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*chemicals - adverse effects  
Occupational diseases - chemically  
induced*

CONSULTATION ON HEALTH SURVEILLANCE OF WORKERS  
EXPOSED TO CHEMICALS

Report on a WHO meeting

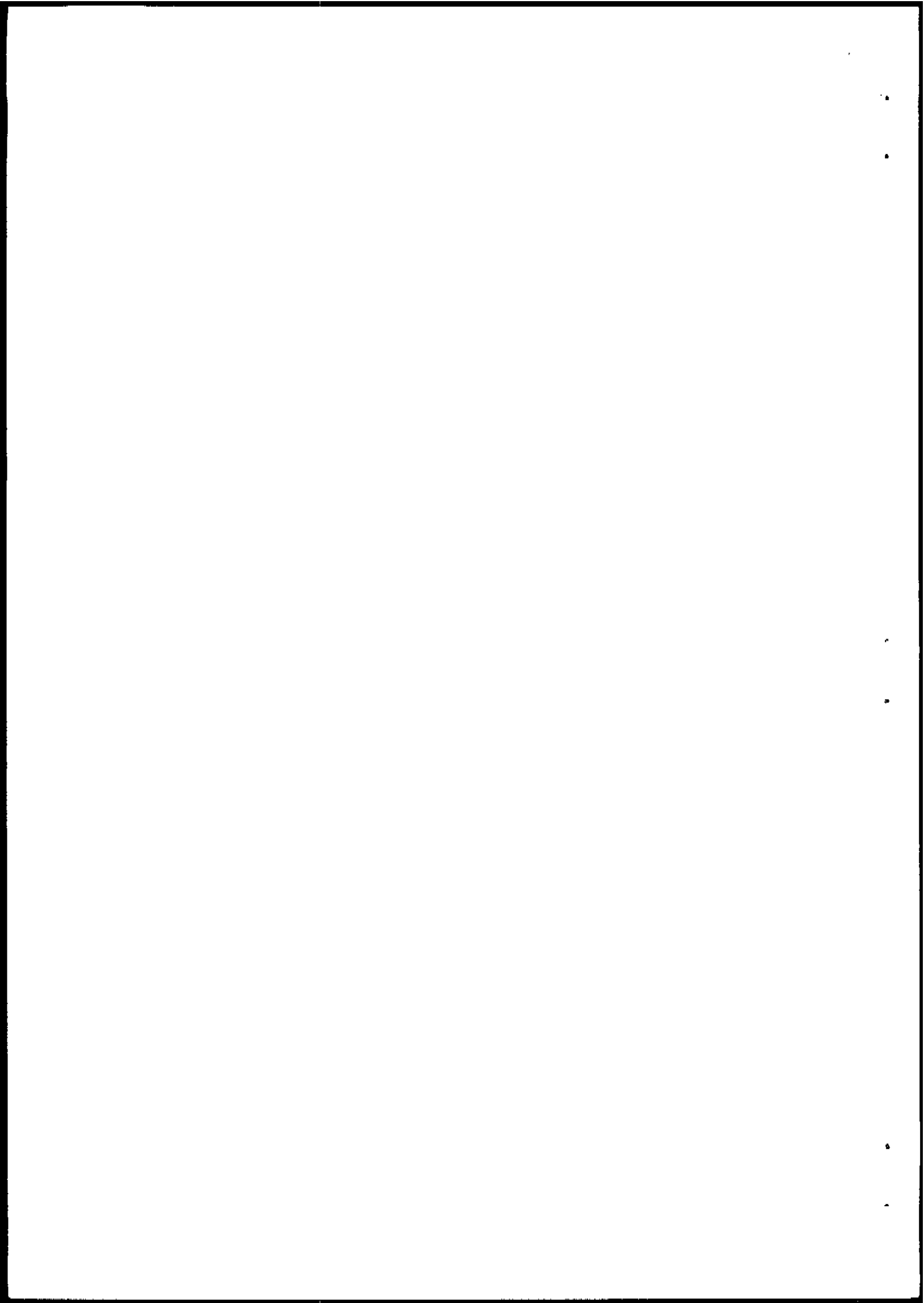
Varna  
26-28 October 1982

Note

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## 1. Introduction

A Consultation on Health Surveillance of Workers Exposed to Chemicals was convened in Varna, Bulgaria, from 26 to 28 October 1982 by the WHO Regional Office for Europe in collaboration with the Government of Bulgaria. The purpose of the Consultation was to review existing health surveillance of workers exposed to chemicals in the Member States, to define the role and place of health surveillance within the occupational health information system, and to develop guidelines for the health surveillance of workers exposed to toxic chemicals, paying particular attention to those exposed to carcinogenic and genotoxic agents.

The Consultation was attended by 11 temporary advisers. Three observers and a representative from the Commission of the European Communities also participated.

The meeting was opened by Dr M.I. Mikheev, Regional Officer for Workers' Health. Professor F. Kaloyanova-Simeonova representing the Government of Bulgaria, was elected Chairman, Dr J. Järvisalo was elected Vice-Chairman and Dr G.S. Sorrie was appointed Rapporteur.

The scope of the meeting was outlined by Dr Mikheev. Health surveillance of workers exposed to chemicals was an important element of health services. The assessment of occupational health risk was used to formulate preventive action designed to preserve workers' health and control hazards in the working environment. Health surveillance of workers exposed to chemicals was organized in various ways throughout the WHO European Region. Nowhere did it cover the entire working population and it was frequently inadequate for the level of risk involved. The registration of exposure and recording of health status and exposure level were not coordinated and required development of general guidelines.

## 2. Current practice in health surveillance (1)

Reports of current practices in health surveillance of workers exposed to chemicals were received from a number of countries within the Region, illustrating the diversity of approach, but also showing a common trend.

### 2.1 Bulgaria

Specific national regulations and guidelines exist in the Labour Code and Public Health Act. These provide for medical and biological examinations before and during employment, medical criteria for individual jobs, associated occupational diseases and environmental hygiene control. Health surveillance is carried out by staff qualified and trained at an appropriate level and is evaluated by designed studies (2).

