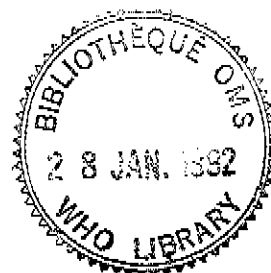


EPIDEMIOLOGY OF OCCUPATIONAL AND OTHER WORK-RELATED DISEASES



Office of Occupational Health
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INTRODUCTION

The meeting was formally opened by Dr E. Chigan, Director, Division of Noncommunicable Diseases, WHO, on behalf of the Director-General. After welcoming the participants and representatives of other organizations, Dr Chigan pointed out that the objective of this meeting of investigators was to review and promote the application of epidemiology in the investigation of occupational and other work-related diseases with particular reference to developing countries, and that the expected outcome of this meeting was a document which could be used as a reference for investigators of occupational and other work-related diseases in different parts of the world.

The meeting took notice of the relevant previous WHO publications (4, 9). It was agreed that the report of this meeting should not intend to be a replicate of these two publications but rather to put together experience and expertise in occupational epidemiology and to produce guidelines for the design, conduct and analysis of epidemiological research in occupational health. The meeting was particularly concerned that this document should be useful for researchers in developing countries without adequate access to experts in epidemiology and statistics.

The lack of resources and information generally distinguished the developing country from the developed, at least for occupational epidemiology. However, the differentiation was considered not to be absolute; for example, there were several developed countries in which information on fact of death and its cause were not available even to recognized epidemiologists for research purposes. On the other hand, it was imperative that those engaged in occupational health made the best of the available resources and information, however meagre these might be.

The meeting of investigators went on to consider the major tasks that faced occupational health physicians and epidemiologists in developing countries. The following list contained the more important tasks:

1. Risk evaluation
2. Health promotion
3. Development of an information collection and retrieval system on the health of workers in each enterprise
4. Development of an area or community-based surveillance network for work-related ill-health
5. Determination of relevant health standards, for example normal values of lung function
6. Occupational epidemiology training of professionals
7. Training of primary health care workers in occupational health to serve effectively with the occupational epidemiology team.

An important question was next discussed: where did the occupational epidemiology question come from, the workplace or the policy-makers? It appeared to originate mostly from the workplace: from the physicians, the health care workers, the managers, the workers' representatives, or the workers themselves. In developing countries, any pressure groups were unlikely to play much role and might not be knowledgeable in occupational health. However, pressure from international organizations might sometimes be effective to initiate an investigation of a particular occupational health problem. Multinational companies might also require assessment of adverse health effects as part of their own general management policy.

There was some indication that policy-makers in developing countries might reject data originating from developed countries. Their assumption was that the working environment and the general health status of workers in developing countries differed enough from the conditions in developed countries to make the developed country research not directly relevant. Under these circumstances, they argued that developing countries required descriptive epidemiology initially to reveal the hazards in the workplace, followed by other more sophisticated studies. Only local work of the occupational epidemiologist could convince the policy-makers to activate intervention programmes.

Such attitude in policy-making was to be regretted, as adverse health effects proven in a developed country were most unlikely to be absent in a developing country. It would be prudent to assume that they were present and to act accordingly. The limited resources should be better used to investigate and mitigate the special problems of the interaction of the effects of work, inadequate nutrition (if present), endemic diseases, child labour, etc., which occurred more frequently in the developing countries.

The combination of primary health care and occupational health in remote areas in developing countries was found not to be easy because countries differed in their policy towards provision of medical services to workers. Sometimes in remote agricultural areas, no medical services of any sort were available. The identification and alleviation of work-related health problems under these circumstances would require a special commitment from national authorities.

1. EPIDEMIOLOGY AND ITS APPLICATION TO OCCUPATIONAL HEALTH

1.1 Definition of terms

The terms used in this report are in general defined as in "A Dictionary of Epidemiology", Second Edition, by John M. Last (6). The reader is also referred to the glossary in "Epidemiology of Occupational Health" (4). It is noted that these definitions have received considerable general agreement but, in some instances, they are still falling short of universal consensus.

The key definitions for this report are:

1.1.1 Occupational epidemiology

The study of the distribution and determinants of health-related status or events in specified populations, defined by occupation, and the application of this study to the control of work-related health problems.

It is usually impossible to study a complete population. Sometimes explicitly, but often implicitly, the study group is a sample of the underlying population about which inference is being made.

1.1.2 Health services research

The integration of epidemiologic, sociological, economic, and other analytical sciences in the study of the health services. Health services research is usually concerned with relationships between need, demand, supply, use and output of health services. The aim of health services research is evaluation. Several components of evaluative health services research are distinguished: evaluation of structure; of process; of output; and of outcome.

1.1.3 Protocol

The plan, or set of steps, to be followed in an investigation, or in an intervention programme. It is most important to create a formal protocol before starting an epidemiological study.

1.1.4 Occupational epidemiology study

The design of study used to investigate the association between exposure to a hypothesized hazard and resulting adverse outcome, such as death, disease or injury. The main study designs are:

- Cross-sectional study (also known as a prevalence study or morbidity survey). A study that examines the relationship between diseases (or other health-related characteristics) and other variables of interest as they exist in a defined population at one point in time. The relationship between a variable (such as current dust exposure) and disease can be examined: (1) in terms of the prevalence of disease in different population subgroups defined according to the presence or absence (or level) of the variables, and (2) in terms of the presence or absence (or level) of the variable in the diseased versus the non-diseased. Note that disease prevalence rather than incidence is normally recorded in a cross-sectional study. The temporal sequence of cause and effect cannot necessarily be determined in a cross-sectional study.
- Cohort study (also known as a follow-up study, a prospective study or a longitudinal study). The method of epidemiologic study in which subsets of a defined population can be identified on the basis of exposure to a factor or factors hypothesized to influence the probability of occurrence of a given disease or other outcome. The exposure

classification can be based on present, past or future exposure. The grading of exposure can be into 2 levels (e.g. exposed and not exposed), or into more than 2 levels. The terms, follow-up, longitudinal and prospective, describe an essential feature of the design, which is observation of the population for a sufficient number of person-years to generate reliable incidence or mortality rates in the population subsets. This generally implies study of a large population, study for a prolonged period (years), or both.

