CANCER AND WORK
Making sense of workers' experience

by John Fox, David Gee, David Jones, David [illegible]

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The connection between cancer and particular occupations is now well known. There is an increasing awareness of the dangers of materials such as asbestos. In general people are becoming more concerned about the health risks associated with exposure to many different things at work and in the community. New reports or suspicions about the cancer risks associated with particular jobs or materials are now almost commonplace.

This booklet is aimed at people with an interest in but little or no experience of the methods that are used to assess these risks. If they are members of health and safety committees at their place of work, it should help them to understand the advice they receive from time to time, to ask pertinent questions and to participate actively in the planning of further work. It describes simple methods to help see whether initial fears are justified and then suggests ways in which these studies should be followed up. It indicates the limitations of epidemiological studies, and encourages people emphasising, in particular, the importance of a sound statistical analysis of the data collected.

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Cancer and work: making sense of workers' experience

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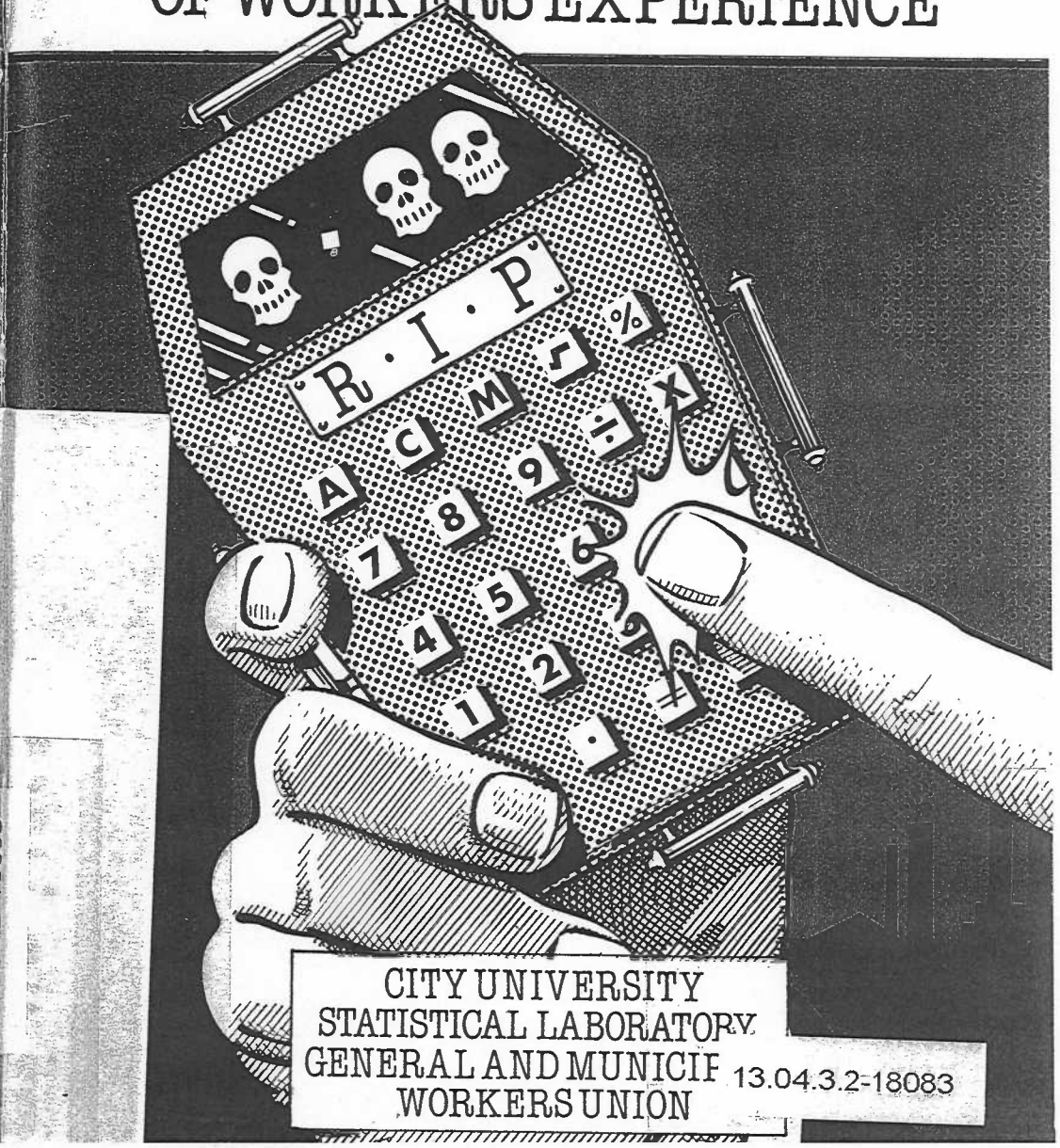
CANCER & WORK

MAKING SENSE OF WORKER'S EXPERIENCE



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Prepared by The City University Statistical Laboratory in collaboration with the General and Muncipal Workers' Union

Authors:
John Fox, David Gee, David Jones and David Leon

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PREFACE

by
David Basnett
General Secretary.
General and Municipal Workers' Union

Experts acknowledge that between 1400 and 7000 cancer deaths a year in England and Wales are caused by harmful substances found at work and are therefore preventable. Many of these deaths have been of General and Municipal Workers' Union (GMWU) members employed in making or handling town gas, dyestuffs, rubber goods, asbestos, radiation, water purification agents, nickel, PVC, cadmium and other products whose manufacture or use carries a risk that those employed will develop and then die from cancer. In industries such as these, important clues to cancer risks were sometimes ignored, occasionally for decades, by employers and by Government departments responsible for the health and safety of people at work and even sometimes by the unions themselves.

In 1978 the GMWU began its "Cancer Prevention Campaign" by asking world experts to show us how the clues to cancer risks from both laboratory and human evidence could be used to prevent or reduce future deaths amongst its members. This booklet explains the ways in which human evidence is collected and assessed to help people more directly involved in each industrial situation to make the most of the early cases of industrial cancer, thereby ensuring that such deaths will not have been in vain.

It has been written for a wide audience, including health and safety committees, union officials, employers, doctors, medical students and others who may be in a position to identify and investigate what may appear to be abnormally high incidences of cancer amongst workers. Other parts of the GMWU Campaign concentrate on how cancer can be prevented by using the clues provided by controlled experiments and the laboratory tests on the chemicals themselves so

that human experiments can be minimised. We realise, however, that for years to come the human evidence afforded by workers will provide the most conclusive proof of occupational cancer. If this booklet helps us to make some sense of workers' health experience by identifying occupational cancers, it will have succeeded.

FOREWORD

by
Professor Sir Richard Doll,
Warden, Green College, Oxford.

Cancer has always been an important cause of illness and death, but has become more so as we have learnt to prevent or cure many other diseases. Now, in Britain, it is responsible for 1 in 5 of all deaths and for 1 in 3 in middle age. We still do not know exactly what happens to make a cell cancerous, so that it multiplies to cause a tumour that can kill the person who suffers from it; but we do know of some 40 different factors that are capable of causing cancer under appropriate conditions. Many of these have turned out to be chemicals or physical agents to which people have been exposed (and in some cases still are) in the course of their work and much of our knowledge of the way cancer is caused can be traced back to the discovery that particular groups of workers, such as those exposed to large amounts of coal tar and soot or to large doses of X-rays, suffered a high risk of developing cancer of a particular type in a particular part of the body. Sometimes too, these risks have been so great that half the workers have developed the disease and one extreme example is known in which all the 19 men who had been employed distilling a particular chemical (in this case 2:naphthylamine) were affected.

That these gross risks could occur was due in part to lack of knowledge of the potential that chemicals and physical agents could have for the production of cancer, in part to the unhygienic conditions of work that were common before the second world war, and in part to lack of medical supervision, and it is unlikely that any new hazards of comparable size could now arise. The expansion of the chemical industry has, however, introduced new agents into the work environment in the last 30 years, many of which have been shown to cause cancer in laboratory animals or to cause changes in cells that indicate the possibility that they might do so, not all of which have

been eliminated. Moreover, not all susbtances have been fully tested for carcinogenic potential and, even if they were, some substances (like arsenic and benzene) are capable of causing cancer in man even though they escape detection in all the standard biological tests. It is, therefore, most important that we should be on the look out for possible risks of cancer, even when none can reasonably be suspected.

Several important risks have been discovered in the past because individual doctors have been struck by the fact that some of their patients with a particular type of cancer had a common type of work – as few as 2 or 3 men with nasal cancer or angiosarcoma of the liver were sufficient because these cancers are normally so rare – and anything which encourages workers as well as professional health staff to keep a look out for odd 'clusters' of this sort is to be welcomed. Most of the clusters will, of course, turn out to be chance effects, but every now and then they will not be; an important discovery will have been made, and a number (possibly a large number) of premature deaths will have been avoided. The techniques required to discover clusters of this sort and to carry the investigation through to establish a prima facie case for the existence of a possible occupational hazard of cancer are described in this short text with admirable clarity and it is much to be hoped that they will be widely adopted. Everything is to be gained by knowing the truth of a situation on the basis of which sensible decisions can be taken in the interests of the workers' health, maintenance of jobs, and the needs of society as a whole.

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1. BACKGROUND

On January 30th 1974 the Daily Mirror carried the headline

CANCER ALERT AT A PLASTICS FACTORY

Similar headlines appeared in a number of national and international newspapers. They were based on the observation that three men who worked with vinyl chloride monomer (VCM) in the manufacture of PVC in a big plant in the USA had died of a very rare kind of liver cancer. This observation supported suggestions from earlier experiments on animals that the chemical might cause cancer in man.

Immediately following this observation PVC manufacturing plants all over the world were invaded by epidemiologists (scientists concerned with the study of the distribution of disease in groups of people). Many studies were mounted to estimate the risk to workers, to see whether the general public were also at risk, and to provide a basis for deciding whether PVC should continue to be manufactured and if so how tightly exposure to vinyl chloride should be controlled.

The vinyl chloride story is not an isolated example. People are probably more aware of the relationships between asbestos and various cancers, especially as the risk is more widespread in the community and control has been less successful.

THIS BOOKLET is aimed at people with an interest in but little or no experience of the methods that are used to assess these risks. If they are members of health and safety committees at their place of work, it should help them to understand evidence they receive from time to time, to ask pertinent questions and to participate actively in planning further work. It describes crude methods to help see whether initial fears are justified and then suggests way in which these studies should be followed up. It indicates the limitations of epidemiological studies of groups of people emphasising, in particular, the importance of a

sound statistical analysis of the data collected. Finally, it discusses briefly how laboratory studies complement population studies in the assessment of risk.

Many epidemiological studies rely on company record systems for some of the information required. Even if you (as a safety representative for example) are not concerned about any immediate problem you should try to ensure that proper record systems are maintained (see reference 1, Guidance Note, Appendix 10). These may be essential in assessing a possible health risk that confronts the people you represent in a few years time.

We should stress that there are many causes of cancer other than substances at work, such as smoking and diet. It is usually impossible to tell the difference between a cancer caused by say, smoking, and one caused by a workplace chemical. Cancer is also a very common disease, being the second major cause of death. Many workers will therefore die of cancer, and unless the cancer is an extremely rare kind, as in the VCM case, it will be difficult to prove that something in the workplace is responsible. Appendix 1 lists some rare kinds of cancer that should not occur more than once in 10 years in several thousand employees.

2. WHY DO WE STUDY THE NUMBERS?

There are many situations which demand the use of epidemiological methods of study. First, consider a lunch-time conversation between two workers.

"Have you heard? John's got cancer."

"It's strange isn't it? Dave died of cancer last year. He worked with John in Shed B, didn't he?"

"Do you think it had anything to do with that powder they were mixing?" .....

As the conversation develops the two men remembered that over the previous few years four other of their mates in Shed B had died of cancer. By trying to remember and count more and more cases and by finding out what work these people did, these two workers are starting down the epidemiological road. In these circumstances the main question they are asking is:

"Is there a problem?"

Asking the same question, on a regular basis, a good employer systematically goes through (or 'monitors') the company health records to see if there are any problems which need following up.

In general terms the answer to this question is obtained by comparing the number of cancers observed with an estimate of how many would be expected for this size of population. At the stage in which hazards are being identified the techniques used to estimate the number of cancers expected are often very crude. They are designed to provide answers *quickly* and *cheaply* to this simple question. However, once we have the answer "yes, there may be problem" then we are faced with a whole series of new questions:

"What is causing the problem?"

"How big is the risk?"

Until we can answer the first of these two questions, we don't know what exposure to control. The second question helps us assess how important it is that we do control the risk and what control measures to adopt.

One central feature of this stage is that we compare the risks faced

by people working in the relevant area with those faced by other employees of the company or people not employed by the company, who are assumed not to have been exposed to the potential work hazard being studied.

The PVC example above was one of the few examples where the initial evidence that there was a real problem and the identification of its cause was so clear and specific that most epidemiological attention was focused on the question "how big is the risk?" If the risk had been very big there may have been strong pressure to abandon PVC production. As it was the risk was found to be relatively small and methods were sought to control exposure so as to reduce the risk to a level acceptable to industry, employees and government. Thus epidemiologists had to begin tackling questions such as

"What factors other than specific exposure at work affect the risk?"

"How is risk related to exposure?"

Answers to these questions provide the central component of an assessment of risk and the control measures to be recommended. They enable those responsible for regulation in government and those with responsibility at the workface to estimate the harm that may be incurred by inadequate control. At the same time they help those faced with the risks to compare the magnitude of the risk with risks they face in other aspects of their lives, which may help them to assess the acceptability of the risks they face at work.

The history of occupational medicine teaches us not to give up monitoring the risk after we have set control limits. Often the risks that occur in practice are underestimated and control limits are shown by subsequent studies to have been based on inadequate data. Epidemiology therefore also plays an important part in answering the further questions:

"Is control effective?"

Sometimes industry introduces an element of regular medical examination of workers exposed to carcinogens. They argue that this is one way of reducing the risk. There are, however, few examples when this approach has been effective. We should therefore suggest that if such screening is introduced it should be subject to systematic evaluation by answering the question:

"Is there evidence that other methods such as medical screening reduces the risk of those exposed?"

Clearly these last two questions should be asked as long as the substance is in use.

