

Environmental health: problems and prospects

ABSTRACT—Public health has benefited greatly from control of some major sources of environmental pollution, but newer and more subtle types of pollution have led to a major loss of public confidence. This has often been aggravated by the tendency of authorities to issue quite improper reassurances in order to protect their own interests, as well as by the failure of medical experts to explain risks in an intelligible way. Control measures have mainly been focused on protecting individuals from conspicuous or hazardous levels of exposure. This may be grossly insufficient if—as with radiation—the dose–response curve is considered to be linear or threshold-free: it is then the total emissions which need to be controlled, since many people exposed to a small risk may generate a large total of cases, albeit with no conspicuous risk to any one person or group. Unfortunately it is generally impossible to measure these all-important low-dose effects. Environmental policy should take account of this uncertainty.

Within the animal kingdom the human species has an unequalled capacity to live and to breed in a wide range of environmental circumstances. Our genetic design enables us to maintain internal homeostasis in the face of very varied lifestyles and diets, and hitherto our intelligence has enabled us to control our environment more efficiently than other species. Recently, however, the pace of technological development has been producing rapid and unprecedented changes, affecting not only how we live but also the chemical and physical environment around us.

The net effect on health of these changes has been strongly beneficial: we live longer and are less subject to physical disease than ever before, and cancer trends generally are not alarming—despite our careless habits with noxious chemicals. Our towns no longer smell of sewage; flying into London Airport at night, the city lights are not hidden by smoke; and our medical wards are no longer filled with ‘blue bloaters’ and ‘pink puffers’.

Despite these impressive advances, the past decade has seen a remarkable loss of public confidence in our

environment. Florence Nightingale’s most aggressively held tenet was that fresh air was good for patients, and she insisted that the windows must always be open. Her belief in the virtues of fresh air has now given way to widespread alarm at the dangers of passive smoking, of too much (or is it too little?) ozone, and the unseen presence of radiation. We have lost confidence in the safety of our food lest it contain listeria, or noxious additives. Riding on the back of all this public concern, environmental medicine has entered the arena. If you want your grant applications to succeed, this is the area to choose for your research!

It is not an easy field in which to work: science and emotion are intermingled. On the one hand there are serious scientific grounds for concern, and a need for objective evidence; on the other hand, neither the public nor the investigators find it easy to be dispassionate. There is often a perverse preference for alarm rather than reassurance. ‘They are poisoning us’ is a favourite refrain of the media, but only because people want to hear it.

Sellafield

The Sellafield incident illustrates many of the difficulties. The Black inquiry [1] concluded that over a 20-year period there had been an excess of five cases of childhood leukaemia in the neighbouring village of Seascale. Many parents would decide that they do not want to live there: the environment contains a hidden threat, and both radiation and cancer set off instant alarm bells. In fact, the chances of survival for children are better in Seascale than in many inner city areas, and the excess risk of death from leukaemia is probably less than the urban risk from road traffic accidents; but we are not very successful in explaining risks in a way that helps decisions.

Observations create hypotheses

The Sellafield inquiry came about because Yorkshire Television, looking around for a story, discovered this little cluster of childhood cancers. It is scientifically hazardous to draw conclusions from data which themselves generated the question, but such reports have to be investigated. Mrs X writes to me to say that two neighbours have just developed cancer, and on inquiry she finds that seven other cases of cancer have recently occurred in her street; and what am I going to do about it? Some alert doctors find that in the little Cotswold village of Blockley there have been 12 cases of Crohn’s disease [2]. Those who encounter such clusters are naturally impressed; but we have to remember R. A. Fisher’s remark [3] that ‘the one-in-a-

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Based on a Lecture delivered at Royal College of Physicians Regional Conference, Bristol
21 September 1990.

million chance will happen with no more and no less than its expected frequency, however surprised we may be when it happens to us'.

Taken on its own, the Sellafield experience strongly suggested a real local excess of childhood leukaemia, but confirmation had to await later similar reports from the Dounreay and Aldermaston nuclear sites.

The problem of a timelag

Any inquiry into an environmental risk of cancer is likely to be looking at the effects of exposure many years ago, and no one can ever know the actual doses which individuals received. At Sellafield we were given information (which, it later transpired, was incorrect) of the total radioactive emissions from the plant, but the exposure levels of the children were a matter of speculation. The radiation experts on the committee calculated 'best estimates' and they concluded on theoretical grounds that these could not have caused any major excess risk: 'It couldn't have happened, so it didn't happen'. The epidemiologists, on the other hand, were pragmatic: 'We can't explain it, but there is a problem here'. (This contrast in thinking runs all through medicine.)

