This article describes two new occupational hazards, and the role that epidemiology has played in their discovery.

**Pneumonia and metal fume**

Every ten years, the British government publishes national statistics of occupational mortality. Traditionally, analyses have been carried out for a period of several years surrounding each census. Information about the numbers of deaths from specified causes in different occupations is obtained from death certificates, and is related to the numbers of people in those occupations estimated from census returns. Death rates are summarised by standardised mortality ratios (SMRs), which compare the number of deaths observed in an occupation with the number that would have been expected had the occupational group experienced the same age- and sex-specific mortality rates as the total national population. Thus, for example, an SMR of two would imply that the occupational group had twice the national rate of mortality, taking into account its age and sex distribution.

Table 1 shows SMRs for pneumonia in welders from three successive decennial analyses of occupational mortality. Their death rates for pneumonia were substantially and consistently elevated, as also were those in two other occupations involving exposure to metal fume – furnacemen in foundries, and moulders and coremakers.

A few years ago, I and my colleagues at the MRC Environmental Epidemiology Unit were contracted by the Health and Safety Executive and the Office of Population Censuses and Surveys to carry out the latest national analysis of occupational mortality. This differed from previous investigations in that it covered a longer time period (11 years in total) that was not centred on a census year, and instead of summarising mortality by SMRs, we used proportional mortality ratios (PMRs). A PMR compares the number of deaths in an occupation with a specified cause with the number that would be expected if within each age and sex band, the cause accounted for the same proportion of deaths as in all occupations combined. In other words, a PMR of two for pneumonia would imply that after allowance for age and sex, an occupation had twice the proportion of deaths from pneumonia that was found in all occupations combined.

When embarking on this analysis we were keen to explore further the risk of pneumonia in welders and others exposed to metal fume. Table 2 summarises our findings. In men of working age a clear excess of deaths from pneumonia was again apparent. However, in welders and in moulders and coremakers, there was no corresponding excess at ages 65–74. This prompted us to review the data for 1970–72, where we found a similar pattern with elevated mortality before normal retirement age, but not thereafter.

Because our study was based on a long time period, we had sufficient deaths for an analysis by specific types of pneumonia. We found that the increased risk in metal workers was largely explained by a high rate of pneumococcal and unspecified lobar pneumonia, with a much smaller increase in bronchopneumonia. By reviewing their death certificates, we established that most of the men who had died of lobar pneumonia had undergone a coroner’s necropsy which had confirmed the diagnosis. It seems unlikely, therefore,

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| Time period | Age range | Deaths | SMR (95% CI*) |
|-------------|-----------|--------|---------------|
| 1949–53     | 20–64     | 70     | 2.26 (1.76–2.85) |
| 1959–63     | 15–64     | 101    | 1.84 (1.50–2.24) |
| 1970–72     | 15–64     | 66     | 1.57 (1.21–2.00) |

*CI = confidence interval.

Table 2. Mortality from pneumonia in occupations with exposure to metal fume – men, England and Wales, 1979–80 and 1982–90

| Occupation        | Ages 20–64 | Ages 65–74 |
|-------------------|------------|------------|
|                   | Deaths PMR (95% CI) | Deaths PMR (95% CI) |
| Welders           | 152        | 1.70 (1.44–1.99) | 153 | 0.96 (0.81–1.12) |
| Moulders and coremakers | 40 | 1.55 (1.11–2.11) | 86 | 1.02 (0.82–1.26) |
| Furnacemen        | 22         | 1.35 (0.85–2.05) | 86 | 1.40 (1.12–1.73) |
that these were misdiagnosed cases of toxic pneumonia. However, the causative microorganism was not in general recorded on the death certificate.