This set of seven basic questions is listed in Table 1. The design of the study and the information that is collected will become more

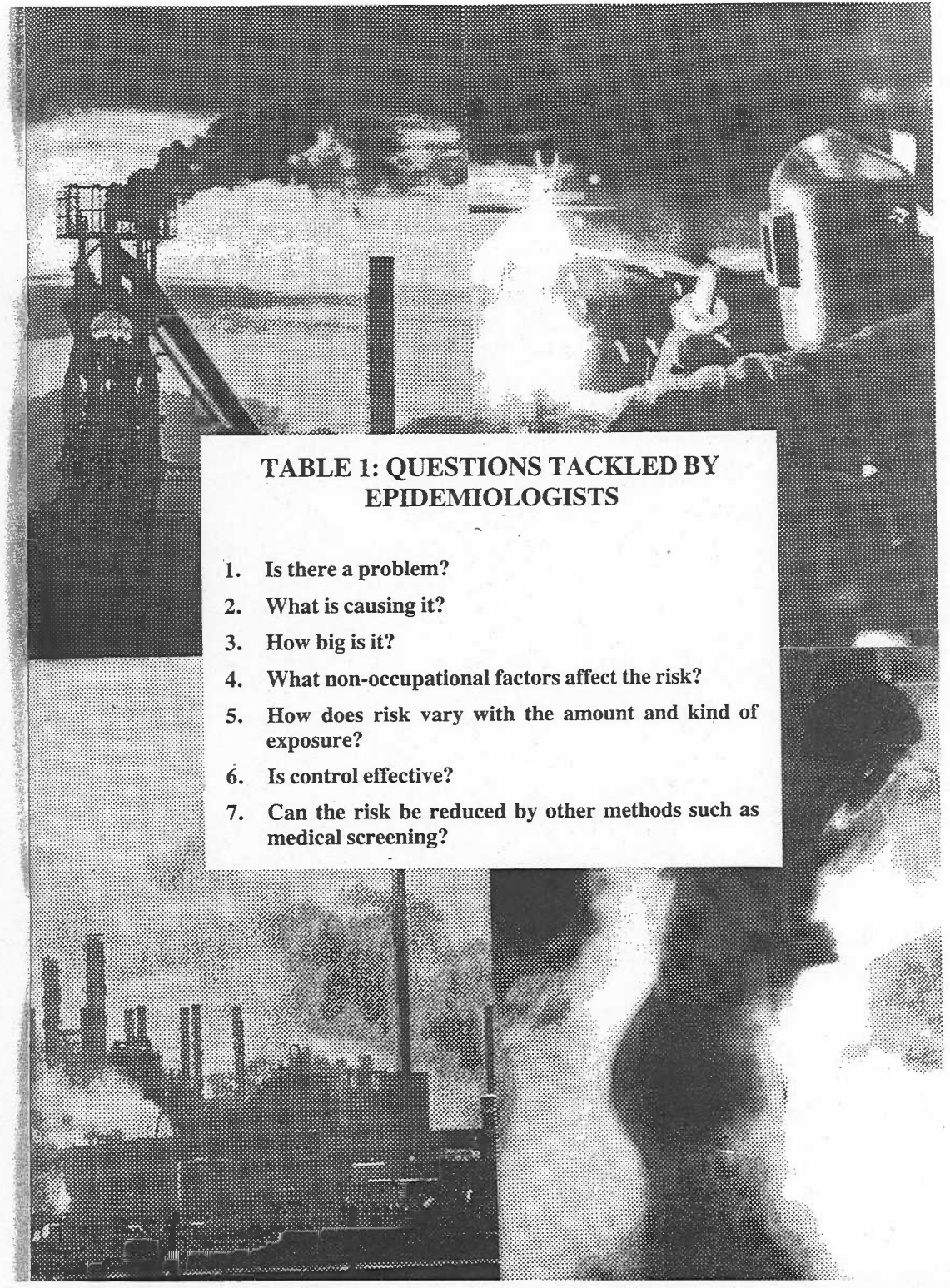

TABLE 1: QUESTIONS TACKLED BY EPIDEMIOLOGISTS

1. **Is there a problem?**
2. **What is causing it?**
3. **How big is it?**
4. **What non-occupational factors affect the risk?**
5. **How does risk vary with the amount and kind of exposure?**
6. **Is control effective?**
7. **Can the risk be reduced by other methods such as medical screening?**

specialised as we move down the list. In this booklet we outline epidemiological methods relating mainly to questions 1, 2 and 3. These are questions which can be tackled reasonably easily and at minimal expense. Depending on their outcome, they may help to allay initial fears or be used to press for further action in situations that require it.

The last few questions in Table 1 will generally require more sophisticated studies. They are the questions usually posed by government agencies such as the Health and Safety Executive whose responsibility it would be to recommend control practice across industry. The studies required are largely beyond the scope of this booklet. It is nevertheless important that people with day to day experience of 'shopfloor' conditions are fully involved in planning such studies. For example, they should sit on the investigation committee, discuss with management the aims of the study, discuss with epidemiologists the records available and methods to be used, help compile histories of past exposure, receive regular progress reports and have access to independent expert advice.

Although industry and unions are encouraged to initiate their own investigations to answer the three preliminary questions we would suggest that they should always seek outside advice and guidance, particularly when it comes to evaluating and interpreting the results.

Do not be afraid to seek independent advice

People experienced in conducting epidemiological studies may identify flaws in the analysis and may also be helpful in working out, and pressing for, any further action which should be taken following the initial investigation.

While this booklet is concerned with describing epidemiological methods and their uses, epidemiology should never provide an excuse for *not* controlling the environment (see reference 2 "Clearing the Air" in Appendix 10) particularly if you find that you are in an industry which is already under suspicion (see Appendix 2) or handling material which is known to be carcinogenic (see Appendix 3).

3. LIMITATIONS OF EPIDEMIOLOGICAL STUDIES

Although in general it is necessary to study groups of workers or other groups of people to answer questions of the kind posed above, we should not pretend that such studies can always provide answers, or that they are without difficulties. Towards the end of this booklet we discuss briefly the need for laboratory experiments in many situations. Perhaps the most obvious example is the evaluation of possible hazards associated with the use of new substances. Cancer often takes many years to develop. People who died of occupational cancers following exposure to substances like vinyl chloride and asbestos often did so many years after their initial exposure. Consequently we can not rely on studies of groups of workers to look at the effects of exposure to substances which have only been used in the past few years.

This possible time delay between exposure and effect also makes the question "What is causing the problem?" more difficult to answer. Occupational *injuries* result from accidents which occur while the person is at risk – we can therefore ask what he or she was doing at the time of the accident. For many occupational *cancers* and other diseases which take a long time to develop we may not be sure when he or she was exposed to the relevant substance – it could have ben ten years earlier, fifteen years earlier or even thirty years earlier. As people frequently change jobs and as job practices vary over time, ideally we need to build up a complete picture of the person's working history.

Work history is only one example of ways in which risk is determined by people's choices and circumstances. People live in different parts of the country, they eat different foods, have different drinking patterns and have different smoking habits. Some of these factors also influence the risk of people getting cancer (or some other diease). In most preliminary investigations these factors are taken into account only superficially. The way in which these

factors alter the risk may be properly evaluated in more detailed studies under question 4 in Table 1.

The fact that people move from job to job or even out of the labour force adds a further complication to assessing the effects of exposure to many substance. Job-change is often related to health. People who are sick may not seek work or may not be offered it. Those who become sick while at work may be moved to lighter work, may be retired early or may even be made redundant. These changes lead to the common finding in occupational cancer studies that people at work have lower mortality rates than the rest of the population. This is often called the **healthy worker effect.** *You should not be confused into thinking that this low mortality demonstrates the beneficial effect of work.* It can usually be shown that it is a direct result of the selection processes which determine who gets jobs and who loses jobs. However, in some cases it may reflect, for example, the beneficial effect of physical effort involved in work, leading to a reduction in the risk of, say, heart attacks.

4. SHOULD WE STUDY "DEATHS FROM CANCER" OR "CASES OF CANCER"

The two workers discussing John and Dave in our earlier example tried to remember other people in Shed B who had got cancer. Epidemiologists do this by reference to indexes which may list cases of cancer. For example, the company medical department or pensions department may keep an up-to-date record of all people who died or developed serious illnesses while working for the company or who were pensioners of the company. These records may indicate which of these people had cancer. Alternatively, the epidemiologist may seek support from the local cancer register (which tries to record all new cases of cancer developing in the local area) to see if it can help identify cases.

To evaluate our findings we will need to compare the number of cases in our factory with the number we would expect in other groups. Every death in Britain must be registered before the person can be buried and national statistics on deaths have been published for many years. These are of relatively high quality and are usually the basis of the main analysis. In other words, most comparisons are based on *the number or proportion of people who have died from cancer.*

Recently, however, as national and regional cancer registration statistics have improved, a number of studies have started to look at *how many people develop cancer.* This distinction becomes very important as for some cancers the treatment is effective and not everyone who develops the cancer will die from it.

Newly developed cases of cancer have only been registered *nationally* since 1971, so this booklet concentrates on studies looking at *deaths* from cancer. However, similar approaches can be used to analyse cancer registrations.

One further question which is often raised is: "Why study

mortality, when we all have to die sometime?" In studying mortality we look at how old people are when they die and what diseases they die from. By identifying the causes of illness and death at young ages, that is, premature and perhaps preventable deaths, we aim to enable people to live to a *healthy* old age.

5. PRELIMINARY FACT-FINDING SURVEY

Having talked a little in general terms about the need for epidemiological studies, let us consider what should be done following the conversation in the canteen. We need to try to make the question "have we got a problem?" more precise to obtain a crude answer and perhaps to do some preliminary work which will influence how we follow-up the question with a proper study if this is deemed necessary. This first stage, which we have called the *preliminary fact-finding survey,* comprises an attempt to establish crude evidence about the cancer risk and to identify what records would be available for a more formal investigation. These two aspects are treated separately in Table 2.

There are several arguments for suggesting that these approaches should be followed at the same time and that there is little reason for waiting for an answer to the crude assessment before doing the background work for a more formal study. In particular, we may have difficulty in trying to track down individual cases and by looking at the company or union record systems we may identify other ways of obtaining information of value to our crude assessment. At the same time, if we have completed the background work for a formal study by the time the crude assessment is completed, we should have a fairly good idea as to practical ways of following up the crude assessment.

(i) Crude assessment of problem –

a. cases of the disease of interest.

Let us look first at what the crude assessment may involve. The conversation in the canteen identified six possible cases of cancer. There may have been others which have been overlooked. Can we

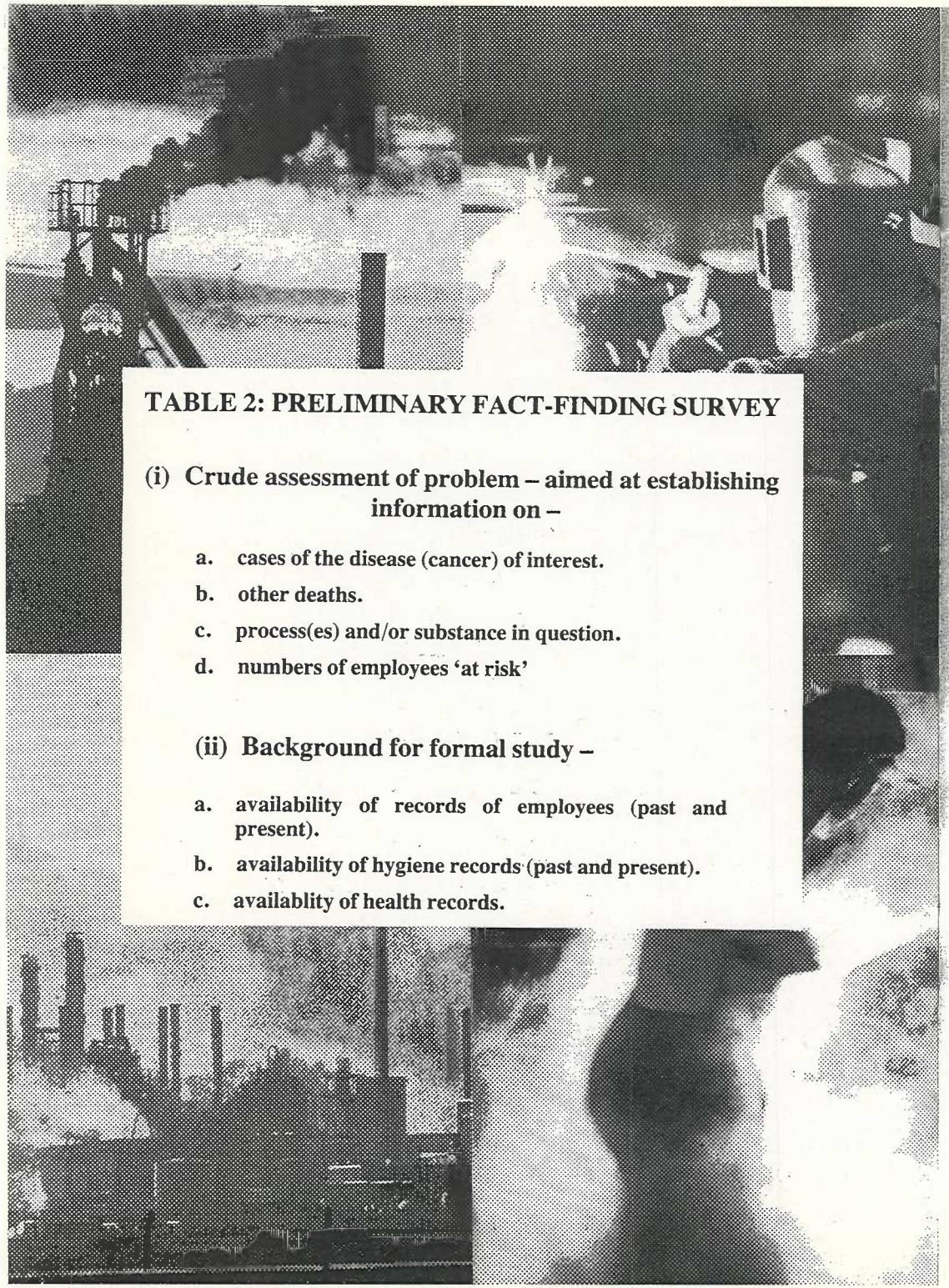

TABLE 2: PRELIMINARY FACT-FINDING SURVEY

(i) Crude assessment of problem – aimed at establishing information on –

a. cases of the disease (cancer) of interest.
b. other deaths.
c. process(es) and/or substance in question.
d. numbers of employees 'at risk'

(ii) Background for formal study –

a. availability of records of employees (past and present).
b. availability of hygiene records (past and present).
c. availablity of health records.

by asking around, particularly among colleagues who have worked in Shed B, identify any other cases? **Remember not to overlook people who have left shed B either to work in another area of the plant, to work elsewhere or to retire.** Older workers will often remember friends who left or died some years earlier.

Useful sources to consider are described in Table 3. The first four will provide the main indication of which workers have died. The last two will confirm the death and provide evidence of the cause, thereby establishing those workers who developed cancer.

If the disease we are interested in is usually very *rare* collecting details of 'all' cases in this way may be sufficient to establish that there *is* a problem. For example, if the cancer is on the list in Appendix 1 it would be highly suspicious to find more than a couple of cases unless the population was large or the deaths covered a long period of time.

Generally, in order to help put the cancer deaths into perspective, we will also need to have a count of the numbers of deaths from non-cancer causes.