From experience at Sellafield and elsewhere I have become aware that in investigating the environmental health impact of large industries (especially if they have military interests) we are confronting the seat of immense economic and political power. The natural reaction to threat is defence and doctors constitute no more than an innocent and ill-equipped David confronting Goliath, the well-armed and experienced giant.

The Sellafield inquiry left us with no explanation of how radiation could have caused leukaemia among local children, but new light has now been shed by the subsequent case-control study of Gardner [4,5]. This links the occurrence of childhood leukaemia with paternal exposure to radiation during the months before conception. Regardless of whether this finding can be confirmed by further studies, it is a mind-widening hypothesis. It teaches us that the explanation of disease in one generation may need to be sought in the environment of the parents.

Table 1. Risk of death from lung cancer according to exposure to asbestos and cigarettes (Risk in non-exposed = 1.0)

		Cigarettes	
		No	Yes
Asbestos	No	1.0	10.9
	Yes	5.0	53.2

After Hammond *et al.* [6]

Where (as may have occurred at Sellafield) the risk originates with genetic damage to the sperm, the relevant paternal exposure will have been in the few months before conception, since sperm do not live long. The situation is different if transmission is maternal, for the ova shed during reproductive life were actually formed when the mother herself was *in utero*. Thus, for example, the chromosomal derangements which cause Down's syndrome originated when the mother was herself a fetus; and if we seek an environmental component to its aetiology, we need to look at the grandmother's experience during her pregnancy.

Monitoring localised risks

The problem at Sellafield had been around for years before it was discovered. This was not through negligence but because routine statistics are not able to reveal the experience of small areas; and when the problem is very localised (as at Seascale), the local effect may be drowned in the statistics of a larger area. The Black inquiry report recommended the development of a new system to deal with the analysis of health statistics in the immediate locality of suspect industrial sources of pollution, and the outcome was the creation in my department of the Small Area Health Statistics Unit. The unit holds post-coded mortality, cancer, and congenital malformation data for the whole country. An elaborate computerised system relates this to the corresponding population data, so that we are now able very quickly to produce disease rates in specified zones surrounding any named point source. Recognition of a hazard to local residents should be more readily detected in the future.

Explaining risk

Sizing up risks and taking appropriate decisions is a part of everyone's daily life, as well as of medical practice. Curiously, the whole process tends to become more difficult when we are confronted with statistics: it may be easy to judge when to overtake another car on the road, but it would become harder if we were given a precise probability of incurring a fatal accident. People are not used to interpreting very low order risks, such as that of cancer in the neighbourhood of a radiation source: the nature of the risk then tends to be more influential than its size, which is not very logical. We need to find ways of describing risk which carry more meaning than the jargon of epidemiologists.

Table 1 presents risk estimates for lung cancer in men exposed to asbestos and/or cigarettes, relative to the risk in the doubly non-exposed. In both non-smokers and smokers it can be seen that asbestos increases risk five-fold. However, the *absolute* increase in risk is many times greater in smokers, and hence the realisation that asbestos is far more dangerous to smokers, which would not have been evident had we only considered *relative* risk. This illustrates that all policy deci-

sions should be based on absolute measures of risk: relative risk is strictly for researchers only. The distinction is important. For example, the cost/benefit ratio for building modifications to houses with a high radon concentration is likely to be far less favourable in non-smoking households.

Individuals and populations

In the great public-health movement of the last century the emphasis was on prevention through action at the level of the community, but in this century the emphasis has shifted towards a concern for individuals. Aetiological research has been dominated by case-control and cohort studies, whose purpose is to discover how sick and healthy individuals differ: they identify risk factors, and this enables us to take preventive action in high-risk individuals.

An individual-centred concern is naturally attractive to clinicians, because we deal with individual patients. It is also the focus of interest for molecular biologists and other laboratory workers, who investigate the mechanisms of disease in sick individuals. In the climate of today's medical thinking it has become more difficult to consider the wider viewpoint of public health action.