Factories are generally equipped with special occupational health units or services. According to size of establishment, these may be large, hospital-type services, or small units consisting of one doctor with supporting staff. They may include dispensaries responsible for the general health and rehabilitation of persons at work. Factory-based services provide both occupational health and toxicological facilities and they are guided by a central Institute of Hygiene and Occupational Health and by the Ministry of Public Health.

The aim of health surveillance is to prevent occupational disease, by spotting early reversible changes in workers' health, and to improve their general health.

Epidemiological studies are widely undertaken and cases of occupational disease are reported centrally. The data are analysed and taken into account in developing preventive measures.

### 2.2 Czechoslovakia

Statutory national instructions for health surveillance of workers, which is compulsory according to Health Care Act 20/66, are provided under the supervision of the Ministry of Health and guidance is also given on medical criteria for employment, transfer of workers and nature and content of medical examinations.

Health surveillance involves pre-employment and periodic medical examinations of workers exposed to certain defined hazards, where specific fitness is required, for certain age groups, and routinely for all workers. Treatment services for occupational diseases are closely linked. The purpose of the examinations is to detect deviations from the normal state of health at a stage when early treatment or removal from further exposure or from specific employment will benefit the

individual worker's health or safeguard the health or safety of others. They also enable improvements to be made in working conditions, and facilitate production. The examinations thus serve individual and group purposes.

Additional special medical examinations may be required if workers are thought to be at increased risk. Up-to-date diagnostic methods are incorporated into the examinations. The relationship between working conditions and health status is an important aspect of the system and is specifically directed towards avoiding and measuring work-related factors that may adversely affect health, assessing any health impairment associated with unfavourable working conditions, evaluating and verifying such associations and developing effective regulations and standards to control hazards.

### 2.3 Denmark

Comprehensive legislation exists for occupational health and safety but specific health surveillance programmes are limited. Only for workers exposed to ionizing radiations is periodic examination and environmental control obligatory.