- Case-control study (also known as case-referent study or retrospective study). A study that starts with the identification of persons with the disease (or other outcome variable) of interest, and a suitable control (comparison, reference) group of persons without the disease. The relationship of an attribute (such as exposure to a toxic substance) to the disease is examined by comparing the diseased and non-diseased with regard to how frequently the attribute is present or, if quantitative, the levels of the attribute in each of the groups. The information collected in a cohort study can be used to identify cases and control subjects for a case-control study.
- Intervention study. An epidemiologic investigation designed to test a hypothesized cause-effect relationship by modifying a supposed causal factor in a population. The effect of the intervention may be determined by comparing the study group with another, originally similar, population for which no intervention was made, or by comparing outcome in the population before and after the intervention. Evaluation of health promotion activities often use intervention methods.

1.1.5 Study Group

The group of all individuals selected for study. (Under some circumstances such as in an intervention study, the individual unit of study may be a factory, or other similar entity, comprising more than one person.) If the study involves time, the study group may be dynamic or fixed, dependent on the study design:

- Dynamic study group. A group that gains and loses members, for example by recruitment and wastage, such as in the study of variation of pneumoconiosis incidence from year to year.
- Fixed study group. A group for which membership is fixed by being present at some defined point of time or event. For example, the study group could be defined as all workers employed on some fixed date, with mortality followed from that date. As another example, the group could comprise workers exposed to an accidental emission of a toxic substance.

1.1.6 Control group

A comparison group, identified as a rule before a study is done, comprising persons who have not been exposed to the disease, intervention, procedure, or other variable whose influence is being studied.

The use of the word "control" may confuse even careful readers. In this sense, the adjective is used to describe a control group assembled for comparison with a group of cases. It does not automatically imply that sources of extraneous variation have been "controlled", either by the study design or by the statistical analysis.

1.1.7 Ratio

The value obtained by dividing one number by another. This includes rate, proportion, percentage, prevalence. Whereas rate specifically includes time as an element of the denominator, a ratio need not. The ratio is always an observed quantity.

1.1.8 Rate

A rate is a ratio whose essential characteristic is that time (per minute, hour, etc.) is an element of the denominator and in which there is a distinct relationship between numerator and denominator. The numerator may be a measured quantity (e.g. litres per day; centimetres per year) or a counted value (e.g. hospital admissions per year). Additional terms may be included in either numerator or denominator and usually are in the latter (e.g. calories per kilogram per day; attacks per 1000 population per annum).

While a number of commonly used demographic and epidemiologic "rates" are true rates in the above sense, others do not meet this definition. Even though the term "prevalence rate" is often used, it is not a true rate.

1.1.9 Risk

Risk is the probability that an event will occur, usually to an individual. It is often estimated by the incidence rate, but it is not an observable quantity at the time the estimate is made.

1.1.10 Incidence Rate

The rate at which new events occur in a population. The numerator is the number of new events that occur in a defined period; the denominator is the population at risk of experiencing the event during this period, sometimes expressed as person-time. The incidence rate most often used in public health practice is calculated by the formula:

$$\frac{\text{Number of new events in specified period}}{\text{Number of persons exposed to risk during this period}} \times 10^n$$

In a dynamic population, the denominator is the average size of the population, often the estimated population at the mid-period. If the period is a year, this is the annual incidence rate.

1.1.11 Prevalence Rate (Ratio)

The prevalence is the total number of all individuals who have an attribute or disease at a particular time (or during a particular period). The prevalence ratio is the prevalence divided by the population at risk of having that attribute or disease at the same point in time (or averaged during the same particular period). For a chronic or irreversible condition, the prevalence ratio may be high, even though the incidence rate is low. For short-term or acute conditions, such as asthma or the common cold, the incidence rate may be high (many cases per year), but the prevalence rate may be low (few cases today).

1.1.12 Standardized Mortality Ratio (SMR)

The ratio of the number of deaths observed in the study population, overall or for specified cause, to the number of deaths expected if the study population had the same death-rate structure as the standard reference population.

1.1.13 Proportionate Mortality Ratio (PMR)

The ratio of the number of deaths from a given cause as a proportion of all deaths in a study population to the number of deaths from the same cause as a proportion of all deaths in the standard reference population. The PMR differs from the SMR in that no knowledge is required of the numbers of people in the study or reference populations. PMR analyses can detect excess mortality from a particular cause, but they cannot detect overall increases, or decreases, in mortality rates relative to the reference population.

1.1.14 Exposure-response relationship
(also often known as a dose-response relationship)

A relationship in which a change in amount, intensity or duration of exposure to a substance is associated with a change - either an increase or a decrease - in risk of a specified outcome. Strong evidence of an exposure-response relationship is one of the more important criteria for judging that the exposure causes the effect. Care should be taken in differentiating between exposure (e.g. the amount of airborne dust) and dose (e.g. the amount of dust deposited, or retained, within the lungs).

1.2 Uses of epidemiologic methods

The need for epidemiological studies is extensive. They provide the primary evidence (apart from individual case reports) in people on the extent to which work affects health for good or ill. It is the ethical responsibility of all enterprises to determine what circumstances at work adversely affect health and to strive to eliminate such circumstances. This requires the assessment of cause and effect - the interpretation of findings of association.

It is very rare that individual case reports of disease can identify cause with certainty. Epidemiological methods are needed to determine what is probably a true cause and what is likely to be just a chance association. For injuries at work, an immediate cause may be obvious, but the underlying cause could also be in poor design, inadequate training and unsatisfactory management attitudes. The occupational physician must be prepared to identify such problems and to take necessary actions.

A Joint ILO/WHO Committee on Occupational Health has described the tasks carried out by an occupational health physician as follows (7):

- to assess the incidence and prevalence of ill-health in relation to work conditions;
- to identify occupational health problems in the light of the general health of the working population;
- to prepare and evaluate statistical records of sickness absences, use such records to identify causes, and propose measures to eliminate those causes;
- to use epidemiological and other methods to investigate occupational risk factors, the possibility of their prevention, and the means by which they may be prevented.

Hernberg (2) argues that the general health problems in a community "have a bearing on occupational health, since almost any disease can interfere with the working capacity of the employee and interact with his or her ability to cope with occupational exposures and stress. Hence, a complete picture of the community health of a workplace is crucial for any well-functioning occupational health service". The reader is referred to this text for a fuller discussion of the uses of epidemiology.