To help with the record keeping we suggest that you fill in answers to relevant questions for each death of a person who has worked in the department of interest (shed B in the example) on the sort of form given on Document A in Appendix 4.

Some of this information is needed even for the earliest crude assessment of the problem; other aspects may be important but if not available at first may be left to a later stage. For each of our cases we would like to know:-

– names
– age at death (or present age if not dead)
– date of death
– type of cancer (or cause of death)
– work area/skills/jobs
– date of joining the company
– length of service.

While we need this information for each case of cancer we can often make do with less information for people who did not die of cancer. For example, the proportional mortality analysis and the simple prospective study methods described in Section 6 can both be done without knowing the causes of death for people who did *not* die of cancer, although this would give misleading results in some studies. For cancer cases, particularly if it is likely that the problem will be followed up with a more formal study, it is often desirable to obtain formal evidence of the cause of death. In Appendix 5 we indicate how to obtain a copy of the case's death certificate, which records the medical cause of death. This document is *not* a confi-

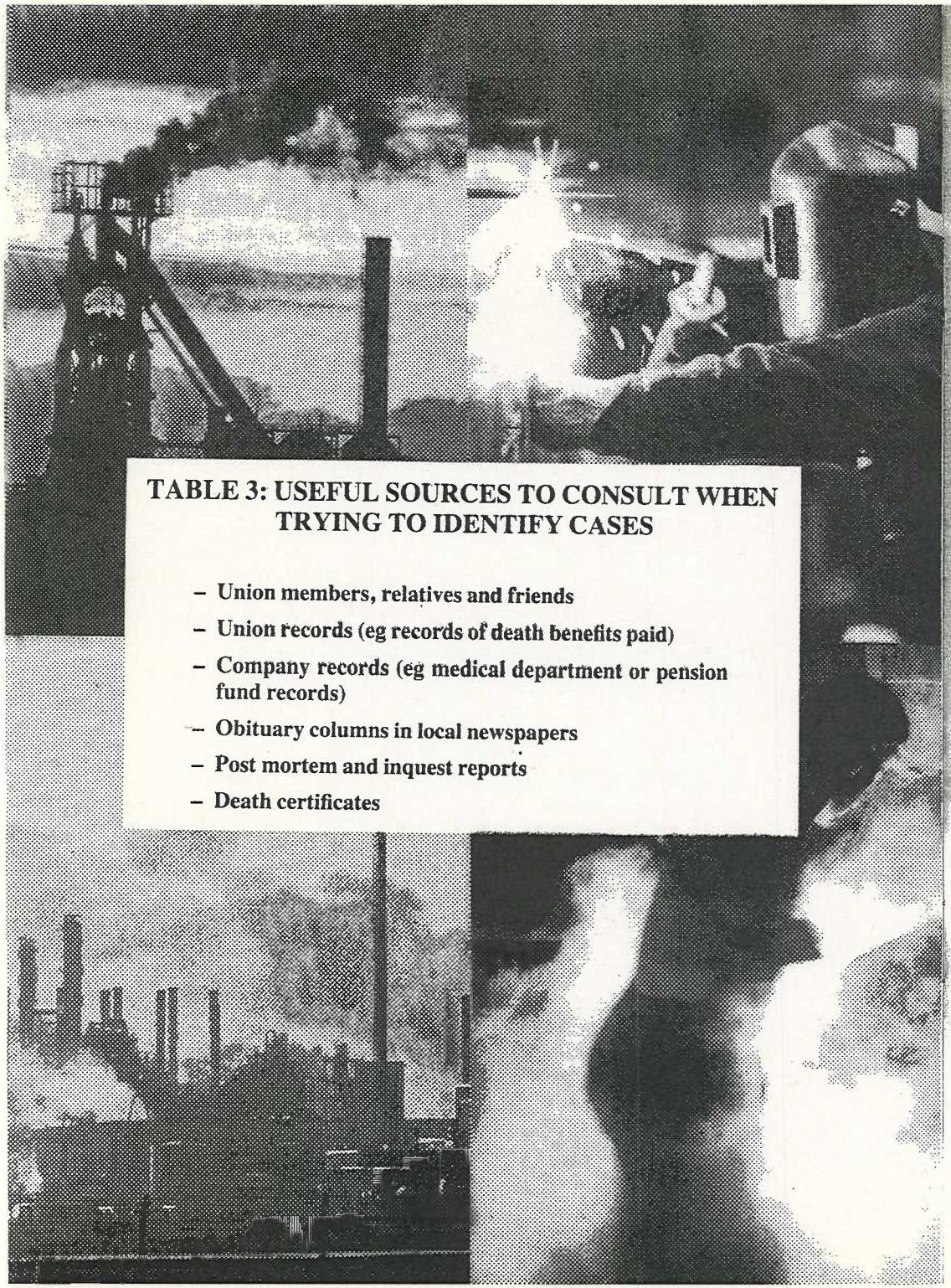

TABLE 3: USEFUL SOURCES TO CONSULT WHEN TRYING TO IDENTIFY CASES

- **Union members, relatives and friends**
- **Union records (eg records of death benefits paid)**
- **Company records (eg medical department or pension fund records)**
- **Obituary columns in local newspapers**
- **Post mortem and inquest reports**
- **Death certificates**

dential medical record and is used as the basis of all epidemiological studies of deaths.

A death certificate may include more than one cause of death and is in two parts. Most analyses are based on the *underlying cause of death* and there are strict rules for deciding which is the underlying cause. In general, if **cancer** is mentioned in Part I of the death certificate it is considered to be the underlying cause, but not if it is mentioned in Part II. You will also need to know some of the medical jargon the doctors use if you are not to miss some cancers, e.g. "papilloma", "tumour", "carcinoma" or "sarcoma" are all ways of describing cancers. Most of these terms are explained in the *Penguin Medical Encyclopedia* (see Appendix 10). If in doubt, ask your G.P. or a medical student.

b. other deaths.

It should be clear that we collect the information described above for each cancer case and for non-cancer deaths because we are trying to see whether the mortality pattern is in some way different **from what we might expect.** On page 26 and in Appendix 6 we describe how we might analyse this list *if we were unable to get any further information in our preliminary fact-finding survey*. Better methods are appropriate if we can obtain some information about the numbers 'at risk' (see below).

c. processes/substances.

Table 2 suggests that while we are following up leads about individual people who may have died of cancer we should also make preliminary enquiries about the work involved in Shed B. Working people may be exposed to a wide variety of substances during the normal course of their activities. The evidence that there is a problem would therefore be far stronger if it can be shown that it was located in a particular area of the plant or among those people who handled one particular substance. In our example if the higher risk of cancer was confined to people who worked in Shed B, whilst people working in other areas of the plant were at lower risk, we would have good reasons for looking more closely at Shed B. This is one of the reasons why in the survey form in Appendix 4 we include information about the work area, skills and jobs performed for each case. Another reason is that, by knowing which areas to look at, we can now ask questions about the substances to which the cases may

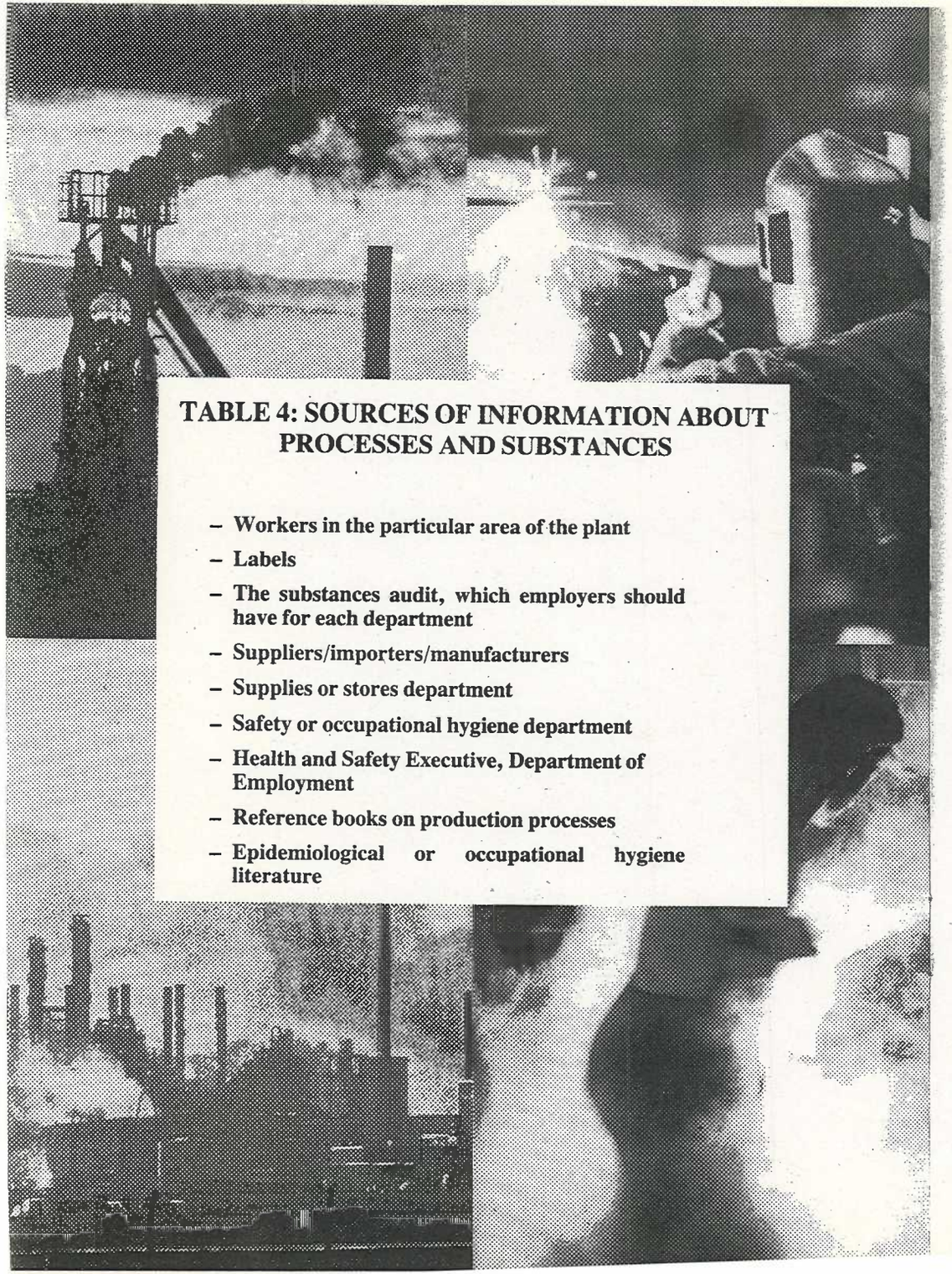

TABLE 4: SOURCES OF INFORMATION ABOUT PROCESSES AND SUBSTANCES

- **Workers in the particular area of the plant**
- **Labels**
- **The substances audit, which employers should have for each department**
- **Suppliers/importers/manufacturers**
- **Supplies or stores department**
- **Safety or occupational hygiene department**
- **Health and Safety Executive, Department of Employment**
- **Reference books on production processes**
- **Epidemiological or occupational hygiene literature**

have been exposed. Once we have obtained a list of substances we can ask what is known about these substances:

"Have laboratory tests been performed?"

"What compounds may be formed in use and what is known about them?"

"Have there been other epidemiological studies?"

Not only should the manufacturers be able to answer these questions but the company may also be *required* (under the Health and Safety at Work etc. Act, 1974) to document relevant information about the substances.

Table 4 summarises the main sources of information about processes or substances. It is unlikely that each on its own will provide all the information needed at this stage although every one could provide vital clues.

d. numbers 'at risk'

By focussing on particular areas of the plant or particular substances we are doing background work before posing the questions "who has been exposed?", "who worked in the relevant areas?" or "who may be 'at risk'?". As mentioned earlier, if we can estimate the numbers of people involved in the processes and how long they may have been exposed (ie. the turnover characteristics of the group) there are a number of methods which we can use to calculate how many cases we might expect. This information may best be gathered with the aid of the sort of sheet shown as document B in Appendix 4. *Even with very crude estimates of numbers of people and their length of exposure we can do some approximate calculations.* (see pages 28-9 and Appendices 7 and 8).

Remember, this is only a preliminary investigation, the answers need not be precise; they provide the first attempt at seeing if the problem is a real one and trying to quantify it. Remember also to conduct your enquiries in such a way as to minimise alarm, *until you are more certain of the facts of the case.* When you feel confident that you have a problem then you are justified in doing everything in your power to ensure that it is properly investigated. At this stage it is probably worth your while discussing the problem with other people, including those in other parts of the same industry, those who have had experience of similar problems and people in university departments of epidemiology, occupational health or medicine.

(ii) Background for a more formal study

The second part of the preliminary fact-finding survey is the background work necessary to help make an assessment of the best way of tackling the questions "what is causing the problem?" and "how big is the risk?"

(a) records on employees

The main task in an epidemiological study following-up the preliminary fact-finding survey and analysis will be to obtain a more accurate count of the number of relevant cases and the characteristics of the numbers 'at risk'. The usual starting point is a list of people 'exposed' or 'at risk', found by searching personnel and pension records – company pay sheets and union records often provide very useful sources. As part of the preliminary fact-finding survey it would be helpful if we could discover what information is contained in the various record systems maintained by the company and the unions, and of particular importance, how far back in time the records go.

Records for early years are often more valuable than records of current workers, because of the long time which some cancers take to develop after the 'exposure'.

(b) hygiene records (e.g. atmospheric measurements)

As well as information about the people it is helpful if we can identify information relating to exposures in earlier years. Generally hygiene records, recording measures of the levels of different substances in the atmosphere at the workplace, will not have been kept systematically. However, the company may have conducted an occasional survey. Alternatively some ideas as to how the processes have changed over time or what materials were handled in the past may be obtained by talking to older colleagues. Try to identify the materials that were used and the jobs which probably involved the

greatest exposure. Often a very crude classification of 'high', 'medium' and 'low' exposures is of great benefit for studying whether the excess or high risks are related to the level of exposure. Again this sort of information may be collected, together with the estimate of the numbers in each department, on the sort of form shown as document B in Appendix 4.

(c) health records

Although company health records are often incomplete (not everybody comes into contact with the medical department) these records sometimes contain information useful to any follow-up study. In particular it may be of value to ask the company medical department to confirm information we have obtained from other sources. Medical records may also contain information about apparently minor complaints made by people who worked with the substances in question.

Medical records are usually regarded as confidential. However mortality studies are generally based on the cause of death reported on the death certificate, which is not a confidential document.

Also, we should stress that there are several methods used by epidemiologists to find out whether or not people who have left the plant are still alive. In a more formal, detailed study we could therefore find **all** the deaths from cancer among people ever included on the pay role. Because these procedures for following up the leavers may be expensive we first want to make the best use of information available within the factory.