Industrial and workers' organizations have agreed that health surveillance should be performed only where simultaneous environmental control is available. Results of individual health surveillance are confidential, though group results are made available to the employer; results of simultaneous environmental control are available to workers in the area concerned. The combined surveillance and environmental control programme must concentrate on otherwise unacceptable risks; screening methods must be available and beneficial, and the programme must be cost-effective.

### 2.4 Finland

Health surveillance is based on a comprehensive statutory framework with specific requirements covering exposure to particular agents such as asbestos, benzene, lead, carcinogens and waste materials.

Statutory occupational health services are obligatory, the scope depending on an assessment of hazards present in various categories of employment. The function of such services and the training of their personnel are also regulated.

The Occupational Health Care Act requires examinations before placement in employment, and for work which involves considerable health risk, taking into account such factors as age, sex and physiological state, concurrent exposures and potential hazard of new substances.

The National Institute of Occupational Health plays an important advisory, training and expert role within the system, as well as providing industrial hygiene and biological monitoring services. It maintains registers of occupational diseases, of industrial hygiene measurements and of workers exposed to carcinogenic compounds. Others on biological monitoring and chromosomal aberrations are planned.

### 2.5 Italy

Teams of health surveillance monitors are part of the overall national strategy for occupational health. Legislation devolves on local authorities the responsibility for adopting a unified approach to prevention in the community and in the workplace, including the detection of risk factors, the provision of such information to workers, advice on ways to counteract hazards at work, and monitoring of workers' health.

Local authority health units serve a population of 40 000 - 300 000 persons and 60% of them have specialized occupational and industrial hygiene services, staffed by doctors, chemists, engineers, technicians or nurses. These local health units are aggregated into regions, whose authorities have a planning, liaison, training and evaluation role, and these in turn report to the central ministry and institutions.

In larger factories, company-owned occupational health services are well established, and themselves provide the required health surveillance and environmental services.

Health surveillance and environmental controls are required for possible agents associated with a list of compensatable occupational diseases. Programmes are implemented not only because of legal requirements, but also through agreement between public authorities, employers and employees.

The methods used have been widely discussed and there is an increasing tendency towards specific tests and biological monitoring, and for the development of or health promoting interventions. Screening tests are being increasingly scrutinized for their validity. Emphasis is placed on the collection of reliable data which can be used in epidemiological studies, which are themselves progressively being changed from cross-sectional to follow-up in design.

## 2.6 Poland

Health surveillance is based on a national system of statutory requirements and guidance closely allied to general health care. This requires routine health surveillance of workers, the nature and frequency depending on the type of industry. Curative services are incorporated. Surveillance is performed by medical staff, many of whom are occupational health specialists. In larger factories there are occupational hygiene laboratories for the investigation of environmental conditions.

Workers in the chemical industry are given high priority within the system, and the requirements for pre-employment and routine medical examinations are more stringent than for most other industries. Examinations are generally performed annually but the present system is being reviewed and rationalized.

## 2.7 Union of Soviet Socialist Republics

The forms of organization for individual health protection of workers exposed to occupational hazards (and chemicals in particular) are very similar in the USSR and the other socialist countries of Eastern Europe, and are approved by legislation.

A total health care system providing facilities in the community and at the place of work exists to provide both preventive and therapeutic care. Workers exposed to chemicals, like all workers, are served by this system. Within its framework, occupational physicians are responsible for health surveillance in a ratio of one physician to every 1000 chemical workers. The physician is assisted by a nurse and is responsible for the treatment, organization of first aid, selection of patients for health promotional care in sanatoria, and the conduct of pre-employment and periodic medical examinations and programmes of health surveillance. The physician also has preventive and advisory functions concerning working conditions.

Health surveillance consists of pre-employment examinations to establish baseline health from which any subsequent departure may be detected and to avoid employment of those with medical conditions which may increase susceptibility to occupational hazards. Routine medical surveillance is primarily designed to reveal early biological changes due to exposure to harmful substances. These improve individual protection and the promotion of healthier working conditions. Medical examinations include biological tests and are emphasized in respect of exposure to certain hazardous substances, and in industries where carcinogens are produced or used.