In summary therefore, national analyses of occupational mortality indicate a consistent excess of deaths from pneumonia in welders and other occupations with exposure to metal fume. The excess is largely of lobar pneumonia, but we do not know whether it is related to a specific microbial infection or infectious pneumonias in general. The fact that it is confined to men of working age suggests that the explanation does not lie in confounding exposures outside the workplace (which would not normally cease at retirement); rather it points to an occupational hazard, the effects of which are reversible when exposure ceases.

What might be the nature of this hazard? The obvious exposure shared by all three groups of welders, furnace men, and moulders and coremakers is to metal fume, but it is not clear whether the association is with a single type of metal fume or with fumes from all metals. Perhaps metal fume has an immunotoxic effect in the lung.

An alternative hypothesis, proposed by my colleague, Dr Keith Palmer, links the increased risk of infection with elevated levels of free iron in the lung. Bacteria, like people, need iron to replicate and grow, and there is evidence that pathogens compete with their host for access to free iron. Within the body fluids of humans and animals, levels of free iron are restricted by the presence of high affinity iron-binding proteins – transferrin in serum and lactoferrin in external secretions. To counter this, pathogens adapt in various ways to obtain the iron they need. For example, some produce their own low molecular weight iron chelators, and some make haemolsins which liberate iron from haem. It is possible that inhalation of iron fume temporarily increases the availability of free iron in the lung and thus promotes infection. In support of this, low levels of unsaturated transferrin have been associated with high fatality in pneumococcal pneumonia. In the longer term, the inhaled iron would become sequestered and bound, and in the absence of further exposure the excess risk would disappear, a prediction that accords with the absence of excess mortality from pneumonia in metal workers after normal retirement age.

Some support for this theory comes from earlier national analyses of occupational mortality which distinguished ferrous from non-ferrous foundrymen. During 1949–53 mortality from pneumonia was elevated in ferrous moulders and in furnace men and labourers in ferrous foundries, but not in brass moulders or non-ferrous foundrymen. However, the numbers of deaths in the last two groups were rather small, and an increased risk may have been missed by chance. Furthermore, during 1930–32, they too had high rates of pneumonia. Thus, the picture is far from clear and more data are needed.

To obtain further information, we are now embark-

ing on a three-year prospective case-control study of hospital-treated pneumonia in men of working age in Birmingham and neighbouring areas of the West Midlands. Among other things, this will allow us to look at risk in relation to different types of metal fume and the influence of time since last exposure.

**Hip osteoarthritis in farmers**

Osteoarthritis of the hip is an important cause of pain and disability, especially in the elderly, and it is the main reason for the more than 20,000 hip replacement operations carried out each year in the UK. The first suggestion that it might be unusually common in farmers came from anecdotal observations by orthopaedic surgeons. One of the challenges in designing epidemiological investigations of the alleged hazard was to distinguish causes of the disease from factors that might lead people who had already developed osteoarthritis to present earlier for treatment. For example, it was possible that in farmers hip osteoarthritis was not more common than in other occupational groups, but that because their work is physically demanding, they were more likely to seek medical care when it occurred. This would lead to their over-representation in clinical case series.

In our first study, therefore, we identified cases not from orthopaedic clinics, but from outpatient intravenous urograms that had been carried out for non-musculoskeletal indications. The investigation was carried out in Stoke-on-Trent and Shrewsbury, and focused on men aged 60–75. From a consecutive series of urograms, we identified 53 patients whose radiographs showed either a hip replacement or narrowing of the joint space in the hip to 1.5 mm or less. We had earlier shown that such joint space narrowing was a good index of osteoarthritis for use in epidemiological studies. The 53 cases were compared with 294 controls whose joint space was at least 3.5 mm, and occupational histories were obtained from both groups of subjects at interview. We found that for those who had farmed for 10 years or longer, the risk of hip osteoarthritis was doubled. However, the numbers of such farmers were relatively few, and the 95% confidence interval (CI) around the estimate was therefore wide. Table 3 summarises the findings of our study alongside those of three Swedish investigations. These studies used different methods to ascertain cases, but each found a marked increase in the risk of hip osteoarthritis among agricultural workers.