1.3 Concept of work-relatedness

A joint ILO/WHO Committee on Occupational Health (9) has suggested that the concept of work-related diseases should include not only recognized occupational diseases, but other disorders to which the work environment and performance of work contribute significantly as one of several causal factors. The Committee stated that: "when it is clear that a causal relationship exists between an occupational exposure and a specific disease or injury, that disease or injury is usually considered both medically and legally as occupational and may be defined as such. However, not all work-related diseases or injuries can be defined so specifically. Conceptually, they may be considered to comprise a wide range of diseases and injuries related in some way or other, not necessarily causally, to occupation or work

conditions. Classical occupational diseases represent one end of the continuum, while disorders with only a very slight occupational connection represent the other extreme. Many of the diseases contained within the continuum have a multifactorial etiology and may be work-related only under certain conditions. It should be mentioned that work can also have beneficial rehabilitative effects on certain pathological conditions, provided the workers concerned are properly placed in jobs suited to their capacities and limitations".

If the work-related factor is a sufficient cause for the disease, which is true for diseases referred to as "occupational", the demonstration of a cause-effect relationship is straight-forward. But when the work-related factor is only a contributory cause, i.e. one of several etiological factors, the cause-effect relationship is not so evident and its demonstration requires good epidemiological methodology. The smaller the work-related etiological factor, the higher the requirements for sensitive study designs. It should also be stressed that the magnitude of work-related etiological factors varies from one situation to another; in some settings, work may contribute significantly to the development of a certain disease, in others the work-relatedness of the same disease may be small or nil.

Work-related diseases other than classical occupational diseases comprise a spectra of disorders (8). For example, the occurrence of coronary heart disease can be elevated by chemical exposure such as carbon disulfide and nitroglycol, or by stress at work, exposure to cold or sedentary work. Chronic bronchitis is more common than usual in many dusty works, such as foundries, cotton mills, coal mines and in farming. In many developing countries, exposure to vegetable dusts such as those of cotton, flax, grain and wood is an important cause of the high occurrence of chronic bronchitis. Repeated infections during childhood due to overcrowding and exposure to smoke from cooking and baking in the home increase the sensitivity of many workers to organic dusts. Smoking is often an important co-factor, which illustrates the multifactorial etiology of this group of work-related diseases (9). Also, many musculoskeletal disorders are typical multifactorial work-related diseases, for example low-back disorders connected with heavy lifting and work in a bent position, or shoulder disorders among those working with their hands over shoulder level (9).

In some instances, diseases without any work-related causal relation can be aggravated by work; the disease then can be considered to be work-related (although not caused by work). One example may be a sports injury of the back, which starts giving symptoms in poor ergonomic settings at work.

Because work-related diseases, by definition, are at least partly caused or aggravated by work, their occurrence can also be reduced by means of reducing the hazard at the workplace, i.e. by improving work conditions.

Successful prevention requires identification and quantification of the problem; this is a task for occupational epidemiology. So is the application of epidemiological methods in evaluating the effects of the preventive measures undertaken.

1.4 Health services research

As can be seen from the definition in Section 1.1.2, health services research is concerned with the evaluation of the performance of health services. It is pertinent to ask how well occupational health services perform their tasks, how well they meet the goals of the enterprises they serve. Clearly, an inadequate occupational health service is unlikely to be able to meet the targets set out by the Joint ILO/WHO Committee on Occupational Health given above.

Epidemiological techniques form one of the evaluation methods for health services. However, the full evaluation methodology is outside the scope of this report and health services research will not be considered further.

2. OCCUPATIONAL HEALTH IN DEVELOPING COUNTRIES

This section is intended to highlight the main problems that those concerned with occupational safety and health in developing countries have to face when implementing occupational epidemiology studies. It is not the intention to review occupational health services or occupational health activities in developing countries.

2.1 Problems are not necessarily the same in developing countries

The specific problems in developing countries result from a combination of characteristics that differ from country to country and also within a country, like the interaction between various degrees of economic development, ethnic and cultural factors, climatic and geographic conditions.

In developing countries, numerous social and cultural problems frequently accompany rapid urbanisation and industrialization. Labour is weakly organized and there is a potentially large workforce which is most often provided only with minimum wages and services. A large part of the population may not know how to read and write or does not have an elementary education. Widespread poverty means that the fulfilment of basic needs of workers and their families is directly linked with the continuation of their occupation, almost on a day-to-day basis. Eating and sanitary conditions may be far from adequate. Malnutrition often causes a reduction of physical resistance and contributes to the increase of morbidity, facilitating the impact of occupational and work-related hazards. Climate and endemic infections also contribute to undermine workers' health making them more susceptible to certain hazards.

Agriculture is still the means of subsistence for much of the population in these countries. With the introduction of mechanisation and the extensive use of pesticides in agriculture, occupational hazards have increased. Most agricultural workers do not have medical facilities for early treatment, due to long distances, poor communications and insufficient medical personnel or basic health structures in the rural sector. Furthermore, temporary and permanent migration may facilitate the spread of contagious and endemic diseases. It is difficult to develop studies of seasonal workers and of long-term effects of occupational hazards.

In urban areas, most workers are employed in small enterprises with no social security protection or access to occupational health services. The unemployment rate is high and many workers are either temporarily employed or forced to be self-employed. Conditions of work are poor and there is often a low level of health in these populations.

In developing countries the general health needs of most workers in agriculture and small enterprises are usually met by rural health centres and peri-urban health care facilities; in most cases the provision of health care at work is separated from the general health services. In some developing countries, the concept of occupational health covers not only the work and working conditions, but also the global health of the workers and their families.

In developing countries occupational diseases or injuries arising out of work appear to be a relatively small proportion of the total morbidity in most working populations. But the ordinary health problems of the workers may be a reason for an increased susceptibility to occupational hazards. In addition, the high incidence of epidemic and endemic diseases may contribute to the appearance or aggravation of chronic multiple-origin illnesses and also to complicate or delay recovery from occupational disorders. A combination of malnutrition and infectious diseases like tuberculosis or malaria are often the cause of underweight, anaemia and a state of chronic fatigue resulting in a reduction of working capacity. Poor sanitation, a hot climate and overcrowding in slum areas aggravate the problem.

Climatic and geographic factors in tropical and sub-tropical regions are directly linked to an excessive physical workload in arduous jobs and to the difficulty of wearing personal protective equipment, when working in direct sun-light or confined places. The combined effect

of increased respiratory rate and a hot climate, can increase the absorption of chemicals. Furthermore, the altered level of normal bodily functions resulting from work at high temperatures should also be considered when undertaking epidemiological research on occupational health and working conditions. The risk of endemic diseases like malaria and other biological hazards should also be taken into account when developing epidemiology studies in these regions.