## 2.8 United Kingdom

Surveillance of workers exposed to chemicals is part of a comprehensive framework to provide health and safety for all persons at work. But exposure to only a few specific substances or work processes requires statutory surveillance, though many industries provide a wider range of examinations carried out by firms' own occupational health services.

Statutory examinations are performed by doctors employed or appointed by the government agency for health and safety at work, the employer bearing the cost.

The principal chemicals for which examinations are currently mandatory are lead, certain aromatic amines, and some nitro compounds. More limited controls apply to chromic acid and some mineral petroleum substances.

There is an increasing tendency requiring specific biological tests, the frequency being determined by a risk assessment of the hazard.

## 2.9 Yugoslavia

Health protection of workers is an integral part of general health care. Statutory regulations prescribe health surveillance for workers exposed to chemicals, as well as environmental control limits. Pre-employment and periodic examinations, incorporating appropriate biological and specialist tests, are required for workers exposed to chemicals recognized as being capable of causing disease. Special requirements exist for females, young and aged workers.

The list of chemicals involved includes heavy metals, such as lead and mercury, many solvents, amino and nitro compounds, and many chlorinated hydrocarbons.

### 3. Occupational health surveillance

In order to achieve practical goals of improving and promoting the health of workers uniformly it seemed essential to clarify the term "health surveillance". In some countries this has been taken to mean the product of the total health care resources allocated to safeguard workers' health, including medical and paramedical prevention and treatment in the community and at the workplace, and assessment and control of the working environment.

Elsewhere, the term has been more narrowly interpreted to imply only medical examinations or biological tests applied to groups of workers exposed or potentially exposed to specific hazards at work.

Health surveillance may subserve several functions: it may, by detecting departures from a pre-exposure norm or from accepted health norms, trigger action to protect the health of individual workers. It may also provide collective results from groups of exposed workers to indicate any inadequacy of control measures and thus instigate environmental improvements.

There are many difficulties in assessing specific biological effects attributable to exposure to individual chemical substances. Few chemicals occur in isolation in the workplace, and the human results of exposure to mixtures of chemicals are poorly understood. Furthermore, the attributable effects of personal and social habits, when combined with exposure to workplace chemicals, have been inadequately studied.

Health surveillance in an occupational setting concerns changes in the health of individual workers or groups of workers, measured clinically or biologically. The aim is to contain the effects of exposure to noxious agents by serving as a basis for active intervention to improve the working environment or to suggest remedial action for individual workers.

Action may be instituted at commencement of employment, or as periodic measures during the course of employment. It may also be continued after exposure has ceased. Surveillance should be valid for a specific purpose. Appropriate effective personal or environmental remedies should be introduced when indicated by the results of surveillance.

Surveillance must, in principle, benefit workers, and be considered complementary to other methods of controlling exposure to hazardous agents. Worker and management representatives and individual workers must understand the objectives and willingly cooperate. Workers must be informed of the results and of any proposed remedial action.

### 4. Occupational health information

The results of health surveillance constitute an important part of the whole spectrum of occupational health information pertaining to hazards encountered at work. Only by taking account of and relating them to measurements of environmental exposure can adequate control measures be developed. There are, however, many practical difficulties in developing integrated information systems in health practice (3).

Information for clinical purposes is an established prime requisite of any health care programme, but the extent to which data collected at the operational level can be fully utilized for control purposes is, in most countries, an unresolved problem. Reliability is an obvious requirement, but validity is much more important than formal mathematical accuracy. If proper decisions are to be based on available information, knowledge of the direction and magnitude of errors inherent in the system is essential.

Statistics form an important part of the occupational health information system, but the latter term also includes other types of health, biomedical and environmental information - information service centres, mechanisms for obtaining information, information flow and processing, and appropriate technologies. There should always be close links between various parts of a system, even though they may be administered by different authorities.

The main task of an information system should be to minimize doubt as to decisions, and the ultimate objective is to help a health-related organization to achieve its goals. Accordingly, the information produced should be relevant to this objective. Other needs, such as research, must also be encompassed (3).