6. SIMPLE APPROACHES TO "DO WE HAVE A PROBLEM?"

Having carried out the preliminary fact-finding investigation we will consider ways of answering the question "do we have a problem?" quickly and cheaply. However, it should be recognised that cheaper studies usually involve making assumptions which may not be valid and may therefore lead to mistaken assessments. The mistake could be either failing to spot a risk which is present or suggesting a risk is present when in fact it is absent. However, at this stage, the simple approach is used to help decide how much more effort to put in to ensure that the answer is right. Irrespective of the effort at this stage it will be necessary to weigh the evidence against that from a number of different studies.

Table 5 lists simple epidemiological approaches that are commonly used at this early stage. The choice of approach is most often influenced by what data are available, or what data can be made available quickly and at little cost.

(i) Proportional mortality –

Consider the situation in which in the example above we have established that a number of deaths have occurred to people who used to work in Shed B. We know the age at death and the cause of death for each case, but we do *not* know the total number of people who worked in Shed B. *Proportional Mortality Studies* look at the distribution of deaths by cause of death *without estimating the population at risk.* They answer questions such as "in our group, do lung cancer deaths represent a higher proportion of all deaths than might be expected for deaths of people of the age studied at the time". The calculations in this method are as described with an example in Appendix 6.

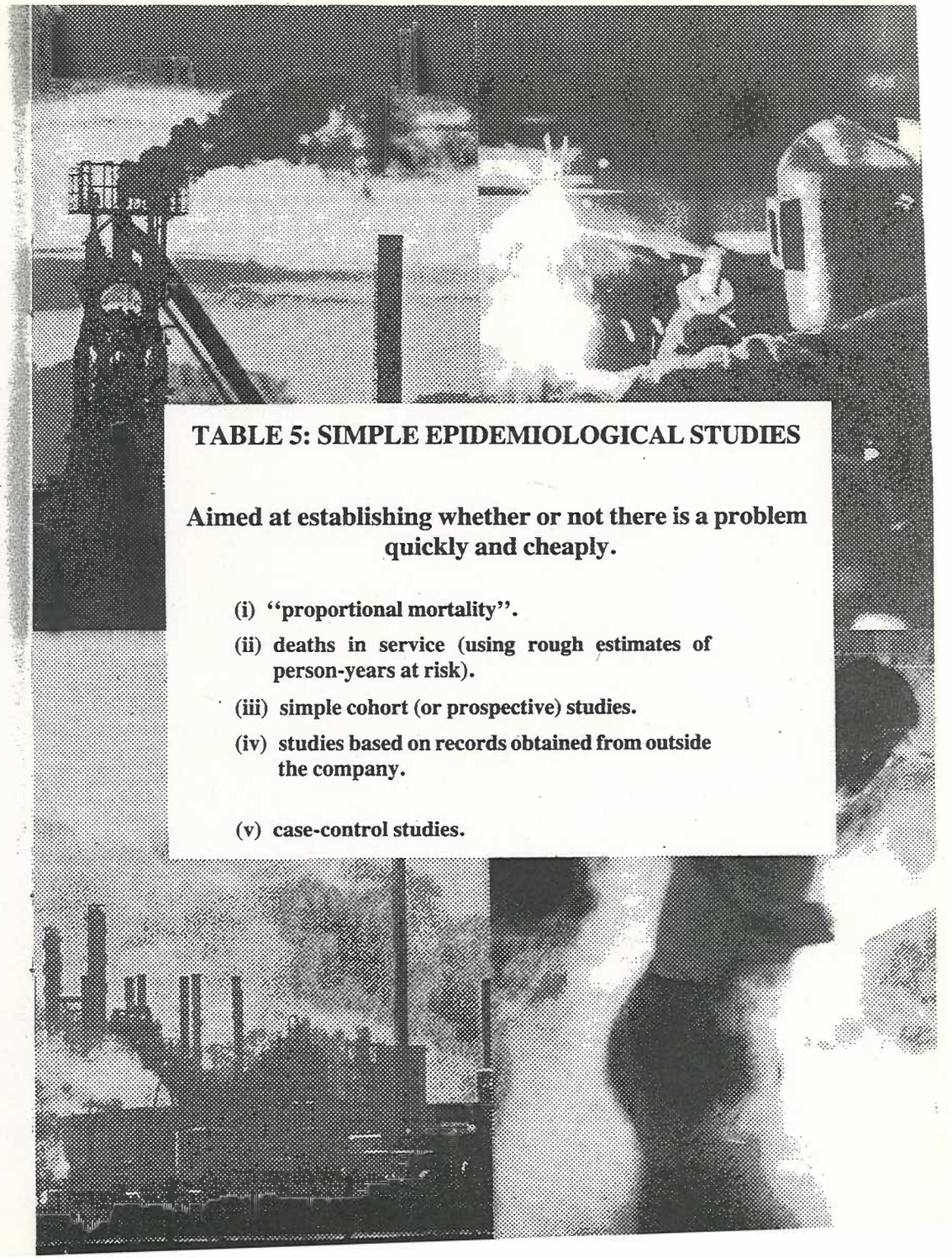

TABLE 5: SIMPLE EPIDEMIOLOGICAL STUDIES

Aimed at establishing whether or not there is a problem quickly and cheaply.

(i) "proportional mortality".

(ii) deaths in service (using rough estimates of person-years at risk).

(iii) simple cohort (or prospective) studies.

(iv) studies based on records obtained from outside the company.

(v) case-control studies.

Although the question this approach answers is a useful one it is less valuable than the question "is the mortality of this group higher than might be expected in people of the age studied?" for two reasons. First, the proportion of lung cancer deaths may be high because the proportion of deaths from some other disease, such as heart disease, is low (or low because the proportion of deaths from other diseases is high). Thus the method is inappropriate if we have reason to expect that the occurence of some other disease is unusual in the group. Second, even though the proportion of deaths from lung cancer is high, the overall mortality may be low, or vice versa.

(ii) deaths in service –

The preliminary fact-finding survey may also have enabled us to estimate the population to which these deaths relate – the 'population at risk' (see Appendix 7).

Before indicating how these numbers at risk are used it is perhaps worthwhile emphasising the differenc between 'guestimates' based on the approximate size of the work force and its broad sex and age structure, and more precise estimates based on a full list of people in various record systems. The former calculations can be done with limited resources in order to get a rough idea about the size and nature of the problem. The latter approach would require somebody to prepare a complete list of the workforce being studied, with relevant details for each person. Clearly the former approach would be biased by the inaccuracy of the guestimates.

Assuming that we have some estimate of the numbers of people 'at risk' at each age, we can use the method described in Appendix 8 to calculate the number of expected deaths. These are then used to calculate the SMR (Standardised Mortality Ratio), a ratio similar to the PMR (Proportional Mortality Ratio). The SMR is more useful than the PMR (in Appendix 6) because it indicates whether or not the overall *level* of mortality is raised. The PMR only indicated whether or not the *proportion* of deaths from particular causes was raised.

(iii) simple cohort (or prospective) studies –

Here we only make a few general comments about this type of study because a simple introduction to these has already been prepared (see the booklet "Two statistical methods for assessing

health hazards at work", Appendix 10), and this should be used by those who wish to try this approach.

Using the approach a group of people who worked in a particular company or with a particular substance are followed over time by taking a register of the people and matching against registers of cancers or deaths. If sufficient resources are available, a well designed cohort study will include **all** people who started working in the company (or a particular part of it) in a period say 20 or 30 years earlier and will look at their employment histories and at their subsequent mortality *including deaths of people who moved on to work in other companies and those who retired (even those without occupational pensions)*. Occasionally such studies are based on the follow-up of a census sample of people employed on a particular date.

A cohort study is a powerful way of looking at the effects of work or exposure to different substances at work on mortality because it aims to identify all the deaths to the initial population. Its main limitations relate to the choice of study population, the occupational/exposure details one has available about them and the ability to trace *all* deaths.

(iv) studies based on records from outside the company –

In some instances enquiries within the company may not be fruitful because of the small size of the company or because appropriate information is just not available from the record systems that have been maintained. Remember that in an epidemiological study most interest centres on what happened to people who first worked with the company many years earlier. Companies often throw away records when they see no further use for them and *thereby lose the opportunity for epidemiological evaluation of potential health risks.*

Even though companies may not have relevant records various record systems held outside the company can sometimes contribute useful evidence on the problem. The first source that should be considered is Union records. From these it should be possible to identify those members who worked for a particular company, although descriptions of the particular jobs of individual members are often not given. Such records are currently being used in a major study of cancer in printers and this has confirmed their potential value.

National or local record systems might be a further source, although access to such record systems is likely to be difficult

without the active assistance of epidemiologists or other outsiders. Such systems are being used to look at cancer in tin miners, cancer in hairdressers and millers, in pharmaceutical workers and in fertiliser workers. Similar sources are also being used in studies of cadmium and lead workers.

In each of these studies the objective is to look at the mortality of a group of people who have been exposed to suspect substances some time in the past. Because they are not based on detailed nor reliable information about the precise work done they tend to underestimate a real risk (see discussion of dilution of population 'at risk' on pages 35–36). Most studies based on records held outside the company would be described as simple cohort studies. (See (iii)).

(v) Case-control studies –

The methods described above attempt to compare the death rate or number of deaths from a particular disease in a group of people 'exposed' to a suspected hazard with the death rate or number of deaths to be expected in an unexposed or normal group.

Case-control studies use a different approach (one of greater importance than the emphasis it receives in this booklet might suggest). In a case-control study we look at a group of *cases* of a disease of interest (e.g. bladder cancer) and compare the pattern of exposure these cases have experienced with the exposure experienced by a group of *controls* – comparable people who do *not* have the disease. In effect, we are asking if there is any evidence that people who develop the disease have been exposed more than comparable people who do not develop the disease. Work history may provide a crude measure of exposure; we might compare the proportion of bladder cancer cases in our factory who have worked in Shed B at some time with the proportion of a group of controls who have worked in Shed B. If a much higher proportion of cases than of controls have worked in Shed B, this may suggest that something connected with working in Shed B, perhaps an exposure to a substance used only there, is an important factor in the risk of developing the disease, bladder cancer.

Case control studies represent an attractive epidemiological approach because they are generally quicker and cheaper to perform than simple cohort studies (iii) and their more advanced forms. This is because they concentrate on the relatively small group of people of particular interest – the cases – instead of looking at a larger group and seeing how many cases appear. However, the results obtained depend on the appropriateness or otherwise of the

controls with whom the cases are compared. In principle, for each case we should find a control who was working in the same factory at the time at which the case developed the disease and who is similar to the case in 'important' respects, except of course for those details of exposure or work history which we want to investigate. 'Important respects' are those such as age, sex and smoking habits, since these will usually be associated both with the risk of getting the disease and with work history (perhaps only older, more experienced men work in Shed B). If cases and controls are not comparable in these respects a misleading under-or-over-estimate of the association between exposure and risk of disease might be made.

Although it is easy to outline the design of a case-control study, practical constraints on the selection of a group of controls (we may not know when each case developed the disease, what all the important factors are for a particular disease, or whether each case *is* a smoker, etc.) mean that in practice a less than perfect group of controls is often chosen, and thus that it is more difficult to make a valid estimate of the degree of association between the exposure and disease of interest.

You should be cautious about embarking on such a study and look critically at reports of case-control studies, particularly at the choice of control group. Case-control methods are becoming more common in epidemiological studies of occupational risks. For example, at the Yorkshire cancer registry they are being used to see which occupations cases of bladder cancer are more likely to be in than members of the control group, and so to suggest occupations in which the risk of bladder cancer is higher. Similarly, they are used within companies to identify processes or exposures which are contributing most to a high risk found by other methods.

7. HOW DO WE DRAW CONCLUSIONS FROM EPIDEMIOLOGICAL STUDIES

In this section we discuss briefly the epidemiological way of thinking, indicating the sort of questions to be asked to put the findings of such a study into perspective. However detailed the study and however carefully it is carried out, there are a number of limitations arising from factors beyond the control of the epidemiologist (see Section 3). Researchers have therefore developed rules of thumb which help them assess the less-than-perfect evidence. One list of questions to help make the assessment is shown in Table 6.

If many of the answers are 'yes' for a given study this strengthens the case for taking the evidence of the association between the exposure and disease seriously. *However, it must be emphasised that a few negative answers should not be taken to indicate that the exposure does not cause the disease.*

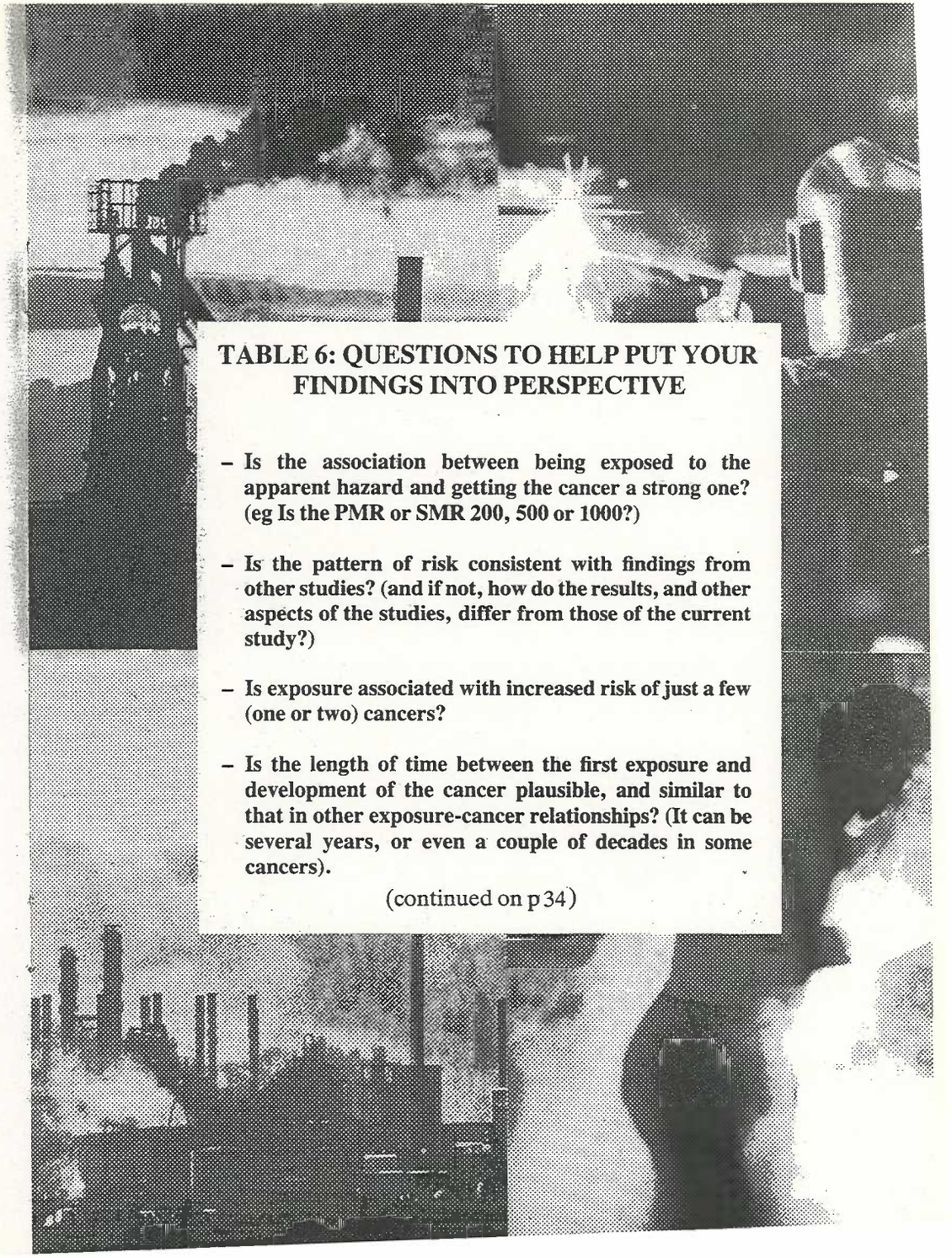

TABLE 6: QUESTIONS TO HELP PUT YOUR FINDINGS INTO PERSPECTIVE

- **Is the association between being exposed to the apparent hazard and getting the cancer a strong one? (eg Is the PMR or SMR 200, 500 or 1000?)**
- **Is the pattern of risk consistent with findings from other studies? (and if not, how do the results, and other aspects of the studies, differ from those of the current study?)**
- **Is exposure associated with increased risk of just a few (one or two) cancers?**
- **Is the length of time between the first exposure and development of the cancer plausible, and similar to that in other exposure-cancer relationships? (It can be several years, or even a couple of decades in some cancers).**