An occupational focus to health care provided by "the rural and community health centres" may prove appropriate for disease and accident reduction and for the promotion of health among these workers and their families. The primary health care structure in these countries can be a focal point for occupational health actions, giving the opportunity of a more systematic planning of the allocation of scarce resources to achieve improvement of health for the largest possible number of workers.

Occupational health priorities vary between developed and developing countries. Developed countries have a long tradition in occupational health management. Therefore most of the main hazards have already been controlled to some extent or at least recognised. Even though occupational epidemiology could be considered to be in a "developing stage" in almost all countries, in the developed countries epidemiological research is more oriented to the problems related to analytic epidemiology as, for example, the identification of work-related diseases and their control.

In developing countries, the facilities for the application of occupational epidemiology are limited, not only for the study design itself but also because of the difficulties in obtaining sufficient and reliable information from existing data sources. Data bases on the health of workers and on hazards of specific sectors are insufficient. In many cases the size of the working population is unknown and census data are out of date and inadequate.

In most developing countries the magnitude of exposure problems at the workplace is very high, but not well-known. Sometimes the need for improvement and the solutions of the problems may be so self-evident that biological monitoring is not necessary. The epidemiological priorities in these countries still lie in the "mapping" of the field through epidemiology.

The application of epidemiological techniques and methods to occupational health in developing countries should be mainly oriented towards making techniques "at grass root level" accessible to health care personnel with little or no formal statistical training. The specialist needs to select and adapt the more relevant methods and techniques to the actual needs of developing countries.

2.2 Variations among and within developing countries

Among developing countries there is a great variety of models of occupational health organization and planning. There is an extremely low coverage of occupational health services and insufficient occupational health action. As occupational health is not considered a priority, financial resources are oriented mainly to solve basic needs of the population and very little is dedicated to occupational health.

Occupational health resources in developing countries are low and the needs in this field are rarely covered effectively. In most of these countries, there is a shortage of medical and health personnel. The services available to workers are provided mainly by governmental or state institutions. The local or centralized services that can provide preventive programmes, first aid assistance and control of occupational hazards are insufficient.

National bodies concerned with occupational health and safety do not always have a clear definition of their responsibility. Most of the time there is no coordination among them, resulting in duplication of effort and waste of the already limited resources available. In many cases legislation on occupational health and safety matters is poorly developed and sometimes it is mishandled or not applied as originally intended.

There is insufficient education and training in occupational safety and health matters for workers and technical personnel in all branches of occupational health and safety. Most universities do not include postgraduate courses in occupational health and safety, although this also applies to many universities in developed countries.

In some countries the institutions that traditionally deal with occupational health services (Ministry of Labour, Ministry of Health, Social Security System) have their own standards for the control of the working environment, and for compensation. These standards have usually been adopted from developed countries without taking into account the local conditions. Due to lack of coordination there may be contradictions among standards between the different national bodies. Factory inspection systems are often weak. Technical personnel are usually insufficiently trained. There are many administrative obstacles to an appropriate surveillance of the working environment.

In spite of this fragility and insufficiency, the variety of organizational models in the different countries, and, in some cases, within the same country, is a clear demonstration of the potential and creativity existing in these countries to overcome these prevalent deficiencies. So, for example, cooperative service models for groups of industries have been developed in some countries. In others, employers' organizations have been developing occupational health programmes efficiently, but such models are not known in other countries. In other cases, public health services develop occupational health activities; experience based on these models has begun to appear in various countries, but the progress and characteristics of these developments are not widely known.

2.3 New technologies

Some developing countries have suffered from adverse effects due to a very fast process of industrialization. The introduction of new technologies in modern industry provokes the reorganization of working methods, working conditions and new forms of work management. These may result in new environmental hazards, modification of physical and mental workloads, stress and other psychosomatic illnesses. The introduction of new production processes and equipment, together with a lack of information of new work processes makes estimation of exposure to hazards very difficult. Risky work induces a high turnover of the workforce, obliges the workers to accept hazardous occupations and makes epidemiological follow-up difficult.

2.4 Workers' participation

Occupational health cannot develop extensively and have an effective influence without the active participation of workers.

In developing countries, workers' participating in the collection of information on occupational health may be a key source for obtaining relevant information for epidemiological research. Workers involved with a small part of the production process usually know a lot about that particular process and can assess their health conditions directly. They can provide appropriate information about the hazards they encounter in the working environment. They have direct experience of the factors outside and inside the workplace that, taken together, determine their health. This experience can be systematised with training in a method to determine their needs, making them able to verify whether their particular job carries a high risk of work-related accidents and diseases. Their active participation in the management of occupational health may become a primary contribution to epidemiological research at the local level where work groups perceive their circumstances directly. Workers can become promoters for the improvement of their own health in the workplace and for the application of epidemiology in the prevention of hazards.

It is frequently necessary at the same time to make employers aware of the importance of occupational health problems and of the exact nature of their responsibilities towards their employees. This places an accent on the usefulness and economic value of their contribution.

3. NEEDS AND PRIORITIES OF OCCUPATIONAL EPIDEMIOLOGY IN DEVELOPING COUNTRIES

3.1 General Needs

3.1.1 At the individual level

Even one small-scale epidemiologic study that helps to document or solve a specific occupational health problem for a small group of workers is an important achievement. The sum of all such studies and preventive measures leads to improved health and safety in the workplace.

The most important requirement is that a person with some knowledge of occupational epidemiology decides to plan, implement, and follow up upon a study according to epidemiologic principles.

A good and useful study need not be expensive. Both exposure and effect measurements may sometimes be performed with inexpensive, readily available equipment and facilities.

Development of occupational epidemiology in a developing country is most likely to proceed in a stepwise fashion, with one study leading others with a gradual growth in competence. It is rather unlikely that an integrated set of capabilities and facilities would be established during a short period.

3.1.2 At the national level

In the long-term, there are several general needs of occupational epidemiology in developing countries. Many of these should develop as evidence on occupational and work-related hazards grows, particularly following confirmation from epidemiological studies within the country itself. These include:

- Commitment to occupational health and safety by government, employers, and workers;
- National occupational health and safety policy;
- Laws and regulations on occupational health and safety;
- Financial and administrative support for occupational health and safety;
- Availability of adequately trained personnel, which requires education and training programmes as well as employment (job) opportunities for trained personnel;
- Information systems on industries and workers, exposures, and, at a national level, morbidity and mortality;
- Determination and national priority-setting of problems and what can be done about them.