It may be necessary to coordinate results from several areas in order to collect sufficient relevant information. The standardization of methodology and record-keeping, essential if comparable records are to be obtained from different sources, may present problems. Some performance control of health personnel may be necessary, and periodic checks made of compliance with defined procedural rules for health surveillance. Adequate guidance and information must be given to health staff, and their active cooperation, as well as that of workers and management, should be sought.

Accurate and reliable measurements of environmental contaminants over appropriate periods of time are particularly difficult to obtain. When available, these may be directly integrated with the results of surveillance or may be maintained separately for later matching. Particular methods of keeping and maintaining records will depend on the given circumstances, but whatever systems are devised should be kept as simple as is consistent with the desired objectives.

Ideally, the recorded information should consist of workers' personal details, the results of health surveillance, job history and, preferably, a record of exposure to hazardous agents. This last may be difficult to define when multiple or intermittent exposures have occurred. It may not currently be possible to include relevant personal factors such as smoking, alcohol or drug consumption, or communal factors such as exposure to atmospheric pollutants or ambient climatic conditions, but these should be borne in mind.

Whenever possible, occupational health surveillance and exposure records should be linked to records of general health, thus creating a fully integrated record for each individual. Where general and occupational health services are based on a unified organizational structure this may be easier than in cases where the two are separated in organization or provision. Regardless of source, however, attempts should be made to link all available information about each worker.

To facilitate data handling it may be necessary to employ computerized systems. This will be essential if large amounts of data are produced, and will enable analyses to be made more frequently and more promptly. Computerization requires strict methodology, with attention to standardization of measurements and procedures, but offers speedy response, direct output analysis and the possibility of incorporating features such as automatic reminders for surveillance and ready detection of missed measurements.

Current practice in many facets of health surveillance of workers, its role in information systems and its integration into and links with environmental exposure measurements and general health records, is still at an early stage of development. Much work still needs to be done to clarify problems and to devise solutions: these will inevitably be related to the needs of individual countries and complete unification may be a slow process.

## 5. Specific occupational groups

### 5.1 Female workers

Women, young persons and elderly workers are frequently regarded as particularly vulnerable to the effects of many hazardous chemicals. In many countries, special provision is made for them in health surveillance programmes. Constitutionally, women differ from men in respect of their reproductive and associated hormonal processes. These may affect the metabolism of absorbed chemicals whose effects may be expressed in ways particularly affecting the female organism. Pregnancy is an additional complicating factor. Many chemicals are potential teratogens and readily cross the placental barrier. Unborn children may be affected and future generations are put at risk. Workers should always be given full information about the potential dangers of chemicals to which they are exposed and women may require special warning of the reproductive or teratogenic effects. It may be desirable, in some cases, to prohibit exposure of women to certain substances or to limit that exposure by specific controls. Special health surveillance may be necessary. Women who are likely to become pregnant are particularly at risk and must be adequately advised as to suitability of occupation, preferably before conception (4).

### 5.2 Male workers

The male reproductive system is also specifically affected by certain chemicals, e.g. dibromochloropropane (DBCP). It may be argued that the reproductive effect of exposure to chemicals is only one aspect, though essential, of the total risk associated with exposure, in response to which surveillance standards and controls are established. Much additional research is required on this aspect of toxicology.

### 5.3 Young persons

Young persons may require special protection if they are likely to be exposed to chemicals. This may involve prohibition from exposure, or special health surveillance. In the younger age groups, education concerning the health hazards of chemicals and advice about suitability of employment are particularly important.

### 5.4 Elderly workers

With retirement now being more common before the normal age of physical and mental impairment and infirmity, no special provisions are usually required for the older working groups exposed to chemicals. However, possible exposure giving rise to premature onset of disabilities normally associated with old age should not be forgotten.

## 6. Carcinogenic and genotoxic chemicals

The risks of carcinogenic and genotoxic exposure are increasingly recognized, and intensive research is extending knowledge as to possible surveillance at the practical health care level. Current methods may be classified in the following categories:

- (1) measurements of compounds or their metabolites;
- (2) mutagenicity testing of body fluids;
- (3) determination of products of alkylation of macromolecules;
- (4) analysis of cytogenetic alterations;
- (5) determination of products of tumour development and growth;
- (6) measurement of altered immunological functions.

