Medicina"; Singleton, W. T. (1972) *Introduction to ergonomics*, Geneva, World Health Organization; Levi, L. (1972) *Stress and distress in response to psychosocial stimuli*, Oxford, Pergamon; Alekseeva, M. V. (1963) [*Determination of atmospheric pollution*], 2nd ed., Moscow, Medgiz; Manu, P. & Nicalescu, T. (1971) *Occupational medicine*, Bucharest, Editura Medicală; Lazarev, I. V. (1963) [*Harmful substances in industry*], 4th ed., Leningrad, Goshmizdat, 2 vols.; Lazarev, I. V. (1969) [*Harmful substances in industry*] (companion volume), Leningrad, Izdatel'stvo "Himija".