3.2 Priorities

3.2.1 At the individual level

It is the occupational physician, or similar health worker, in the individual enterprise who must eventually be responsible for setting local priorities for epidemiologic research, based on the information and resources available. Priority problems should be ranked according to the frequency and severity of the perceived hazards, the number of workers at risk, and the extent to which the hazard could be prevented or controlled. In setting the priorities, the opinions and perceptions of the workers and employers need to be considered.

Occupational epidemiology in developing countries, as elsewhere, ideally should be action-oriented. The findings of studies should be of practical usefulness. As a priority, studies should be designed to be performed in a short period of time with appropriate available resources. They should be on a focused topic. Workers and employers should be involved not only in the setting of the priorities, but also in participating in the development and performance of any study. Results of studies should be applied for prevention and control of

problems shortly after studies are completed, although prevention and control measures should not wait for implementation until studies are completed. There should be a clear advance commitment by employer, and employees, to take or support appropriate action based on the epidemiological studies.

3.2.2 At the national level

The main task is defining the magnitude of various occupational health and safety problems in a country. This involves obtaining information on work (industries and their size, characteristics of the working population, and exposures at work - which workers are exposed, to what, and at what intensity) and obtaining information on health and safety problems, for example by surveys of health status, use of available morbidity and mortality data, and walk-through surveys in industries thought to be at high risk.

At the national level, priority problems should be ranked according to frequency of the hazard, its severity, the number of workers at risk or affected, and amenability of the problem to prevention or control, by the setting of appropriate control measures.

Scarce national resources for epidemiology in occupational health in developing countries should be used effectively. This implies better coordination, information-sharing and communication among ministries within a given country, among governmental and nongovernmental organizations (including employer organizations and labour unions) within a country, among countries within a region (with establishment of regional projects or even regional resource centres, whenever possible), among developed and developing countries, and with international organizations such as WHO and ILO. There also needs to be:

- better integration of available resources;
- national support for training and appropriate involvement of workers, employers, health and safety personnel, and others;
- a multidisciplinary approach to studies and follow-up prevention and control activities.

4. PRACTISING OCCUPATIONAL EPIDEMIOLOGY IN DEVELOPING COUNTRIES

4.1 Source of data in developing countries

Before planning an epidemiologic study, the investigator must consider if all essential data are available. For example, there is no point in planning a mortality study, if adequate records on fact and cause of death are not available locally or from national records. It needs also to be recognized that epidemiological studies consist of comparisons between at least two groups of people. The investigator must be sure that the availability and quality of information is similar for all groups of people. This may be a particular problem if one of these groups is the national or regional population.

Some sources of data for epidemiological studies are:

4.1.1 National data

- Population census data
- Registers of the number of people employed in each work sector (by industry)
- Compensation fund (social security) data:
 - . injuries (reported by the factory);
 - . diseases (reported by the workers based on certification by a physician - usually much under-reported).
- Mortality and cancer registries
- National health statistics, such as hospital discharge statistics
- National occupational surveys, for example, of workers exposed to asbestos.

4.1.2 Regional or local data sources

- Industry:
 - . Employment registers
 - . Occupational injuries and diseases reporting records
 - . Pre-placement and periodic health examinations records
 - . Environmental monitoring records
 - . Biological monitoring records
 - . Retirement and mortality records
- Trade unions:
 - . Membership records
 - . Retirement and mortality records
 - . Reported injuries at work and work-related diseases
- General:
 - . Medical records of general practitioners
 - . Medical records of health centres and dispensaries
 - . Regional health statistics

4.1.3 Special surveys or studies

- Prevalence surveys of specific diseases and problems
- Surveys of occupational and environmental exposures
- Intervention studies
- Knowledge, attitudes and practice surveys.

4.2 Preparation of study protocol

The first formal step is the writing of a protocol specifying the conduct of a proposed study. This is a written document which includes general and specific objectives of the study, literature review, relevant background information, the design of the study (sampling, controls, etc.), outcome definitions, methods of measurement (equipment, calibration techniques), statistical methodology, study schedule, responsibilities of specific investigators and technicians, costs, confidentiality, and utilization and publication of the results.

The study protocol needs to be submitted for comment to all parties involved in the study: the research team, management, workers' representatives. To increase confidence that the study would achieve its aims, the investigator could prepare an outline of what the results of the proposed study are expected to be. The scientific and practical consequences of these postulated results should be imagined. Then these could be presented to colleagues for assessment and criticism. If the colleagues are convinced that the imagined consequences would follow from the postulated results, then the investigator could proceed with the study with more assurance.

4.3 Selection of study design

In developing countries, there may be severe limitations on the options for study design. These limitations affect the identification of adequate populations (exposed and reference) for study, the assessment of exposure to a possible hazard, and the measurement of the outcomes of interest. The populations for study are affected by labour migrancy, lack of job security and absence of population registers. Exposure to occupational hazards is rarely assessed in developing countries and the frequency of job change means that most workers have been exposed to a variety of unrecorded hazards. Morbidity can be measured by special surveys, but mortality records are often inadequate and biased. Any study design therefore faces serious problems of missing data, and cohort studies would probably suffer most. All these shortcomings make the study of occurrence relations (etiological epidemiology) very difficult indeed, and etiological problems can be addressed only under exceptional circumstances.

Epidemiological studies in developing countries therefore are best suited for:

- the observation of morbidity (any deviation from "health") in relation to occupation, work area or different exposures,
- identification of risks,
- observation of the effects of preventive action (intervention studies),
- surveys of exposure data (by environmental or biological monitoring).

Most of these targets can be addressed by cross-sectional and/or case-control studies. Cohort studies are likely to be unsuitable, unless the working population is reasonably constant and a suitable comparison population exists.

Although cross-sectional studies are seemingly easier to carry out, they can face serious problems of validity. Traditionally occupational cross-sectional studies only assess the health of current workers. However, the very issue under study may have forced the worker to quit the job. For example, if exposure to cotton dust causes severe chest tightness, that may force the most affected ones to quit, leaving a so-called "survivor population" in active work. The lung function of current workers is likely to be better than that of the drop-outs. Hence, cross-sectional surveys can be subject to negative selection bias, resulting in an underestimate of the true effect. In order to estimate the magnitude of that bias, at least a statistical sample of missing persons should be studied. But even in that sample, it may not be possible to obtain data on everyone. Therefore, the interpretation of cross-sectional results must be cautious and it must be kept in mind that the true effect may have been diluted. Yet, cross-sectional studies can demonstrate the existence of major health effects, even if the results are diluted.