In environmental medicine this has concentrated attention on the micro-environment—the individual's local situation. Occupational physicians keep close watch on the heavily exposed; personal sexual practices are seen as the determinants of AIDS and cervical cancer, and they are the target of preventive action; coronary risk factors identify those who need help in order to avoid a heart attack; and so on.

No one should be exposed to an unacceptable risk . . .

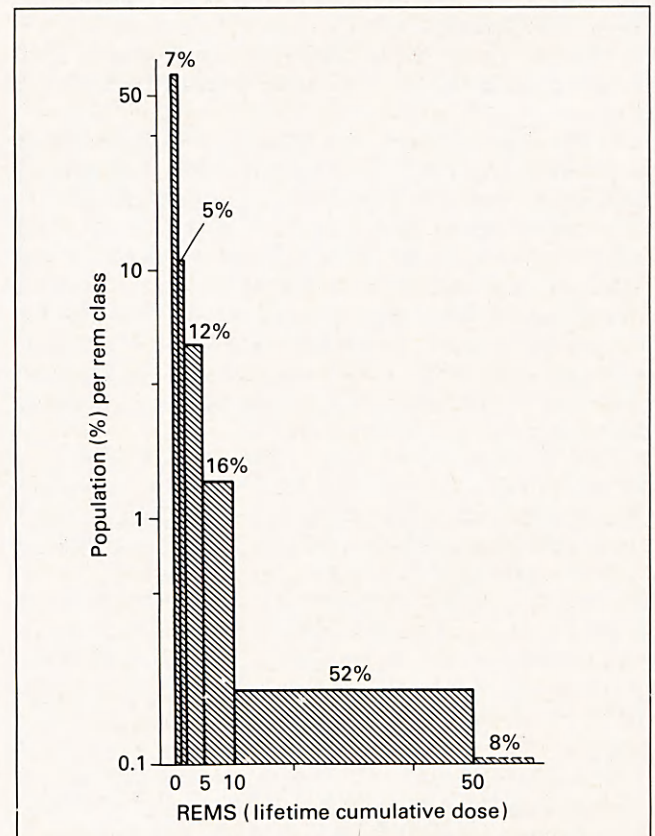
It is only individuals who can sue in the law courts—communities have no rights in law; and it is individual scandals which the news media like to headline. So, provided that no individuals are exposed to conspicuous or unacceptable risk, everyone can relax. This viewpoint influences control policy in a number of critical ways. Doctors are more concerned about multiple or high-dose X-rays to an individual patient than about the total dose to their patients as a whole. Occupational physicians take steps to monitor and limit toxic exposure of individual workers. Factory chimneys are made tall enough for emissions to be spread thinly and widely, so that individuals will not complain. (Tall chimneys do not, of course, reduce the total emissions.) Environmental health experts identify 'critical groups' of the most-exposed individuals (for example, the amount of radioactivity ingested by avid shell-fish eaters), and they ensure that their dose is not unacceptably high. But it may be the total population burden which is critical!

Figure 1 shows the radiation experience of employees of the Atomic Energy Authority [7]. The bars show

the distribution of cumulative lifetime dose, and the figures above the bars represent the percentages of total dose arising within each segment of the range. A dose of 50 rems (500 millisieverts) has been widely accepted as the upper limit of what any worker should incur, and it is clear that this policy was in general excellently observed: few workers exceeded the limit, and only 8% of the total dose arose in this group. Thus the impression is reassuring.

The theory which underlies health policy in this area is that the relation of radiation exposure to cancers is assumed to be linear and threshold-free. From this it follows that the distribution of doses, as shown in Fig. 1, also represents the distribution of radiation-induced cancers; and suddenly the whole implication has changed. The unacceptably exposed individuals do indeed have a personal problem; but because there are so few of them they account for only a very small part of the total problem of radiation-induced cancers. Nearly all of this 'public health' problem arises from the large numbers of workers with small exposure and inconspicuous personal risk. This is one instance of a widespread principle: many exposed to a small risk generate more cases than a few exposed to a high risk [8]. In such situations it is the total dose falling on the whole population which determines the burden of

Fig. 1. Percentage distribution of cumulative radiation dose among employees of the UK Atomic Energy Authority.



health effects, and it is then the total dose which particularly needs to be controlled.

The importance of low-dose effects

The shape of the dose-response curve at low levels of exposure is thus seen to be of critical importance: if it is only high doses that damage health, a policy of preventing high individual exposures is sufficient; but if there is no threshold effect and even low doses carry some risk, it is total emissions or total population exposure which matter, with quite different implications for control policy.