(continued on p 34)

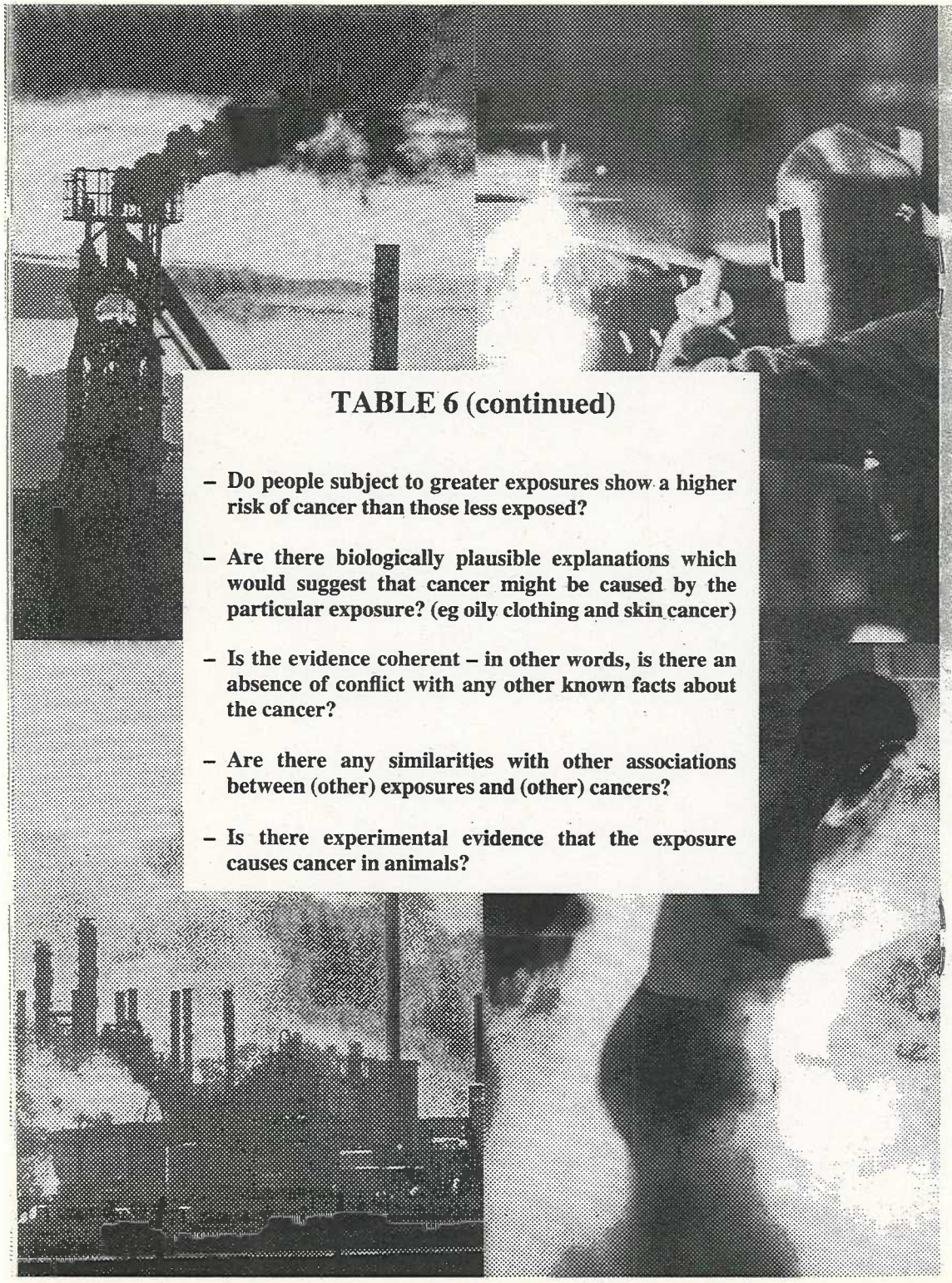

TABLE 6 (continued)

- **Do people subject to greater exposures show a higher risk of cancer than those less exposed?**
- **Are there biologically plausible explanations which would suggest that cancer might be caused by the particular exposure? (eg oily clothing and skin cancer)**
- **Is the evidence coherent – in other words, is there an absence of conflict with any other known facts about the cancer?**
- **Are there any similarities with other associations between (other) exposures and (other) cancers?**
- **Is there experimental evidence that the exposure causes cancer in animals?**

8. HOW DO WE EVALUATE OUR STUDY 'STATISTICALLY'?

Accepting the limitations of our epidemiological approach and its position in relation to other studies we must be careful how we interpret our own findings. We must convince those who are looking at any report we produce that the best use has been made of the material we have collected and that we have drawn appropriate conclusions from it. Table 7 lists the sort of information *every report* of an epidemiological analysis should include, or discuss.

Let us take these one at a time and explain why they are necessary. **The aims (1)** of the study usually determine the approach to be taken and the particular cancer to be studied. If we are trying to get a quick answer without spending a lot of money we may have to accept a greater risk of being wrong. If we only aim to answer the question "is there a problem" we do not need to obtain the same data as if we want to estimate precisely "how big is the problem?" or "how is the effect related to different levels of exposure?" Consequently, the aims of the study help us to understand what the study intended to achieve.

The **study design (2)** must be described clearly so that other people reading the report know exactly what was done. For example, in a cohort study, it is important to document the tracing methods used and to indicate how complete follow-up was. This may enable other people to identify limitations which the researcher has not taken account of and it may enable them to repeat the study in a different setting to compare findings.

The spread or **distribution of exposures (3)** among the group studied is most important. Suppose for example there is one machine which is particularly dangerous and that out of 100 men in Shed B only one man works on the machine in question. The machine may kill one man each year but no other men in Shed B are killed. If we look at the annual accident rate as a fraction of the number of men

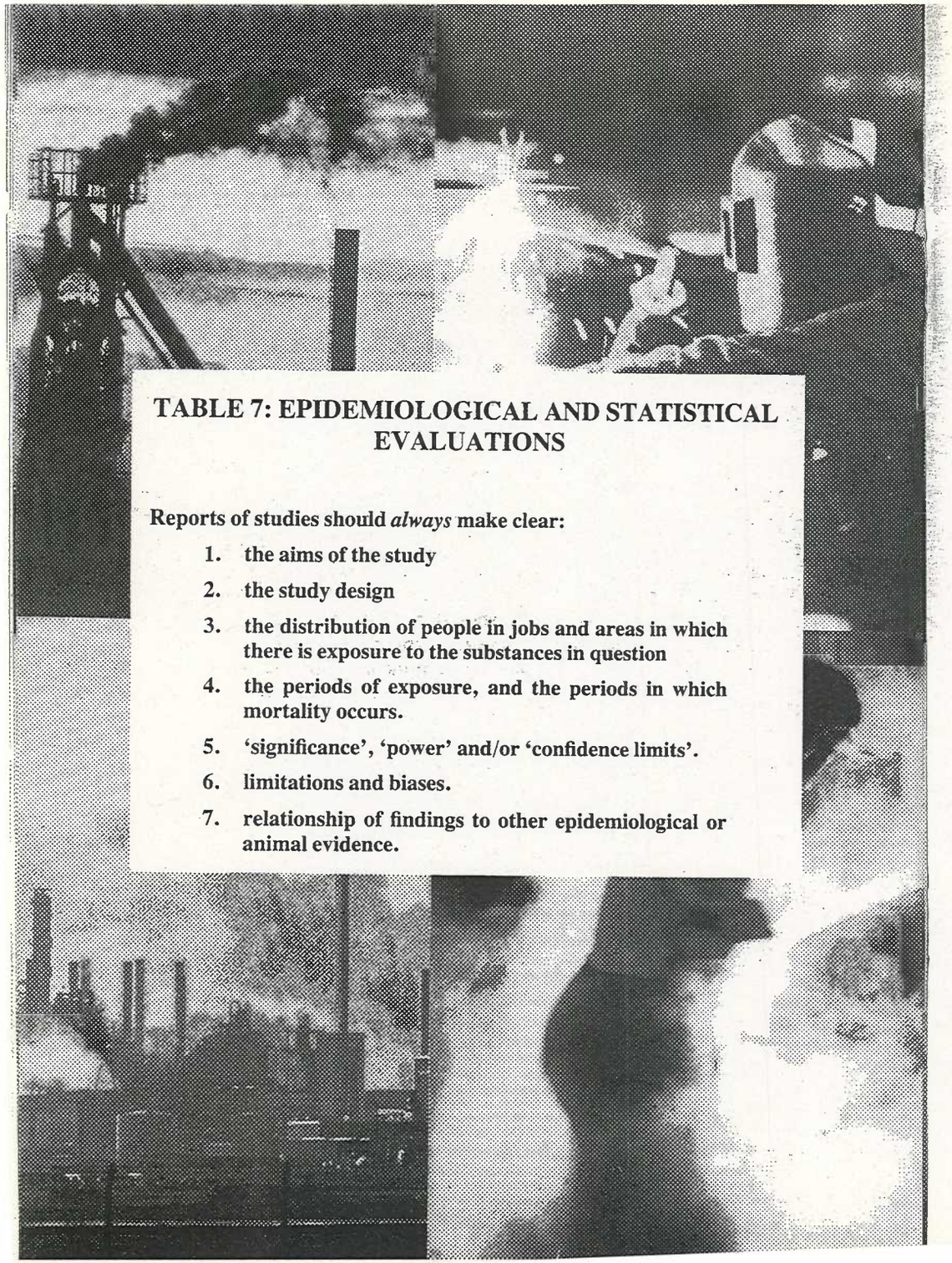

TABLE 7: EPIDEMIOLOGICAL AND STATISTICAL EVALUATIONS

Reports of studies should *always* make clear:

1. **the aims of the study**
2. **the study design**
3. **the distribution of people in jobs and areas in which there is exposure to the substances in question**
4. **the periods of exposure, and the periods in which mortality occurs.**
5. **'significance', 'power' and/or 'confidence limits'.**
6. **limitations and biases.**
7. **relationship of findings to other epidemiological or animal evidence.**

working in Shed B it is 1/100; if we look at it as a fraction of the number of men working on the machine it is 1/1. Clearly by looking at Shed B as a whole we have diluted the risk. A similar effect occurs in cancer studies. If Shed B is the only area where the material in question is handled, then any risk only applies to men in Shed B. Although the whole workforce may be included in our study, we need to be able to identify the people in Shed B. This means that we need to know which jobs involve the material in question, preferably separating those with high exposures from those with low exposures.

As has already been indicated it is essential that we know **when the people being studied were exposed (4).** For example, if there is a long delay between exposure and development of the disease of interest even a large study of 100,000 people exposed last year will be of little use. If they were all exposed 30 or 40 years ago studies of only a few hundred people could be very informative. For similar reasons we need to know the relationship between when the people were exposed and when their mortality was recorded. Reports should therefore indicate the sizes of 'high risk' sub-groups and describe their mortality separately.

The statistical terms **'significance', 'power' and 'confidence limits' (5)** concern very important, but difficult issues. Consider the study aimed at answering the question "is there a problem?" The statistical approach to this question would be to look at the data and see if these were consistent with there being no problem. This is done by asking the question "how likely are these data to have arisen by chance if there was no problem?" Making the assumption that there is no problem, the statistician will see how likely the observations were to have occurred. If the chance of getting these observations, even if there is no problem, is, say, 1 in 25, the results would be reported as $p = 1/25 = 0.04$. To test the statistical significance, this value of p is compared with an arbitrary value, usually 0.05 or 0.01. Then if p is less than this value the result is deemed significant, which means that it is unlikely that the findings would have arisen by chance.

The 'significance test' just described helps us to judge how likely a set of results obtained in a particular study is to have occurred *if in fact there is no special health hazard* in the group studied. It does *not*, however, tell us how likely a study of the kind and size performed is to have found evidence of a problem *if one exists*. This likelihood (or probability) depends on how big the problem really is; for example, is the true mortality rate in Shed B twice the expected rate; is it ten times the expected rate or is it 100 times the expected rate? **Given the same circumstances and study design we would have greater**

probability of detecting a hundred-fold difference than of detecting a two-fold difference. This probability of detecting a problem of a specified size is known as the *power* of the study.

Many statisticians prefer to see results of studies presented not in terms of the significance level of the results obtained, which ignores the power of the study, but in terms of *'confidence limits.'* These give some indication of the range in which, according to the current study, the size of the problem lies, and implicitly take into account both the significance level *and* the power.

Consider, for example, the case of a simple cohort study, where the results take the form of an observed number of deaths to be compared with an expected number. We might have calculated a PMR or an SMR as described in Appendices 6 and 8. The confidence limits would then indicate a range within which the ratio of observed and expected deaths lies with a given probability. For example, they might indicate that the ratio lies between 50 and 150 with probability 0.95. This would then be known as a 95% confidence limit.

A simple way of constructing 95% confidence limits is given by:

$$\text{Lower limits} = \frac{(\sqrt{O}-1)^2}{E} \times 100$$

$$\text{Upper limits} = \frac{(\sqrt{O}+1)^2}{E} \times 100$$

where O is the number of observed deaths, E number of expected deaths.