Of these, the first has been routinely applied in occupational health surveillance. Improvements in analytic techniques now make available measurements of many known carcinogenic substances. The main obstacle to the practical use of measurements in biological monitoring is the paucity of information on the kinetic behaviour of compounds in the human body. These measurements may be combined with results obtained using the second category of methods.

The other categories listed above are not yet sufficiently developed to be used to monitor individual risk of exposure to chemical carcinogens and mutagens. However, if adequate laboratory resources are available, measurements of cytogenetic alterations - such as chromosomal aberrations and sister chromatid exchanges in cultured peripheral blood lymphocytes - may already be applied to the practical health surveillance of groups of workers.

In using all these methods special attention must be paid to measurement strategies, and to the possibility of other confounding exposures. Results must always be interpreted with great care.

Further research is required to explore the scope for using the final four categories of methods in a practical occupational setting. At present, sperm analysis is the only method by which the effects of toxic chemicals on germ cells may be estimated, and further research on the effect of chemicals on sperm function and morphology would be of particular value.

Research is also required into the meaningful interpretation of many of the results, both in terms of chemical exposure and ultimate outcome for the health of the individual. Risk assessment of the possible effects of exposure to chemical carcinogens would then be feasible for groups of workers and ultimately for individuals.

Although such methods are promising, their application in the health surveillance of workers exposed to carcinogens is still at a developmental stage. The surveillance of such workers poses particular problems, since the diagnostic methods currently available often detect cancerous changes only at a stage too late for effective treatment.

Exposed individuals may thus gain little personal benefit from health surveillance, and prevention has to be based on other control methods. Likewise, because of the long latency period between exposure and development of clinically detectable cancers, the adequacy or otherwise of control measures cannot be quickly determined from the occurrence of effects in groups of workers.

For the time being, prevention will primarily be directed at reducing exposures to levels as low as reasonably practicable by the application of engineering techniques, by safe systems of work, by informing and instructing workers of the risks and by adequate supervision. Personal and exposure records are essential and should be maintained for long periods - until death in some cases.

At the same time continuing epidemiological studies of workers, who have been exposed to varying environmental levels of chemicals in the past, should be carried out. Information may thus accumulate to assist in the assessment of risks for workers who are exposed at present. Such information may be a significant and reliable indicator of the extent of risks being run now or in the future.

#### 7. Workers exposed to pesticides

Pesticides are chemicals (which may or may not be mixed with other substances) used to destroy organisms detrimental to man or his environment. About 1500 different chemicals are formulated into many thousands of products for use as pesticides in a wide range of indoor and outdoor situations. Workers may be exposed during manufacture of the active chemical ingredient, during production processes, or while applying the final products. Since the formulated products or their ingredients may occur in various physical forms there is considerable danger of absorption by inhalation, through the skin, or accidentally, by ingestion.

Community health care systems are available to pesticide-exposed workers as to all others. Workers who use pesticides are often employed in agriculture, working in isolated rural areas. The provision of health surveillance for such groups may be practically difficult, and it may be desirable to integrate occupational health services with systems of general health care.

The precise indications for health surveillance of workers exposed to pesticides are mostly poorly defined. It is essential, however, that adequate records containing personal details and information on pesticide usage and exposure be kept for all workers. These records should be kept for an adequate number of years against the possibility of chronic effects arising.

For workers exposed to certain chemicals specific health surveillance procedures are recommended. Where exposure to organophosphorus compounds occurs, a baseline estimation of plasma and erythrocyte cholinesterase should be carried out before employment and repeated at about monthly intervals whilst exposure continues. The results of the tests will determine whether exposure can be contained, or should stop until cholinesterase levels begin to approach normal values again. They may also be used as an indication of the general safety of the work procedures, and may point to the need for improved protective arrangements for workers. Other methods of assessing the potential effect of organophosphorus exposure have been developed, but not to the stage of practical application under field conditions.