It should also be understood that cross-sectional surveys are limited to the study of the prevalence of a disease. Incidence studies always require designs involving time. Cohort studies look forward from exposure to incident disease or death. Case-control studies look backwards from incident disease or death to the exposure. The problems of undertaking cohort studies has been discussed above.

Case-control studies have considerable advantages for occupational health research in developing countries. Scarce resources can be used effectively to investigate prior working and exposure histories of available cases and suitable controls. However, biases can also arise in these studies. A clear definition of the population being studied is essential. Then the cases must be all cases in that population, or an unbiased sample of all cases. The choice of the control group (see section 1.1.6) for comparison requires equal care. Too often, a case-control study has proven irrelevant because the controls differed too much from the cases in factors which could have been associated with the disease being studied.

Even if one or both of the populations at risk is unknown, analyses of mortality data are still possible, using Proportionate Mortality analyses (see section 1.1.13). The basic requirement is that all deaths, together with particulars of cause of death, are known equally accurately for both the population being studied and the comparison population.

The Proportionate Mortality Ratio (PMR) relates the proportion of deaths due to a specific cause to all deaths in the study group, to the similar proportion in the reference population. The PMR has weaknesses, e.g. because, being a proportion, it does not reveal increased mortality from one cause if the others are also increased. A better alternative is to use only one disease category, unrelated to the exposure under study, as the reference disease, and to compare those ratios.

Thus, choice of study design is governed by the question to be asked and the available resources - people, equipment, finance, time. A small well-conducted study which answers a relevant question is far more valuable than a large ill-directed study. The investigator needs to ensure that the study results can be interpreted reasonably in relation to exposure and response.

4.4 Survey instruments

This section presents some information and comments about the tools that can be used in occupational health research. Clearly, it cannot be comprehensive. Different exposures require different measuring instruments and different diseases require different diagnostic instruments. The tools must be targeted at the questions being asked in the epidemiological study.

Nevertheless, there are certain basic and common tools. Most of these have been validated as measuring instruments. But, it must be emphasized that all tools used must be calibrated and standardized. Pre-tests should be carried out and quality control of the measurements must be maintained. For example, there is no point in using the ILO 1980 Classification of the Radiographs of the Pneumoconioses (7) if the standard films are not used or if the study films are of rather poor quality.

4.4.1 Personal

Questionnaires (self-administered or by interview) are very commonly used. An example is the United Kingdom MRC Respiratory Questionnaire, which has been translated into many languages. If a new questionnaire is being designed, the investigator should aim to include only those questions necessary to identify the person, collect relevant personal information (date of birth, sex, ethnic group, smoking habits, etc.), determine pertinent health status, and ask about exposure circumstances (past and present).

The investigator must be aware that variety of language and subject illiteracy could seriously compromise the use of a questionnaire.

Clinical examination should be carried out, if relevant to the aims of the study. In practice, a clinical examination may also be justified as an encouragement for subjects to participate.

Measurement of the person. Examples include pulmonary function tests, radiography, hearing tests, biological monitoring.

For pulmonary function testing, the investigator should use a peak flow meter or a robust spirometer, able to withstand the conditions under which the study is to be conducted. With a suitable spirometer, FEV₁, FVC and all flow rates can be measured simultaneously. More sophisticated tests are either not needed at the survey level or their validity is difficult to guarantee under field conditions. The investigator will need to ensure that technicians are adequately trained, so as to increase validity and reduce operator error.

The ILO Pneumoconiosis Classification is an excellent tool for assessing response to dust exposure. The Classification includes details of required film quality, technical standards, and the methodology of reading chest radiographs to the required standard. Readers require training (3).

Hearing loss detection requires good quality audiometry. As for radiography, this usually means that the person to be tested must attend the place where the equipment is kept. The standards of the laboratory should be checked by the investigator, perhaps using repeat audiograms. Audiometry should be performed well after exposure to noise has ceased to guard against effect of temporary threshold shifts.

Biological monitoring of blood and urine provides much relevant information about effects of exposure to some hazardous substances, including cigarette smoke. Any biological monitoring should only be relevant to the purposes of the study. The investigator should ensure that the laboratory does provide repeatable results, using duplicate samples.

4.4.2 Environmental assessment

Environmental information can be collected at the time of an epidemiological study, using a special survey. This information about current exposure levels would be appropriate if the health problem is acute, such as dermatitis, lead intoxication or asthma related to some dust exposure.

The techniques for measuring environmental pollutants are mainly well-defined. If in doubt, the investigator should seek professional advice on the sampling methodology and measurement techniques.

Often, however, the concern is with a condition that appears many years after exposure, such as asbestosis or lung cancer. Then, the investigator needs some idea of how much exposure there has been in the past. If working conditions have improved, present exposure levels may provide little useful guidance. Years of exposure (or working in a particular environment) may be a useful first proxy for total exposure. Otherwise, estimates will have to be made of past exposures, or at least gradings of past exposures from 'low' to 'high'. These estimates can then be used to differentiate the exposure levels for individuals who have worked for the same lengths of time. This differentiation is particularly important for case-control studies, which require information on past exposures to be able to determine risk associated with the exposure. Note that it may be useful to look at the records of the enterprise to determine when changes in raw materials, technology, production rates, etc., occurred, as an additional guide on environmental exposure levels.

4.5 Reference physiological/biochemical values

At present, the only reference physiological/biochemical levels available are from industrialized countries, such as those provided by NIOSH. These may not be suitable for developing countries, where baseline (unexposed) physiological/biochemical levels differ from those in industrialized countries.

This lack of baseline values can be a problem, but need not always be so for epidemiological studies in developing countries. For example, reference values for lung function for Caucasians are readily available. Indeed, some commercial spirometers include the values within the built-in computer programs. However, these values are inappropriate for many other ethnic groups, if only because of differences in body shape.

However, the essence of epidemiology is comparison. It is often more value to compare lung function in the study group with that in a comparison group. The underlying assumption must be satisfied: the only important difference between the study and comparison groups is in the exposure to the hazard under study. If lung function is measured in both groups at the same time, with the same instrument and by the same technician, then any difference in lung function may reasonably be attributed to the effects of exposure. There is no need to use reference values of doubtful relevance.