Consider the example of cancer of the rectum in Appendix 6. We observed 9 cases with 2.3 expected. This leads to:

$$\text{Lower limit of SMR} = \frac{(\sqrt{9}-1)^2}{2.3} \times 100 = 174$$

$$\text{Upper limit of SMR} = \frac{(\sqrt{9}+1)^2}{2.3} \times 100 = 696$$

This suggests that the SMR lies somewhere between 174 and 696. Since these 95% confidence limits do not include 100 the SMR would be considered significantly different from 100 (at the 5% (=100 − 95%) level) at least from a statistical point of view.

If we took the lung cancer findings of 21 cases observed and 21.7 expected we would derive the following 95% confidence limits:

$$\text{Lower limit of SMR} = \frac{(\sqrt{21}-1)^2}{21.7} \times 100 = 59$$

$$\text{Upper limit of SMR} = \frac{(\sqrt{21}+1)^2}{21.7} \times 100 = 144$$

For this cause the 95% confidence limit does include 100 and so the SMR is *not* statistically significantly different from 100 at the 5% level. Appendix 9 gives a table where 95% confidence limits have already been calculated. It shows the relationship between the confidence limit and the results of the significance test.

The importance of reporting confidence limits is that with small numbers of observed and expected deaths the range within which the ratio of observed to expected may lie could be very large. In the example above the SMR for lung cancer could be 140; the study was, however, too small to detect an excess of this magnitude as significant at the 5% level. The confidence limits become narrower as the expected number of deaths increases; the bigger the study the better the precision of the results obtained. This is very important. If a study fails to show a problem – an excess of deaths over the number expected from a certain cause – it is often claimed that this failure is evidence that the suspected hazard is safe. In fact, if the study is small, it is only *very weak* evidence of safety, because **a small study is very unlikely to detect any but the biggest of hazards.** It would yield *wide* confidence limits. Given the same pattern of exposures, **a larger study has a better chance of detecting a moderate hazard.** It would have correspondingly narrower confidence limits.

Irrespective of the size of the epidemiological study and the precision with which the expected deaths are calculated there will be a number of **limitations (6)**. These include lack of knowledge about factors such as smoking habits and dietary behaviour which may affect the risk of disease and biases such as the healthy worker effect. When evaluating case-control studies the main limitations are likely to lie in the selection of controls and the way in which the history of exposure has been obtained (see page 30).

Finally there is the need, as mentioned in Table 4, for **every study to be compared with other studies (7)** concerned with similar problems. This includes both other studies of groups of workers as well as evidence from laboratory investigation of any suspect materials which workers in the study may have been exposed to. The importance of this sort of evidence is discussed in Section 10.

9. WHAT FURTHER, MORE DETAILED STUDIES MAY BE NEEDED?

Once a broad picture of a problem has been established, the studies needed to take us further will become more refined and more sophisticated. They generally follow similar approaches to those outlined in Table 3 but make the calculations more precise and make great efforts to refine the occupational history and exposure data. This may involve, as in the asbestos field, detailed studies of people exposed to different types of asbestos and studies of people exposed to different levels of each type. Also, these studies may now make special efforts to incorporate direct measures of factors such as smoking patterns in an attempt to assess the relevance of these in the occupational setting. Studies of asbestos workers also indicate how monitoring of health effects helps in the assessment of the effectiveness or otherwise of environmental controls and how regular medical examinations can be offered in a study to see if these are of benefit as an alternative form of protection for those who continue to be at risk.

These types of epidemiological studies are likely to require large resources and will almost always need the active involvement of experienced epidemiologists. Their reports should still, however, comply with the recommendations in the previous section and the lay reader has an important role to see that they do.

10. THE NEED FOR ANIMAL OR LABORATORY EVIDENCE

Animal and laboratory experiments have been widely used to test substances for a considerable period of time. To their credit they have been responsible for the discovery of occupational carcinogens such as 4-amino-biphenyl, vinyl chloride and a number of others. Their evidence in many other situations has been used to support clues from epidemiological studies.

Today many new chemicals are being introduced into the work place each year; some may turn out to be dangerous in that they raise the risk of cancer among people exposed to them. Employers and employees both aim to minimise this risk – although sometimes there is a conflict between 'good practice' and 'profits'. Despite this conflict it is clearly desirable to know as soon as possible about work place risks. We have already indicated the limitation of population studies when it comes to an evaluation of new chemicals – it may take years for the effects to be observed. Also the initial population exposed may be small but as the general population comes to rely on the material, such as asbestos, the industry increases in size and more and more people are 'at risk'. To protect against this situation we need to find alternative ways of identifying risks associated with new substances. A common method is to do an experiment involving exposure of animals to the materials in question and observing their responses.

This experimental approach also provides the basis of initial studies of risk, particularly those concerned with the development of new drugs and food additives. In an experiment the researcher can vary exposures in a controlled way and observe the responses. However, despite the high level of technological sophistication of these laboratory methods there are inherent weaknesses in the approach comparable with the limitations of epidemiological

studies. There are uncertainties in the interpretation of the results (for example, will a substance which causes cancer in an animal necessarily cause cancer in man?) and major difficulties in extrapolating from the doses used in an animal experiment to estimate the risk for man, at other exposure levels. Nonetheless, someone working with a substance shown to cause cancer in animals will not want to wait for conclusive proof of its effect on man before being justified in demanding better control measures.

11. THE NEED FOR MONITORING

Given the limitations of animal experiments discussed above there is a need for us to continue to check the pattern of, or 'monitor', deaths and cancers at work to see if new chemicals, or other substances not previously recognised as hazardous, are causing cancer. One way of doing this is by looking at national data which the Registrar General produces at ten yearly intervals in his Decennial Supplements on Occupational Mortality. These volumes suggest a number of clues which should be followed up. An example in the latest volume is the high lung cancer mortality observed for butchers. Subsequent studies have noted similar rates for butchers in Scotland, Denmark and Sweden. Another suggestion to come out of the latest report is of high stomach cancer mortality for people working in dustier occupations. Such clues should be pursued by workplace studies to see if they are confirmed.

12. CONCLUDING REMARKS

Monitoring using national records is, however, one step removed from the hazards. The most effective way of generating clues is by observing carefully what happens *at work*. The two workers discussing Dave and John in our early example were doing this. It can be done systematically at relatively little cost. Companies do generally maintain personnel records and pension records. They are notified of deaths to people covered by these record systems and could use such notifications as the basis of an early detection system.

However, it is important that companies should not destroy records when they are no longer of obvious use to them. One day they may find themselves in the position of needing these records as the basis of a study to follow up the clues that are coming from much less reliable sources. In this day of computerisation and microfilming there should be little excuse for the records not being kept. It should be remembered that, in effect, **an experiment is being done on the men and women exposed at work. If it is likely that the exposure is having adverse effects it should be stopped or controlled as soon as such effects become apparent. Only by looking can we identify effects early.**

At the same time this evidence may help to relieve fears about non-existent or relatively minor problems. It is important that decisions about environmental control are based on appropriate information.

Everyone is familiar with the saying "one swallow doesn't make a summer". So with epidemiology. One study showing an increased risk of cancer in a particular industry is rarely sufficient on its own to prove conclusively the presence of a specific occupational cancer hazard. Similarly, the fact that a particular study fails to find evidence of a hazard is not conclusive proof that the hazard does not exist. All epidemiological studies have to be assessed in the context of evidence from other similar investigations as well as information from animal experiments and so on. Epidemiology contributes in its

own special way by providing the pieces of a jigsaw which when put together describe the final picture. No one piece is going to give the complete answer; however when they yield positive results, studies of the sort we have concentrated upon in this booklet are powerful levers for pushing for more detailed and complete investigations – which will contribute more to the total picture.

But what about studies that turn out to be negative? As we have seen, to conduct even the simplest study things have to be thought out carefully. Account has to be taken of many factors which would, if ignored, lead to misleading conclusions. The preceding sections should have given you an idea of what basic ingredients are necessary in a good study.

Any study, regardless of its conclusions, should be scrutinised to make sure that it has taken account of the factors we have outlined above.

Most studies, both positive and negative, have their limitations and these should be borne in mind when deciding what should be done to follow-up the study. Sometimes the study will provide sufficient reassurance for it to be decided that works practice need not be changed immediately *but that it would be advisable to review the situation at regular intervals.* In contrast sometimes the study will support the original fears and in this situation it becomes more urgent for those responsible to determine what precautions are necessary and what further studies may be needed.

These are probably the two extreme positions; most studies will leave a wide margin of uncertainty about whether the hazard exists or not, and how big it is. In such circumstances trade unions are likely to argue that while the possibility of a hazard exists, control measures are necessary and appropriate, whereas management may well argue that while the existence of a hazard is not proven, no change of safety policy is required. The judgement of any particular situation will depend not only on the results of the particular study but also on all other available evidence.

People who are responsible for these difficult decisions should, however, recognise the implications of their being wrong. If they decide that there is a problem, when in fact there isn't, they will create some alarm, incur the cost of an "unnecessary" clean up of the work place and perhaps even the loss of jobs. If they decide that there is no problem, when in fact there is, more people will be exposed and unnecessary cancers and deaths will be caused. Because the cost of this type of error is so great we would suggest that everyone with responsibility for work place situations should give such decisions detailed consideration. This booklet should provide the basic tools.

APPENDIX 1 - RARE CANCERS

The cancers listed in the table below are rare in adults (each making up less than about 1% of all cancer deaths in adults in any one year). Even in a large factory population of several thousand followed-up for 10 or 15 years it would be unusual to find more than one death from any one of these cancers.

If you find that you have two or more deaths from any of these cancers this in itself must give rise for concern and should prompt further investigations.

However, in using this table it is important to be as precise as possible in identifying the type of cancer of which a person died. For instance a description of cancer of the gut or intestine is not specific enough. Whereas cancer of the *small* intestine is very rare, cancer of the *large* intestine is quite common. It is best therefore to get the precise details of the cause of death directly from the death certificate which will usually be very specific about the type of cancer concerned.

RARE CANCERS:

(i) Cancers rare amongst both men and women

Bone	Leukaemias other than	Peritoneum
Eye	myeloid and lymphatic	Pharynx
Gums	Lymphosarcoma	Pleura
Hypopharynx	Melanoma	Salivary gland
Larynx	Mouth	*Small* intestine
Lip	Nasopharnyx	Thyroid
Liver	Nose, nasal cavities	Tongue
	Oropharynx	

(ii) Cancers rare amongst women only

Bladder Kidney

(iii) Cancers rare amongst men only

Testis

APPENDIX 2 - OCCUPATIONAL GROUPS WITH INCREASED CANCER RISK BUT NO IDENTIFIED SPECIFIC CAUSE

Epidemiological studies of a number of occupational groups have found that cancer levels in them are raised, although no particular cause to explain this has been identified. The following table lists most of the occupational groups in this category.

Occupational Groups	Cancer Site(s)
Coal Miners	Stomach
Chemists	Pancreas, Lymphomas
Chemical workers	Several
Foundry workers	Lung
Textile workers	Mouth and Pharynx
Printing Pressmen (newspapers)	Mouth and Pharynx
Metal Miners	Lung
Coke by-product workers	Large intestine, Pancreas
Cadmium Production workers	Prostate
Rubber Industry	
Processing	Stomach, Leukaemia
Tyre Building	Bladder, Brain
Tyre Curing	Lung
Furniture workers*	Nasal cavity and sinuses
Shoe workers*	Nasal cavity and sinuses
	Leukaemia
Leather workers	Bladder

Modified from: "Occupational Carcinogens" Hunter, EEC Commission 1981, and GMWU 1982

* *There is little doubt that the nasal cancers are of occupational origin but the cause is as yet unknown.*

APPENDIX 3 - CHEMICALS THAT CAUSE OR MAY CAUSE CANCER IN HUMANS

A. Chemicals and Industrial Processes which are Carcinogenic for Humans

Substance or Process	Site Affected and Type of Neoplasm	Confirming Animal Tests
4-Aminobiphenyl	Bladder - carcinoma	+
Arsenic and certain compounds	Skin, lung, liver - carcinoma	±
Asbestos	Respiratory tract - carcinoma	
	Pleura & peritoneum - mesothelioma	+
	Gastrointestinal tract - carcinoma	
Auramine manufacture	Bladder - carcinoma	Not applicable
Benzene	Blood - leukemia	–
Benzidene	Bladder - carcinoma	+
Bis(chloromethyl) ether and technical grade chloromethyl ether	Lung - carcinoma	+
Chlornaphazine	Bladder - carcinoma	±
Chromium and certain compounds	Lung - carcinoma	+
Diethylstilbestrol	Female genital tract - carcinoma (Transplacental)	+
Hematite mining (underground)	Lung - carcinoma	Not applicable
Isopropanol manufacture (strong acid process)	Respiratory tract - carcinoma	Not applicable
Melphalan	Blood - leukemia	+
Mustard gas	Respiratory tract - carcinoma	+
2-Naphthylamine	Bladder - carcinoma	+
Nickel refining	Respiratory tract - carcinoma	Not applicable

A. (continued)

Substance or Process	Site Affected and Type of Neoplasm	Confirming Animal Tests
Soots, tars and mineral oils	Skin, lung, bladder - carcinoma	+
Vinyl chloride	Liver - angiosarcoma	+
	Brain	
	Lung - carcinoma	
	Lymphatic system - lymphoma	

B. Chemicals which probably are Carcinogenic in Humans

Substance or Process	Site Affected and and Type of Neoplasm	Confirming Animal Tests
Acrylonitrile	Colon, lung	+
Aflatoxins	Liver	+
Amitrole	Various sites	+
Auramine	Bladder	+
Beryllium and certain compounds	Bone, lung	+
Cadmium and certain compounds	Kidney, prostrate, lung	+
Carbon tetrachloride	Liver	+
Chlorambucil	Blood	+
Cyclophosphamide	Bladder, blood	+
Dimethylcarbamoyl chloride	?	−
Dimethyl sulfate	Lung	+
Ethylene oxide	Gastronintestinal tract, blood	±
Iron dextran	Connective tissue	+
Nickel and certain compounds	Respiratory tract	+
Oxymetholone	Liver	−
Phenacetin	Kidney, bladder	±
Polychlorinated biphenyls	Skin, various sites	+
Thiotepa	Blood	+

C. Substances which may be linked to Cancer in Humans

	Animal Tests
Chloramphenicol	No data
Chlordane/heptachlor	Limited
Chlorprene	Inadequate
Dichlorodiphenyltrichloroethane	Limited
Dieldrin	Limited
Epichlorohydrin	Limited
Hematite	Negative
Hexachlorocyclohexane (lindane)	Limited
Isoniazid	Limited
Isopropyl oils	Inadequate
Lead and lead compounds	Adequate
Phenobarbital	Limited
N-Phenyl-2-naphthyamine	Inadequate
Phenytoin (diphenylhydantoin)	Limited
Reserpine	Inadequate
Styrene	Limited
Trichloroethylene	Limited
Tris(aziridinyl)-p-benzonquinone	Limited

Since this list was compiled in 1979, *formaldehyde* has proved to be an animal carcinogen, but only weak epidemiological evidence has been found. It is now classified by the ACGIH (who produce the TLV list) as a suspect carcinogen. In addition to this list of 54 chemicals, at least another 100 have been classified as having sufficient animal evidence for IARC to regard them as suspect carcinogens.*

Source: International Agency for Research on Cancer (IARC) Monograph Supplement No.1 1979

* *This list is available from the GMWU Regional Health and Safety Service.*

APPENDIX 4 – USEFUL DOCUMENTS FOR PRELIMINARY FACT-FINDING SURVEY

Document A

CANCER† CASE SHEET

EMPLOYER'S NAME: .....