It may also be desirable to monitor the effects of other pesticide chemicals in exposed workers. For organochlorine compounds, tests of liver function may be useful. But much more information is required about the chronic effects on health of pesticide chemicals in general.

#### 8. Workers exposed to radioactive chemicals

Systems of health surveillance of workers exposed to ionizing radiation are probably better developed and more uniformly applied than for any other category of occupational hazard. Exposure to radioactive chemicals is included in health surveillance applicable to all ionizing radiations.

The International Commission on Radiological Protection (ICRP) has, for many years, issued recommendations on the health surveillance of exposed persons, including workers exposed in close proximity to or in contact with radiation sources. Health surveillance procedures form only a small part of the total system of control, which is concentrated on limiting individual exposure. In the radiation field actual exposures can be accurately and conveniently measured and assessed quickly, and the likely effects are fairly well known for all but the lowest doses. Accurate records of exposure must be maintained for long periods of time, usually at least 30 years.

Radioactive chemicals are thus not typical of hazardous chemicals as a whole, though the measures designed to control their adverse effects form a useful model for other chemical exposures. Women of reproductive age and pregnant women are deemed to be especially susceptible and lower limits of permissible exposure are set for these vulnerable groups. Otherwise, specific health surveillance procedures such as clinical examination and full blood counts are required for all workers at certain levels of exposure. For those in the lower ranges of exposure no examination, other than an initial one on entering employment, is deemed necessary.

The ICRP recommendations should form the basis for any system of health surveillance of workers exposed to radioactive chemicals and compliance with them will usually suffice.

#### 9. Periodic examinations, advantages and disadvantages

Clinical examinations at regular intervals have been regarded as fulfilling a useful role in protecting the health of the general population, as well as contributing to the health surveillance of workers. Their main purpose has been to detect cases of disease at a stage when they are amenable to treatment, and to promote health through educational activities. As general health has improved, however, and as symptoms and signs of recognized diseases become less pronounced, the value of the clinical approach has been more critically examined and specific clinical or biological tests have tended to supplant medical examination by doctors.

There are differences between countries in the frequency with which medical examinations are required to be performed, both generally and in relation to occupational hazards. Further scientific work is necessary to determine optimum frequencies for various procedures.

Lack of specificity of many of the procedures employed has made the result of clinical examinations difficult to relate to actual occupational exposures. For this reason, biological monitoring procedures have been advocated in place of general examinations. These can offer a speedier and surer diagnosis to indicate departures from a normal state of health. In order to be effective they must be valid, that is, specific and sensitive, and remedial procedures must be available should abnormalities be detected. They may be performed by technicians, but the interpretation of results will usually require a medical specialist. Their overall cost is less than traditional examination and their function is directed more towards preventive measures than to treatment by medical therapies (5).

The use of screening procedures as regards chemical exposure is likely to increase, particularly as valid scientific procedures are developed for different chemicals. Apart from the advantages outlined above, they avoid the false feeling of security engendered by a declaration of normal health based on imprecise traditional clinical methods.

#### 10. Reflection of lifestyle of workers exposed to chemicals

Persons exposed to chemicals at work are also exposed to many non-occupational environmental and personal factors. These may themselves produce adverse effects on health, or they may interact with occupational exposure. Knowledge of the effects of such interactions is scant (6).

It is important, however, that these interactions are not forgotten when considering the effects of occupational exposures. The effects of alcohol or certain drugs, when combined with occupational exposure to organic solvents may be very different in degree from the effects produced by each agent acting alone. So, too, with exposure to asbestos and cigarette smoking, the combination producing considerably more cases of lung cancer than either agent alone.

Amongst the main non-occupational environmental hazards to which workers are exposed are general atmospheric pollution, known to contribute to chronic respiratory conditions, and ambient climatic factors whose effect in relation to occupational hazards is poorly established. General social conditions of living and diet may be important but there are virtually no reports so far of scientific work which might lead to applicable protective measures. Personal habits such as smoking, alcohol consumption and drug-taking may be relevant to the effects of chemical exposures at work, but much more research is required to clarify precise relationships.