4.6 Data processing and analysis

There is a basic assumption that all epidemiological studies require computing facilities with sophisticated programs. If this were true, there would have been no epidemiological study before the advent of computers. For certain studies, graph paper and calculator are the only tools necessary for statistical analysis. Investigators should certainly be encouraged to conduct such simple studies.

For much of the remainder of this section, it refers to situations where the data analysis will be better carried out using a computer. In many cases, a microcomputer is adequate and one should be available to all epidemiological research teams. The following discussion assumes that computing facilities are available.

4.6.1 Data processing

The steps following receipt of data about study individuals and about the working environment involve the entry of data to the computer system, the validation of these data and the statistical analysis.

The entry and validation of data is usually much more time-consuming than expected and takes longer than the data analysis. Its importance cannot be over-emphasized, because the results of a study depend absolutely on the quality of the data available for the statistical analysis.

Data entry requires control procedures to ensure that data created in a study are all entered to the computing system. This will often need formal recording of receipt, entry and checking of each datasheet. During the data entry procedures, simple checks on the items of data should be carried out, preferably by a computer program. These checks can be absolute, for example sex must be male or female; can be type, for example dates must be valid; or can be warning, for example male height should be between 1.4 and 1.9 metres.

The process of data entry must also link together information on the same person even if recorded separately, for example personal questionnaire, blood lead level and exposure information.

The purpose of data validation is to ensure that all data entered are correct, as far as can be judged from examination of the data. There are no formal rules to ensure that data are correct but there are techniques that can help. Most of these involve the "Eye Test", that is looking at distributions of the data. The primary tools are the histogram, the scattergram and two-way tables. A histogram will show when a single value is extreme, beyond the range of the values for other people. Scattergrams are of great value. A Vital Capacity of 0.53 litres is within the possible range, but a scattergram would show that such a value for a young male would be extreme, much too low. It is likely in such a case that the value should have been 5.3 litres. Scattergrams can also be used to detect impossible values, such as a 20 year-old with 16 years duration of employment.

All questions raised by validation and consistency checks need to be answered before statistical analysis starts.

4.6.2 Statistical analysis

The statistical tool to be used is governed by the study design and by the type of variable to be analyzed. The type can be a measurement, such as the level of lead in the blood, or can be an attribute, such as the presence of disease.

Whatever analysis is used, it will involve comparing information on groups. Usually this information consists of the average value of a measurement or the proportion of the group with the attribute.

It is impossible to include a comprehensive manual of data analysis in this report, but some guidance follows. There are several textbooks to which reference may be made, such as Colton (1) and Kirkwood (5).

The seeking of advice from a statistician on design and analysis should be considered.

In prevalence studies, measurements require t-tests for comparison of two groups (e.g. exposed and unexposed). The equivalent analysis of variance techniques are used for comparing more than two groups (e.g. with high, medium and low exposure). Linear regression may be used to relate the measurements to information on exposure and to make allowance for confounding factors, such as smoking habits.

The results from an analysis of a measurement should preferably be presented as the average value of that measurement, after appropriate adjustments for confounding factors, together with some statement of the accuracy of that average. In particular, the confidence interval is an easily understood concept, and conveys more information than a statistical significance test.

In prevalence studies, the response variable can be the presence or absence of disease. Thus for any group, the information reduces to the proportion of people with disease. As for measurements, there is a family of techniques for the analysis of proportions. To compare two or more groups, chi-squared techniques are appropriate. To take account of confounding factors, the groups may be subdivided into strata, such as non, ex and current smokers and the chi-square analysis applied to each. It is important to summarise the evidence in terms of rate ratios or rate differences, as these are the findings on which decisions about actions must be taken. If stratification is used, the combined evidence on rate ratios may be determined by using the Mantel-Haenzel techniques.

Alternatively, the prevalence ratio of an attribute in a group can be related to exposure, taking account of confounding factors. An appropriate technique is logistic regression which is conceptually similar to linear regression of measurements, but takes account of the fact that a prevalence ratio must have a value between 0 and 1.

The characteristic features of incidence studies are: (1) outcome is always related to some measure of prior exposure, and (2) the time course of exposure and the time when response occurred are recorded. By ignoring time, or by stratifying into different time-exposure periods, the techniques described above for prevalence studies may be used.

In addition, analyses involving time can be undertaken using appropriate methods of survival or cohort analysis.

4.6.3 Computing facilities

For most epidemiological studies, access to suitable computers can be extremely important in facilitating the data processing. In most cases, a combination of a relatively simple PC with straightforward inexpensive statistical package programs is all that is needed.

Some suggestions for suitable micro-computer equipment and programs is given in Annex 1.

CHAPTER 5. SUPPORT FOR OCCUPATIONAL EPIDEMIOLOGY IN DEVELOPING COUNTRIES

5.1 Two important needs

In addressing support for occupational epidemiology in developing countries, there appear to be two important needs. First, many developing countries have at the national level, usually in governmental organizations or universities, well-trained occupational health professionals and epidemiologists; however, at the district and local levels, there are few such people, if any. There is therefore a need to develop such capabilities at the district, or intermediate level. Second, in many developing countries, there is inadequate integration and coordination among different organizations dealing with occupational health and also between these organizations and those involved in primary health care. There is therefore an additional need to integrate and coordinate these services.

5.2 Infrastructure development

A critical challenge is to develop expertise in epidemiology in occupational health at the district, or intermediate, level. The major ways of meeting this challenge include generating local and district capabilities to collect, analyze, and disseminate data (conduct basic

surveillance) in order to make decisions and solve practical problems; and clearly defining responsibilities at the local and district level for surveillance, research, training, and enforcement. The needs and responsibilities at each level are described below.

5.2.1 Local level

At this basic level, the main function for occupational epidemiology is to support epidemiological activities at higher levels, primarily by collecting descriptive data. These descriptive data should include information on types of work processes, characteristics of the working population, occupational hazards and risks and workers' exposure to them, and adverse effects on workers' health and safety. Local activities in occupational health include:

- identification and solution of occupational health and safety problems in the workplace;
- diagnosis and treatment of work-related disease and injury;
- implementation of preventive measures;
- dissemination of information;
- education of employees, employers and primary health care workers to increase awareness.

Personnel to carry out these activities need to have a minimum amount of technical training. These personnel can include nurses, public health or occupational health inspectors, or workers with special training.