1. FULL NAME OF CANCER† CASE: .....
2. UNION BRANCH NUMBER: .....
3. HAS THIS CASE COME TO YOUR ATTENTION
   BECAUSE they died of cancer† or DEAD CASE ☐
   BECAUSE they have been diagnosed of cancer† while alive? LIVE CASE ☐
   (tick correct box)
4. DATE OF BIRTH (if full date of birth not known, year of birth is sufficient)
   .....
5. AGE AT DIAGNOSIS OF CANCER† OR DEATH: .....
6. MONTH & YEAR OF DIAGNOSIS OR DEATH: .....
7. PLACE OF DIAGNOSIS OR DEATH: .....
8. TYPE OF CANCER† DIAGNOSED OR STATED ON DEATH CERTIFICATE:
   .....
9. INDICATE SMOKING HABITS: NON SMOKER ☐
   LIGHT SMOKER less than 20 per day ☐
   HEAVY SMOKER more than 20 per day ☐
   HOW MANY YEARS HAS CASE BEEN SMOKER? .....
10. SPECIFY DEPARTMENT* WORKED IN MOST: .....
11. JOB TITLE/DESCRIPTION IN ABOVE DEPARTMENT: .....
12. DATES OF WORK IN ABOVE DEPARTMENT: .....
13. OTHER DEPARTMENTS* WORKED IN: .....
14. DATE JOINED FIRM: .....
15. DATE RETIRED/LEFT FIRM: .....
16. TOTAL LENGTH OF SERVICE (YEARS): .....

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* AS SPECIFIED ON DEPARTMENTAL INFORMATION SHEET
† OR OTHER DISEASE OF INTEREST

Document B

DEPARTMENTAL OR FACTORY INFORMATION SHEET

1. Employer's Name: .....
2. Address of Workplace: .....
   .....
3. What is made or done at workplace: .....
4. Total size of CURRENT workforce:
   ..... MEN ..... WOMEN .....

	NAME AND ACTIVITY OF DEPARTMENT	NUMBER OF CANCER CASES	YEAR STARTED OPERATION	NUMBER OF CURRENT WORKERS	NUMBER OF WORKERS WITH LENGTH OF SERVICE			ANNUAL TURNOVER	MAIN MATERIALS USED	ENVIRONMENTAL CONDITIONS
					LESS THAN 1 YEAR	1-4 YEARS	5+ YEARS			
1										
2										
3										

APPENDIX 5 – HOW TO OBTAIN COPIES OF DEATH CERTIFICATES

By law, a death certificate must be made out for anyone who dies in Britain, and it must specify, as far as is possible, the exact cause of death. Relatives of people who have died may have a copy of the death certificate. Personnel, medical or pensions departments of companies may have copies of death certificates for those employees who have died in service or who are entitled to pensions, and they *may* be prepared to make copies available to, for example, health and safety committees. If certificates are not available from these sources they can be obtained as follows:

At the Office of Population Censuses and Surveys (OPCS), St Catherine's House, Kingsway, London, WC2 (01-242 0262), anyone can inspect an alphabetic list of deceased persons in England and Wales and can obtain copies of the certificate. The certificates for deaths occurring in Scotland are held at the General Registrar Office, Ladywell Road, Edinburgh and for Northern Ireland at General Registrar Office, Oxford House, Chichester Street, Belfast.

The names of those who have died are listed in alphabetical order separately for each quarter of each year since 1837, to within about 3 quarters (9 months) of the current date. Thus with the full name and approximate date of each death of interest it is easy to find the entries required; the approximate place of death is a good check that the right one has been found. The OPCS staff will supply copies of the certificates for each entry required. This costs £4.60 for each certificate. All of this can be done by post, but this costs £9.60 for each certificate.

APPENDIX 6 – HOW TO CALCULATE PROPORTIONAL MORTALITY RATIOS

When we have drawn up a list of deaths such as follows, we want to calculate the number of expected deaths by the method of proportional mortality.

Deaths occurring among men who worked in Shed B

DEATH NUMBER	NAME	AGE AT DEATH	CAUSE OF DEATH
1	Bill Bishop	59	Lung Cancer
2	Archie Acroyd	45	Septicaemia
3	Dave Davies	63	Pneumonia
4	George Silver	50	Leukaemia
.			
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.			
.			
.			
50	William King	45	Peritonitis
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.			
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.			
.			
159	Oliver Brook	38	Accidental Fall
160	Peter Christie	71	Prostate Cancer
161	Mark Steven	84	?

For simplicity alone throughout these Appendices we are assuming the whole workforce is *male*. All of the calculations need to be repeated separately for females if there are both males and females in the workforce.

Note that for everyone who is known to have died we have to have their age at death. However, it is not absolutely essential that we have everyone's cause of death, provided we know about *all the deaths from the causes we are interested in*.

Step 1 – Sorting the Cases by Age at Death

Taking the list of deaths illustrated above, a count is made of the **TOTAL** number of deaths, i.e. deaths from any cause by age at death. This can be done by drawing up a blank table of the following sort and making a 'five-bar gate' count. For each death in the list a mark is made in the appropriate box. (Note that we are restricting our attention to deaths occuring between the ages of 25 to 74 years.)

AGE AT DEATH				
25-34	35-44	45-54	55-64	65-74
4	10	25	59	63

At the end the number of marks in each box can be easily counted up. This has been done in the above table for our example of the 161 deaths that were found amongst people who had worked in Shed B.

These counts have now been drawn up in a table below. Here it is important to check that the individual counts for each age group do add up to the total number of deaths. (In other words, the total on the right of the table (161) should match the total number on our original list.)

Total deaths in the period 1970-79, amongst men who worked in Shed B, by age at death.

AGE AT DEATH

25-34	35-44	45-54	55-64	65-74	TOTAL
4	10	25	59	63	161

Step 2 – Counting the deaths for individual cases

The death certificate may record a number of different causes of death, depending on the sequence of events which led to death. For example, if lung cancer led to respiratory failure and then cardiac arrest (or heart-failure), each may be mentioned. Most analyses are based on the *underlying cause of death* and there are strict rules for deciding which is the underlying cause. In practice, if *cancer* is mentioned in Part I of the death certificate, it is usually considered to be the underlying cause, but *not* if it is mentioned in Part II.

With this background we can turn to our list of 161 deaths in Shed B and count the number of deaths from various cancers. Say we find 5 cancers of the stomach, 2 cancers of the colon, 9 cancers of the rectum, 2 cancers of the pancreas and 21 cancers of the lung.

Step 3 – Calculating the number of expected deaths

We calculate the total number of expected deaths from any particular cause by calculating the number of expected deaths in each of the five age groups, and adding the results.

The number of expected deaths from a given cause in an age group is found by multiplying the number of deaths in the above table by the proportion shown in the appropriate part of Reference Table 1. For example, the number of expected deaths from lung cancer in the 55-64 age group is equal to $59 \times 0.135 = 7.97$.

To make the calculations easier and less liable to mistakes it is a good idea to draw up a table of the form shown in the following example:

Calculation of expected deaths from lung cancer amongst men who worked in Shed B

	AGE AT DEATH				
	25-34	**35-44**	**45-54**	**55-64**	**65-74**
(a) Total deaths (all causes)	4	10	25	59	63
(b) Proportion expected from Lung Cancer	0.012	0.047	0.110	0.135	0.119
(c) Expected deaths (a) × (b)	0.05	0.47	2.75	7.97	7.50
(d) Total Expected Deaths			18.74		

From the above table we have calculated that the total number of expected deaths from lung cancer is 18.74. From our list we found 21 observed deaths from lung cancer in Shed B. The Proportional Mortality Rate (PMR) is the ratio of these two numbers multiplied by 100; in other words

$$\text{PMR for lung cancer} = \frac{\text{observed deaths from lung cancer}}{\text{expected deaths from lung cancer}} \times 100 = \frac{21 \times 100}{18.74} = 112$$

The numbers of expected deaths from other causes in Reference Table 1 have been worked out in a similar way and are shown in the table below.

Expected and observed deaths from different cancers amongst men who worked in Shed B

Cancer Cause of Death	Age at Death 25-34	35-44	45-54	55-64	65-74	Total Exp	Obs	PMR
Stomach	0.02	0.17	0.58	1.65	1.76	4.18	5	120
Colon	0.04	0.17	0.43	0.94	1.01	2.59	2	77
Rectum	0.02	0.08	0.33	0.77	0.82	2.02	9	446
Pancreas	0.01	0.11	0.28	0.83	0.76	1.99	2	101
Lung	0.05	0.47	2.75	7.97	7.50	18.74	21	112
All cancers	0.72	2.18	6.75	17.82	17.01	44.48	49	110
All causes	4.00	10.00	25.00	59.00	63.00	161.00	161	100

Note: Obs = observed death
Exp = expected deaths

A PMR above 100 indicates that we have more of the particular cancers than expected. On p 39 and 40 we describe how we assess statistically the significance of the difference between observed and expected deaths; in other words, how we assess whether it is reasonably likely that the difference between the observed and expected deaths arose just by chance.

NOTE: The proportions in Reference Table 1 will give a useful but crude indication of the pattern of deaths to be expected in the period 1965-85. However, for some diseases, such as stomach cancer, the pattern is changing quite rapidly with time, and a more detailed calculation may be necessary to obtain an accurate assessment. Calculations are often performed separately for each five year period, 1966-70, 1971-75, etc.

REFERENCE TABLE 1
Proportion of deaths from particular cancers, by age and sex

(i) Men

Cause of Death	AGE				
	25-34	35-44	45-54	55-64	65-74
Cancer of stomach	0.005	0.017	0.023	0.028	0.028
Cancer of colon	0.009	0.017	0.017	0.016	0.016
Cancer of rectum	0.004	0.008	0.013	0.013	0.013
Cancer of pancreas	0.003	0.011	0.011	0.014	0.012
Cancer of lung	0.012	0.047	0.110	0.135	0.119
All cancers	0.180	0.218	0.270	0.302	0.270
All causes of death	1.000	1.000	1.000	1.000	1.000

(ii) Women

Cause of Death	AGE				
	25-34	35-44	45-54	55-64	65-74
Cancer of stomach	0.006	0.014	0.016	0.021	0.022
Cancer of colon	0.007	0.025	0.028	0.031	0.027
Cancer of rectum	0.004	0.011	0.013	0.015	0.013
Cancer of pancreas	0.004	0.007	0.014	0.016	0.014
Cancer of lung	0.009	0.031	0.066	0.068	0.039
Cancer of breast	0.074	0.157	0.158	0.102	0.048
Cancer of cervix uteri	0.039	0.042	0.033	0.020	0.008
Cancer of ovary	0.011	0.037	0.047	0.035	0.017
All Cancers	0.290	0.446	0.482	0.411	0.265
All causes of death	1.000	1.000	1.000	1.000	1.000

These reference tables are derived from information given in *Mortality Statistics – Cause* for England and Wales, 1977, OPCS series DH2 no.4, available from HMSO.

APPENDIX 7 – GUESTIMATING THE NUMBERS OF PEOPLE 'AT RISK'

This appendix outlines how to make guestimates of the overall size of a workforce, and how it is divided into various age and sex groups. This provides an estimate of the 'person-years at risk' of dying which involves both the numbers of people at risk of dying and the length of time for which they are at risk. From this we can go on to calculate the numbers of people we would expect to die if standard rates of death applied to them (see Appendix 6).

A very crude estimate of the 'person-years at risk' in a group of workers is easy to make if we know the overall number in a group, and the length of the period of time during which deaths may occur. In our example, suppose that there were 2040 people working in Shed B in 1975, and that we are studying deaths of workers in Shed B in the ten year period 1970-79. A crude estimate of the person-years at risk is $2040 \times 10 = 20400$ person-years:–

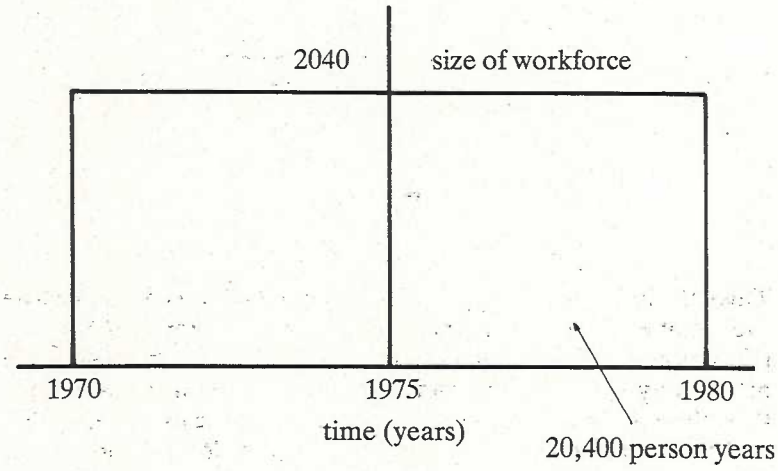

Figure 1: Estimated person-years at risk in Shed B

if we are prepared to assume that the size of the workforce remains steady throughout the ten year period. If this is not the case, but we know the size of the workforce at several points in the ten year, we could take the average of the workforce at the beginning and end of the period and multiply by the number of years in the period, or we can subdivide the ten year period and make a better estimate. For example, assume that the workforce was known to be 2500 in 1979, 2040 in 1975 and 1700 in 1978:–

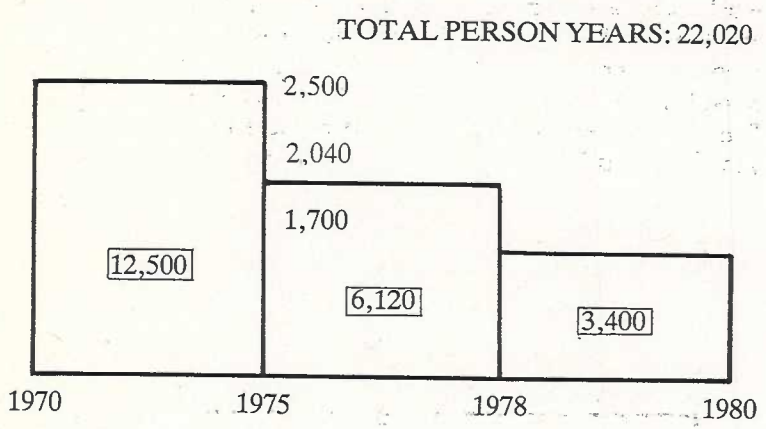

Figure 2

This calculation is making good use of limited knowledge to calculate the number of person-years at risk in the workforce of Shed B, *whilst they are at work there,* since it is during that time that we are most likely to be able to find out about deaths in the workforce ('deaths in service' see page 28). If in fact we hope to find out about deaths in service *or* during retirement or after leaving for another job we need to calculate the person-years at risk during the study period (1970-79) for anyone who worked in Shed B at any time during that period. Thus Figure 2 would need to be modified to:–