In any system the possible effects of social and personal factors should be borne in mind. Opportunities should be taken to promote health as well as protecting individuals from the adverse effects of purely occupational hazards.

#### 11. Conclusions

The Consultation considered various papers and reached the following conclusions.

(1) Systems of health surveillance of workers exposed to chemicals vary greatly from country to country. Some systems are part of a comprehensive framework embracing surveillance for general health, with in-built treatment facilities. Others are virtually independent of general health care services. Surveillance is often organized on the basis of industrial categories rather than in response to specific chemical exposures.

(2) Greater uniformity and precision of health surveillance methods and their frequency of application is desirable. This uniformity has been hampered by inadequate information on exposures and by lack of knowledge of specific effects.

(3) Occupational health surveillance is concerned with changes in the health of individual workers or groups of workers, as measured by clinical or biological procedures. Its objective is to limit the harmful effects resulting from exposure to noxious agents by serving as a basis for active intervention or to enable remedial action directed at individual workers.

(4) Health surveillance must, in principle, benefit workers and be considered along with other methods of controlling exposure to hazardous agents at the place of work. Workers and management, and their representatives, must be kept fully informed of the objectives and methods of health surveillance and of the results. Results must be made available to them, though personal medical information must remain confidential.

(5) Health surveillance includes biological monitoring, an area of rapid scientific development. At present, the application of valid biological monitoring procedures is limited but it is likely that laboratory methods appropriate to workers exposed to many chemicals, including carcinogens and genotoxic compounds, will become available for routine practical use in the near future.

(6) Exposure to chemicals at work does not occur in isolation. Workers are also exposed to a variety of influences in the general environment, in their social conditions, and in personal habits. The effects of mixed exposures at work and the interactions between occupational and non-occupational factors have been inadequately studied.

(7) Information arising from health surveillance procedures constitutes an essential component of the total occupational health information system. To obtain maximum benefit it requires linkage to measurements of environmental exposures. In certain cases data from other health and vital records may be needed to offer individuals greater protection at work or better prospects for treatment.

(8) Certain groups of workers may, by reason of age or sex or specific physiological states, be at special risk from a particular chemical exposure. The pregnant woman is particularly at risk in this context. Special care is needed to safeguard the health of the foetus in the early stages of pregnancy.

(9) Systems of health surveillance depend on an accurate assessment of the hazard to which workers are exposed and to development of appropriate techniques to detect the earliest signs of biological effects. Surveillance is initiated at commencement of employment, with periodic re-examinations while exposure continues. The frequency of re-examination will depend on the time lag between the earliest appearance of biological effect and the development of irreversible changes. It may be necessary to continue surveillance after a worker has ceased to be exposed, or left employment, or has retired.

(10) It was not possible to develop specific guidelines for the health surveillance of workers exposed to individual chemical substances. In general, however, accurate recording of jobs, exposures to chemicals and state of health should be established. Arrangements should be made to retain such records for long periods of time.

(11) The cost-effectiveness and cost-efficiency of surveillance procedures requires further examination.

## 12. Recommendations

(1) Continuing studies of the health surveillance of workers exposed to new and existing substances are required. These studies should be primarily directed at eliciting the earliest biological changes or effects on health associated with measured exposures to chemicals.

(2) Health surveillance procedures require thorough validation before final acceptance and introduction into routine practice.

(3) Research is necessary to establish the effect of mixed exposures at work and also into possible interactions between non-occupational exposures and personal lifestyles and occupational exposure to chemicals.

(4) Further exploration of the possibilities of linking occupational health surveillance records to other personal health and vital records is necessary. Methods should be developed to improve the availability of the combined information to occupational and other physicians and to health authorities.

(5) Further research is required to determine the effect of exposure to chemicals on the pregnant woman and her foetus, as well as on the reproduction processes of both men and women.

(6) Workers must be fully informed about health surveillance procedures and their results, though the confidentiality of individual results must be respected.

(7) Within occupational health services there should be scope for assimilating the health complaints of workers so that previously unsuspected effects may be brought to light.

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Annex 1

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