We were therefore encouraged to carry out a further study with a different design that was statistically more powerful. We started by sending a short screening questionnaire to 1231 men aged 60–76 whom we selected from the lists of five rural general practices. From the questionnaire, to which we had a 72% response, we identified all men who had ever worked in farming, and also those men who had spent all their working lives in office jobs. This subset was
invited to come for interview and examination, and to have a plain radiograph of their hips if they had not already had one recently. Sixty-one per cent of those approached agreed to this.

Among the eventual participants, 167 had worked in farming for more than a year, and these men were compared with the 83 who were office workers or had worked in farming for less than 12 months. A diagnosis of hip osteoarthritis was made in men who had joint space narrowing to 1.5 mm or less, or had had a previous hip replacement for osteoarthritis. Table 4 shows the numbers of cases and prevalence of hip osteoarthritis in each of the two groups by age. In each age band, the disease was substantially more common in the farmers. Furthermore, for farmers, the risk increased with the length of time spent in farming. The odds ratio for men who had worked in agriculture for 10 years or longer was 9.3 (95% CI 1.9–44.5) compared with 4.5 (95% CI 0.8–26.3) for those who had worked for one to nine years.

This is a large increase in risk for a relatively common disease, and points strongly to the existence of an occupational hazard. The question then arises as to what aspect of farming might be responsible. One hypothesis proposes that the hazard stems from exposure to vibration as a result of driving tractors and other agricultural vehicles; another attributes it to the mechanical stresses placed on the hips by frequent heavy lifting. Within our survey of farmers we were unable to test these theories effectively because almost all the farmers had driven tractors and regularly lifted heavy weights – in some cases up to 175 kg.

We do, however, have preliminary data from a new case-control study, sponsored by the Arthritis and Rheumatism Council, that support a role of lifting. In this study we have compared 388 patients aged 46–91 joining the waiting list for hip replacement for osteoarthritis in Portsmouth Health District with an equal number of controls matched for age, sex and general practice. Detailed occupational histories were obtained from each of these subjects at interview, together with information about other potential causes of the disease. After allowance for these possible confounders, risk of hip osteoarthritis tended to be higher in those who had carried out regular heavy lifting in their work for prolonged periods.

We are now expanding this analysis to include data from a parallel investigation in Stoke-on-Trent, which will allow us to look in more detail at the influence of frequency, duration and severity of occupational lifting. Meanwhile, our findings should give further impetus to the steps that are already being taken to reduce manual handling in the workplace.

In summary, I have tried to illustrate how we are following in the footsteps of Dr Sydney Alexander Henry, who endowed this lecture, and other pioneers of occupational epidemiology in this country. Thanks to their efforts, many of the worst hazards in the workplace have now been identified and controlled, but there is still much work to be done. Despite the disappearance of the dark satanic mills, new occupational diseases continue to emerge.

Acknowledgements

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References

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New occupational diseases

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Over one million people work in the National Health Service, making it the largest employer in Europe. However while most major employers monitor the health of members of their workforce and actively promote their well-being, occupational health care has developed only slowly and patchily in the NHS. Moreover many health care workers, often imbued with a sense of their invulnerability, have frequently paid little attention to their own health and safety at work. They may thus be exposed to significant risk from the wide range of physical and psychological hazards prevalent in health care.

There is increasing awareness of the need to protect workers against viral agents, allergens and resistant strains of bacteria — while many of the employment factors influencing mental ill-health, which accounts for up to 30% of sickness absence in the health service, have only recently been recognised.

The perception that health care is an industry in which health risks to employees may be both under-estimated and poorly understood led the Royal College of Physicians with the Faculty of Occupational Medicine to organise a joint conference on which the papers contained in this book are based. It will be of value both to those who work in the health service and to those who are responsible for their health and well-being: managers will also find useful guidance when establishing occupational health services for their staff.

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