In our studies of radiation workers [7] we attempted to measure the effects of low-dose radiation, but with only limited success. Despite the large size of the Atomic Energy Authority study (40,000 workers), the confidence interval around the risk estimates was very wide, ranging from zero at one extreme to an upper limit which would imply that the ICRP safety limit could be 15 times too low.

The lesson is unpalatable but important: the shape of the dose-response curve at low levels of exposure is critically important, but the power even of the largest studies is quite insufficient to determine it. This applies not only to radiation but also to many chemical exposures.

We must learn to live with uncertainty

Following the Camelford accident [9], when 20 tonnes of aluminium sulphate went into the water supply, local residents are now complaining of loss of memory (having no doubt heard of the suggestion that aluminium might be a factor in Alzheimer's disease). For many reasons it seems most improbable that a single exposure in healthy people would cause lasting brain damage; but, since an event such as occurred at Camelford is without precedent, no one can say with certainty what might be the consequences. Unfortunately it may not be possible now to disentangle the undoubted effects of anxiety from the possible effects of aluminium.

The same uncertainty applies to many less dramatic chemical exposures. There is, for example, no substantial positive evidence that fluoridation of water supplies will cause cancer. Equally, if it did cause (say) 25 extra cases of gastric cancer annually, there is no way in which that could possibly be detected.

The implication of such uncertainties is not that people should never take risks: that would mean never using a motor car, or going to a doctor. Rather, when environmental policy decisions are debated, the balance sheet of gains and losses should include the uncertainty limits of each major item, as well as allowing some place also for the unforeseeable consequences.

The dogmatic certainty of experts is unforgivable. After every environmental disaster the immediate reac-

tion of the authorities is to reassure the public—even before they know the facts. This was the response of the South-West Water Authority at Camelford, and after the Chernobyl incident there were immediate reassurances from government scientists that 'This could not happen here'. Further, the experts on nuclear power have issued precise predictions of the expected frequency of accidents leading to melt-down, implying a belief that all contingencies can be foreseen. They need to be reminded of the important dictum that *you can't exclude the possibility you haven't considered*.

Nuclear power policy

Nuclear power generation offers an attractive but threatening alternative to dependence on fossil fuels. Under normal operating conditions the health risk to employees and to local residents is extremely small, with damage to health and the environment being certainly much less than from mining and burning coal. The anxiety arises from two other directions: namely, disposal of radioactive waste, and the possibility of a disaster.

Britain's policy on building nuclear power stations was not restrained by any concern with waste disposal. The responsible approach would have been to limit production of waste to what could be safely disposed of; but this has never been government policy, so we now have the legacy of a large accumulation of radioactive waste for which safe methods of disposal do not yet exist. Current planning envisages burial, using encasement materials (steel and concrete) which, it is thought, are unlikely to start leaking within the next 50 or 100 years. This shows scant regard for future generations, since the half-lives of some actinides are measured in hundreds or thousands of years.

Even more alarming is the extremely small, but still real, possibility of an immense disaster: a melt-down in a nuclear power plant might make it necessary to evacuate Britain!

We are faced here with new kinds of issues in decision-taking. We are used to considering risks that are known, not very remote, and of comprehensible size. We must now learn how to take account of risks that are unquantifiable, and either cumulatively important but remote in time, or else of tiny probability but immense threat.

Medical responsibility

Doctors and other medical scientists are responsible for being constantly on the look-out for untoward effects of the complex and violent changes which our environment is now experiencing. From what we have seen so far, the picture is in the main surprisingly reassuring; but important effects on health could easily be missed, and 'Have not noticed' must never be mistaken for 'Is not there'.

Doctors next have a key role in communication, by explaining and interpreting the evidence to an anxious—often over-anxious—public. That public has learned to mistrust authority, which is rarely disinterested; as doctors we should seek to earn a place as scientifically informed and impartial custodians of the public health.

Finally, it would be good if in the future those making environmental policy took more notice than in the past of health issues. We should be the nation's expert advisers on this important component of its difficult policy choices. It is then up to society, through its chosen political representatives, to decide the balance of health versus social and economic benefits. Doctors do not carry the ultimate responsibility for the nation's health but at least we should seek to ensure that decisions which affect health are well informed.

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