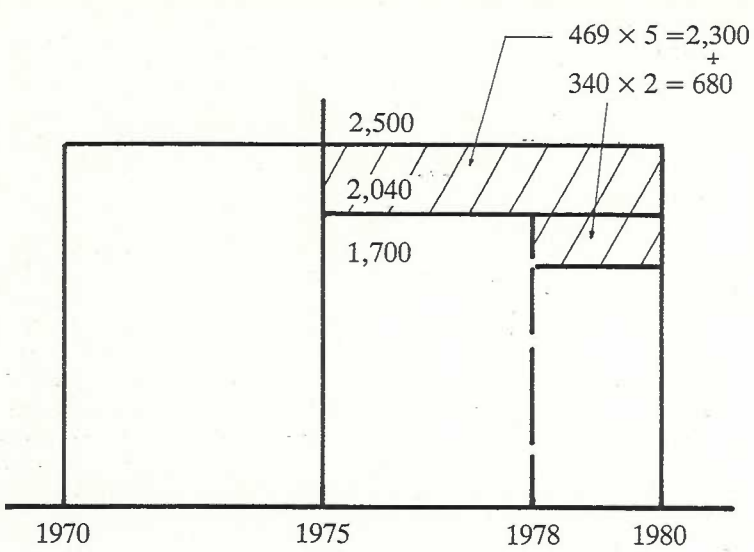

Figure 3

Even if the overall size of the workforce stays the same throughout the study period, there will be some turnover of individual members of staff, with some or all leavers and retirees being replaced by new recruits. If only deaths in service, and thus only person-years at risk *whilst working in Shed B* are of interest, this turnover of staff will not affect the calculations of the total person-years at risk. However, if deaths after retirement/leaving are also of interest (see (iii) p28) the person-years at risk of *each person* after he or she retires must be calculated and included in the total. If there is a substantial turnover of staff (perhaps 10% of the workforce leaving each year) the person-years added in this way can be very considerable.

So far we have ignored the sex-age structure of the workforce; but this is crucial in calculating the number of deaths expected because, as Reference Table 2 (p 67) shows, the death rates from many diseases vary strongly with age and sex. If in addition to knowing that the total workforce was 2040 in 1975, we know how many of the workforce fell into each of a series of 10 year bands of age, and how many in each age group were male and female, we could perform the person-years at risk calculation *separately* for each sex/age subgroup. Thus, if for example the 2040 men in Shed B had the

following age characteristics:–

Age structure of workforce of Shed B in 1975

Age Groups				
25-34	**35-44**	**45-54**	**55-64**	**65-74**
510	580	440	360	150

a crude estimate of the person-years at risk amongst the men aged 25-34 would be 510 × 10 = 5100 person-years, and similarly for the other groups. Of course, this ignores the fact that each individual member of the workforce will be getting older as the study progresses, and some will in fact move from one age group to the next in the course of the study period. If the study period is reasonably short (not much longer than the width of an age band, say) this won't be too serious a problem.

In practice, at this stage of the investigation only crude guestimates of the person-years at risk of the kind illustrated in Figure 1, but for each age group in Reference Table 1, are likely to be made. This gives the following estimate of person-years at risk in Shed B in 1970-79.

Person-years at risk in Shed B, 1970-79

Age Groups				
25-34	**35-44**	**45-54**	**55-64**	**65-74**
5100	5800	4400	3600	1500

As emphasised on page 28 more formal epidemiological studies require a careful and detailed estimation of person-years at risk, by age and sex and taking account of those leaving, retiring and dying. For this a complete list of those who have worked in the group at any time in the study period is required with, for each such person, details of his/her date of joining the workforce, date of and reason for leaving it and his/her age (or date of birth) and sex. The methods used in such surveys are described in an introductory pamphlet (*Two statistical methods for assessing health hazards at work* by David Jones, Peter Smith and Pat Kinnersly; Radical Statistics Health Group, 1982).

APPENDIX 8 – CALCULATING THE STANDARDISED MORTALITY RATIO (SMR)

Let us assume that we now have a list of deaths such as in Appendix 6 and a table of person-years at risk, from Appendix 7. The first step in calculating an SMR is to find for men and women separately the number of expected deaths from the cause of interest within each age group. The SMR is a summary measure which compares as the total observed number of deaths from each cause within the total expected number.

Appendix 7 gave us the table below:

Person-years at risk in Shed B, 1970-79

Age Groups				
25-34	**35-44**	**45-54**	**55-64**	**65-74**
5100	5800	4400	3600	1500

We multiply the person-years at risk in this table for men by age specific mortality rates for men for the cause of death of interest taken from Reference Table 2. For example, the number of expected deaths from lung cancer at ages 55-64 is

$$3{,}600 \times \frac{2{,}539}{1{,}000} = 9.1$$

The following table illustrates the calculation in full:

	AGE AT RISK				
	25-34	**35-44**	**45-54**	**55-64**	**65-74**
Person-years at risk (1)	5100	5800	4400	3600	1500
Mortality rate for lung cancer (per 1000 population at risk) (2)	0.011	0.094	0.750	2.539	5.791
Expected deaths (1) × (2) / 1000	0.1	0.5	3.3	9.1	8.7
TOTAL EXPECTED DEATHS	**21.7**				

As with the PMR, the SMR expresses the ratio of observed to expected deaths multiplied by 100. In the list on which the PMR was based we found 21 deaths from lung cancer. This gives an SMR of

$$SMR = \frac{21 \times 100}{21.7} = 97$$

The following table gives the SMRs for a number of different cancers based on the same list of observed deaths from Appendix 6 and the person-years at risk in Appendix 7. We suggest you check the expected deaths to make sure you have understood the calculations.

Cause of Death	Observed Deaths (1)	Expected Deaths (2)	(1) x 100 ÷ (2)
Stomach cancer	5	4.9	102
Cancer of colon	2	3.2	63
Cancer of rectum	9	2.3	390
Cancer of pancreas	2	2.3	87
Cancer of lung	21	21.7	97
All malignant neoplasms	49	51.7	95
All causes	161	187.4	86

On page 35 we describe how we evaluate statistically differences between observed and expected deaths. The same approaches are used irrespective of the way in which the expected deaths are calculated.

Note: The rates in Reference Table 2 will give a useful but crude indication of deaths to be expected in the period 1965-85. However, for some diseases, such as stomach cancer, the death rates are changing quite rapidly with time, and a more detailed calculation may be necessary to obtain an accurate assessment. Calculations are often performed separately for each five year period, 1966-70, 1971-75, etc.

REFERENCE TABLE 2
Mortality rates per 1000 'person-years at risk' for various causes of death by age and sex

(i) Men

	AGE				
Cause of Death	**25-34**	**35-44**	**45-54**	**55-64**	**65-74**
Cancer of stomach	0.005	0.035	0.156	0.534	1.365
Cancer of colon	0.008	0.034	0.116	0.306	0.800
Cancer of rectum	0.004	0.017	0.089	0.247	0.616
Cancer of pancreas	0.003	0.022	0.077	0.268	0.572
Cancer of lung	0.011	0.094	0.750	2.539	5.791
All Cancers	0.168	0.438	1.838	5.670	13.180
All causes of death	0.933	2.013	6.810	18.774	48.852

(ii) Women

	AGE				
Cause of Death	**25-34**	**35-44**	**45-54**	**55-64**	**65-74**
Cancer of stomach	0.003	0.020	0.066	0.204	0.542
Cancer of colon	0.004	0.036	0.113	0.307	0.679
Cancer of rectum	0.002	0.016	0.055	0.147	0.326
Cancer of pancreas	0.002	0.010	0.058	0.153	0.343
Cancer of lung	0.005	0.044	0.271	0.672	0.993
Cancer of breast	0.040	0.222	0.644	1.002	0.201
Cancer of cervix uteri	0.021	0.060	0.136	0.195	1.208
Cancer of ovary	0.011	0.052	0.193	0.347	0.438
All cancers	0.157	0.630	1.969	4.058	6.672
All causes of death	0.542	1.413	4.087	9.869	25.183

These reference tables are derived from information given in *Mortality Statistics – Cause* for England and Wales, 1977, OPCS series DH2 no. 4, available from HMSO.

APPENDIX 9 95% CONFIDENCE LIMITS FOR PMRs AND SMRs

NUMBER OF EXPECTED DEATHS

Number of observed deaths		0.1	0.2	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
1	Upper	4000	2000	800	400	267	200	160	133	114	100	89	80
	Lower	0	0	0	0	0	0	0	0	0	0	0	0
2	Upper	5828	2914	1166	583	389	291	233	194	167	146	130	117
	Lower	172	86	34	17	11	9	7	6	5	4	4	3
3	Upper	7464	3732	1493	746	498	373	299	249	213	187	166	149
	Lower	536	268	107	54	36	27	21	18	15	13	12	11
4	Upper	9000	4500	1800	900	600	450	360	300	257	225	200	180
	Lower	1000	500	200	100	67	50	40	33	29	25	22	20
5	Upper		5236	2094	1047	698	524	419	349	299	262	233	209
	Lower		764	306	153	102	76	61	51	44	38	34	31
6	Upper				1190	793	595	476	397	340	297	264	238
	Lower				210	140	105	84	70	60	53	47	42
7	Upper				1329	886	665	532	443	380	332	295	266
	Lower				271	181	135	108	90	77	68	60	54
8	Upper				1466	977	733	586	489	419	366	326	293
	Lower				334	223	167	134	111	96	84	74	67
9	Upper				1600	1067	800	640	533	457	400	356	320
	Lower				400	267	200	160	133	114	100	89	80
10	Upper				1734	1155	866	693	577	495	433	385	346
	Lower				468	312	234	187	156	134	117	104	94
15	Upper						1187	950	792	678	594	528	475
	Lower						413	330	275	236	206	183	165
20	Upper							1198	998	856	749	655	599
	Lower							482	402	344	301	268	241
25	Upper								1200	1029	900	800	720
	Lower								533	457	400	356	320
30	Upper										1049	932	839
	Lower										501	445	401
35	Upper											1063	957
	Lower											537	483
40	Upper												1073
	Lower												567
45	Upper												
	Lower												
50	Upper												
	Lower												

Notes:

1. See page xx for method of calculating limits for particular observed and expected deaths.
2. Below dotted line observed deaths are significantly greater than expected deaths ($p < 0.05$)

NUMBER OF EXPECTED DEATHS

6.0	7.0	8.0	9.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	Number of observed deaths	
67													Upper	1
0													Lower	
97	83	73											Upper	2
3	2	2											Lower	
124	107	93	83	75									Upper	3
9	8	7	6	5									Lower	
150	129	113	100	90	60								Upper	4
17	14	13	11	10	7								Lower	
175	150	131	116	105	70								Upper	5
25	22	19	17	15	10								Lower	
198	170	149	132	119	79	59							Upper	6
35	30	26	23	21	14	11							Lower	
222	190	166	148	133	89	66							Upper	7
45	39	34	30	27	18	14							Lower	
244	209	183	163	147	98	73							Upper	8
56	48	42	37	33	22	17							Lower	
267	229	200	178	160	107	80	64						Upper	9
67	57	50	44	40	27	20	16						Lower	
289	247	217	192	173	115	87	69						Upper	10
78	67	58	52	47	31	23	19						Lower	
396	339	297	264	237	158	119	95	79					Upper	15
138	118	103	92	83	55	41	33	28					Lower	
499	428	374	333	299	200	150	120	100	86	75			Upper	20
201	172	151	134	121	80	60	48	40	34	30			Lower	
600	514	450	400	360	240	180	144	120	103	90	80	72	Upper	25
267	229	200	178	160	107	80	64	53	46	40	36	32	Lower	
699	599	524	466	420	280	210	168	140	120	105	93	84	Upper	30
334	286	251	223	200	134	100	80	67	57	50	45	40	Lower	
797	683	598	531	478	319	239	191	159	137	120	105	93	Upper	35
403	345	302	269	242	161	121	97	81	69	60	54	48	Lower	
894	766	671	596	536	358	268	215	179	153	134	119	107	Upper	40
473	405	354	315	284	189	142	113	95	81	71	63	57	Lower	
990	849	743	660	594	396	297	238	198	170	149	132	119	Upper	45
543	465	407	362	326	217	163	130	109	93	81	72	65	Lower	
	931	814	724	651	434	326	261	217	186	163	145	130	Upper	50
	527	461	410	369	246	184	147	123	105	92	82	74	Lower	

3. The range between upper and lower limits reflects the statistical power of the study (small studies will lead to a wider range).

APPENDIX 10 – FURTHER READING OR REFERENCE

1. *Health Surveillance by Routine Procedures*, HSE Guidance Note – MS 18, March 1981
2. *The Penguin Medical Encyclopedia* by P Wingate. (A useful medical dictionary to help understand terms and diseases)
3. *Two Statistical Methods for Assessing Health Hazards at Work* by the Radical Statistics Health Group. c/o BSSRS, 9 Poland Street London W1V 3DG, £0.60p + 25p p&p. (An introductory guide to cohort studies, aimed at safety representatives, medical and epidemiology students.)
4. *The Causes of Cancer* by Sir Richard Doll and Richard Peto, Oxford University Press, 1981. (A review of all the evidence about the causes of cancer in the USA.)
5. *Cleaning the Air – A Guide to Controlling Dust and Fume Hazards in the Rubber Industry*. Published by the Rubber and Plastic Research Association, Showbury, Shrewsbury, Salop SY4 4NR, £2.50, available Autumn 1982. (A document prepared by GMWU, ASTMS, HSE and the British Rubber Manufacturers' Association with relevance to a number of other industries with dust and fume problems.)
6. *Cancer Causing Chemicals* by Irving Sax. Published by Van Nostrand Reinhold Co Ltd. (A summary of evidence, mainly animal, on 2,400 substances. Expensive, so see if you can obtain it from local library.)
7. IARC Monographs. The International Agency for Research on Cancer have published 23 monographs under the heading *Evaluation of the Carcinogenic Risks of Chemicals to Humans*. (Again, copies should be borrowed from reference libraries).
8. *Chemicals, Work and Cancer* by Le Serre, Vose, Wigley and Bennetts. Published by Thos. Nelson 1980, £1.40, 85 pages. (An introduction to how chemicals appear to cause cancer and what can be done to prevent occupational cancer.)