5.2.2 District level

This is the main level for analyzing data obtained from several local areas, for making decisions in order to control hazards, for implementing monitoring programmes, and for conducting action-oriented research. In order to carry out these activities, there needs to be a minimum of technical support available at the district level to conduct measurements in the field, to develop and present training programmes for people at the local level, and to perform other activities. These individuals require a basic knowledge of epidemiology and basic equipment to conduct surveillance and perform epidemiological studies.

5.2.3 National level

At this level, occupational health policy is made and national occupational epidemiology studies are designed. At the national level, those responsible for occupational health should guarantee that technical assistance and support are given to people at the district level. Therefore, there needs to be at the national level people who have been well trained in epidemiology in occupational health with adequate technical support and equipment, such as computers and laboratory equipment. There needs to be adequate postgraduate training. These people should offer postgraduate or other relevant courses to people responsible for occupational health at the district and local levels. At this level, people also have the responsibility for ensuring that there is adequate coordination among the several institutions dealing with occupational health.

5.2.4 International level

International support can play an important role in the development of epidemiology in occupational health in developing countries. Forms of support include financial and other administrative support, technical support (including provision of information, training and education, technical assistance and consultation) and partnerships. Support can cover a variety of activities ranging from fellowships to learn research techniques to expenses for attending courses or conferences, and can result from bilateral or multilateral agreements.

Sources of support are:

- United Nations Specialized Agencies:
 - . World Health Organization (WHO)
 - . International Labour Office (ILO)

- International Nongovernmental Organizations (NGOs):
 - . International Commission on Occupational Health (ICOH)
 - . International Epidemiological Association (IEA)
 - . International Association of Agricultural Medicine and Rural Health (IAAMRH)
- Important Funding Organizations:
 - . Rockefeller Foundation
 - . International Clinical Epidemiology Network (INCLEN)
 - . International Development Research Centre (IDRC)
 - . Canadian International Development Agency (CIDA)
 - . Swedish International Development Agency (SIDA)
 - . Others: FINNIDA, DANIDA, NORAD, USAID, GTZ, JICA
- Regional political or economic associations, e.g. European Communities (CEC)
- Important National Occupational Health Institutes:
 - . US National Institute for Occupational Safety and Health (NIOSH)
 - . Finnish Institute of Occupational Health
- International Trade Organizations
- International Labour Unions.

6. RECOMMENDATIONS

The meeting of investigators considered what actions could be taken by the workers' health programme in the World Health Organization to promote the good practice of occupational epidemiology in developing countries.

6.1 Investigators' Forum

Many occupational epidemiology investigators in developing countries are believed to work in isolation. This occurs because there are few such people practising epidemiology, so there will be few peers within easy contact distance. There are also very limited resources for funding travel to meetings at which they could present their work and discuss their problems.

The meeting recommended that WHO should seek and provide some funds to arrange meetings to which developing country investigators could be invited to meet and share experience with colleagues from neighbouring countries in the same WHO Regions. Experienced investigators from developed countries could also be encouraged to join these meetings to share their knowledge.

6.2 Role of WHO Collaborating Centres for Occupational Health

The WHO Collaborating Centres for Occupational Health should be involved to play at least three major roles in support of developing countries on occupational epidemiology.

First, they should host the investigators' meetings recommended above. This would involve encouragement of their staff to participate in these meetings - probably to the benefit of all parties.

Second, they should actively encourage the practice of epidemiology by direct support: the short-term secondment of staff to assist in the design and conduct of studies; and the provision of an "at-distance" help line for investigators in developing countries.

Third, they should encourage their occupational health students from developing countries to appreciate that they could readily undertake basic epidemiological studies themselves in their own countries. Through such encouragement, the practice of epidemiology could develop rapidly in developing countries.

6.3 Basic epidemiology manual

While assessing the texts available for reference on epidemiology and statistics, the meeting concluded that there was no inexpensive manual suitable for use in developing countries covering the basic requirements for the design, conduct and analysis of occupational epidemiologic studies.

The meeting recommended that WHO should commission such a manual as a matter of urgency. It was also recommended that this manual should be distributed, free of charge, to those wishing to practice basic occupational epidemiology in developing countries.

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COMPUTING EQUIPMENT AND SOFTWARE

A. Hardware

There is a wide range of makes and powers of microcomputer available. Most are "IBM-compatible" and it is strongly recommended that any computer purchased should meet that standard. This is because most of the suitable software has been written for such compatible computers. The prices quoted below are approximately those for which equipment can be bought in USA in 1990.

If there may be problems with the stability of electrical supply, then a battery-driven model is recommended. These generally have battery-chargers built in and they can run on mains supply, when available. With the mains, they can also operate with standard display screens rather than the LCD (liquid crystal display) or similar flat screens fitted. Unfortunately, battery driven computers tend to cost rather more than others for the same facilities.

The 386 series and later machines are not only generally faster than the 86 and 286 computers, but their architecture provides additional facilities which could be useful.

A hard disk is essential for storing programs and data. The additional cost of buying a larger, say 100 Mb (megabyte = 1 million characters), rather than a 20 Mb hard disk is small, particularly when contrasted with the cost of an epidemiological study.

Effectively, the investigator should purchase the most powerful machine, with the largest hard disk capacity, that funding permits. Typically, in 1991, this would be an IBM-compatible 386 with 110 Mb of hard disk storage (\$2800). Battery versions with a 40 Mb hard disk are available (\$4000). The investigator should also consider the purchase of the maths co-processor, if much statistical work is to be undertaken (\$700). The co-processor is an additional computer, in a single micro-chip, designed solely to speed up mathematical calculations.

A printer will be essential. These can range from basic dot-matrix printers for 1/4 the price of a computer to laser printers suitable for high quality text printing (\$2200). Laser printers are to be preferred because of the quality of their output and because of the low noise levels. Inexpensive portable printers are also now available, with output nearly as good as laser printers (US\$700).

B. Software

The cost of software for carrying out the tasks can far exceed the cost of the computer. The investigator must be aware that there is a considerable increase in effort to outlaw software piracy - that is the copying of programs from other computers. In some countries, penalties can be severe.

The following lists examples of software packages that the investigators attending this meeting use and have found useful:

Word processing:	WordPerfect, MS Word, Wordstar
Spreadsheets:	Lotus, Quattro
Graphics:	Harvard Graphics
Databases:	dBase, DataPerfect
Statistical packages:	EPI-INFO (data entry and editing) Nanostat, Minitab (for most statistics) SAS, SPSS (for large datasets) GLIM (for linear modelling analyses) Epistat (for epidemiological analyses).

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