Pollution and People

Sources of lead pollution

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Environmental lead concentrations today are grossly increased over the natural levels, even far away from cities. Nevertheless, the results of the EEC survey¹ (see box) seem reasonably reassuring so far, even for children specially exposed to lead. But even 2% of children exceeding the limit of 1.69 $\mu\text{mol/l}$ (35 $\mu\text{g}/100\text{ mg}$) might be too many—that is, if slightly raised levels can cause subtle neurological impairment (see last article, p 1622).

Young children tend to have higher blood lead concentrations, which will not be apparent from blood samples taken when they are older. Some studies carried out near factories producing lead pollution have shown considerably raised blood lead concentrations in many preschool children, and also mothers.² In Birmingham, although both the schoolchildren and the younger children surveyed had low mean blood concentrations, a worrying proportion of inner city preschool children had concentrations over 1.69 $\mu\text{mol/l}$.^{3,4} These were mostly Asians and their sources of lead exposure are being investigated, with a detailed dietary survey to look at both dietary lead content and possible nutritional deficiencies that would make them more susceptible to poor environmental conditions.

Sources of lead

Thus over the whole country an appreciable number of young children, and possibly pregnant women, may have undesirable concentrations of lead in their blood. What then are the important sources of lead? The Lawther Report concludes that most adult city dwellers not specially exposed to lead, and with blood concentrations in the usual range of 0.05–1.0 $\mu\text{mol/l}$ (10–20 $\mu\text{g}/100\text{ ml}$), derive 45–90% of their blood lead from food, 0–45% from water, and 10–20% from air, though in certain circumstances, it says, inhaled lead might be the main contributor.¹ The much more tentative estimates for children are 55–95% from food, 0–40% from water, and 3–10% from air, provided that no substantial amounts are ingested from paint, dust, or other sources. The Conservation Society's recent report proposes a range of 32–69% for inhaled lead in adults (less in children).⁵ In addition, it argues that airborne lead makes an important contribution to the lead content of food. The practical issue is whether a drastic reduction of lead in petrol, the main source of airborne lead pollution, would give a commensurate reduction in lead uptake, particularly in the vulnerable groups, and protection against possible neurological damage.

EEC blood lead survey

In Britain the EEC blood lead survey,¹ carried out mainly in 1977–8, covered the following groups: 16 groups of randomly selected adults in major urban areas; 16 groups of children of lead workers and children living near lead works; and two groups of children and two of adults living near main roads or motorways. The results from mothers in Glasgow exposed to high lead concentrations in drinking water and their newborn babies are to be reported shortly. The EEC "reference levels" that should be met in each group are: a maximum of 0.97 $\mu\text{mol/l}$ (20 $\mu\text{g}/100\text{ ml}$) for 50% of the group; a maximum of 1.45 $\mu\text{mol/l}$ (30 $\mu\text{g}/100\text{ ml}$) for 90%; and a maximum of 1.69 $\mu\text{mol/l}$ (35 $\mu\text{g}/100\text{ ml}$) for 98%. The following groups failed to meet the reference levels because more than 2% had blood lead concentrations over 1.69 $\mu\text{mol/l}$: randomly selected adults in Glasgow (4%); children of lead workers (6%) and children living near lead works (7%) in Chester; and children of lead workers in Leeds (3%).

LEAD IN AIR

Lead in the atmosphere comes mainly from petrol and to a lesser extent from industrial processes. The concentration of lead in the air varies with population, or, more precisely, traffic density, though traffic speed and weather conditions also make a difference. Averages may be as low as 0.02 $\mu\text{g}/\text{m}^3$ in remote areas; but in some cities of the European Community metropolitan residential areas may have daily averages up to 8 $\mu\text{g}/\text{m}^3$ or 10 $\mu\text{g}/\text{m}^3$ in traffic, though monthly averages are considerably less—the residential value being under 2 $\mu\text{g}/\text{m}^3$.⁶ Urban daytime averages quoted for Britain range from about 1 $\mu\text{g}/\text{m}^3$ outside a house by the M6 to 8.8 $\mu\text{g}/\text{m}^3$ in West London.¹ Indoor values might be around two-thirds of the outdoor ones, but the two readings are about the same in some houses^{1,3}; a bungalow 34 m from a motorway had a concentration of 4.8 $\mu\text{g}/\text{m}^3$.⁷ The Lawther Report concludes that few people in Britain are likely to be exposed to long-term averages over 1 $\mu\text{g}/\text{m}^3$; that for most city dwellers the concentration will be under 0.5 $\mu\text{g}/\text{m}^3$; but that some "hot spots" may have averages as high as 6 $\mu\text{g}/\text{m}^3$.¹ An EEC directive proposes that long-term average concentrations, away from traffic, up to 2 $\mu\text{g}/\text{m}^3$ are acceptable.

The lead concentration quickly falls with distance from the road^{1,7}; and in Germany, where lead in petrol has been reduced from 0.4 to 0.15 g/l, there was a proportionate reduction in air concentration only in streets exposed to heavy traffic.⁸ On the other hand, an Italian experiment with a changed isotope ratio in petrol lead underlines the distances travelled by airborne lead

from petrol since the "labelled" lead was found to be mixed with ordinary lead from outside the experimental area (S Facchetti, paper presented to International Conference on Management and Control of Heavy Metals in the Environment, London, 1979). Further results from this study are awaited. The Conservation Society argues that merely reducing lead in petrol—instead of abolishing it altogether—would tend to reduce particle size and so increase its ability to remain airborne and thus its respirability.⁵ But since the lead is present in complex aggregates, with other pollutants, particle size does not just depend on the lead content, and it is not clear in any case how bioavailable the lead is in this form.⁹

The Lawther Report accepts that about 90% of lead emitted into the air is from petrol.¹ If lead were totally removed from petrol what practical difference would this make? The air lead concentration would depend chiefly on industrial sources and these would vary considerably; in the average urban area it would be close to zero. Blood lead concentrations are thought to rise by 0.097 $\mu\text{mol/l}$ (2 $\mu\text{g}/100\text{ ml}$) per $\mu\text{g}/\text{m}^3$ atmospheric lead with the blood concentrations normally found,⁷ though the uptake is possibly less than this when blood concentrations are relatively high and greater when they are very low. The Conservation Society criticises the Lawther Report for its method of calculating the percentage contribution of inhaled lead to the blood concentration,⁵ but the correct basis of calculation is far from clear in the absence of more information about the dose-response relationship for lead in air and food. A study in London taxi drivers (admittedly a small one) found no significant difference in blood lead concentrations between day and night drivers, despite the significantly greater exposure of the former to traffic fumes as judged by their blood carboxyhaemoglobin concentrations.¹⁰

With the continuing average of about 6 $\mu\text{g}/\text{m}^3$ to which the Lawther Committee envisaged that certain people could be exposed, and given a blood lead concentration of 1.4 $\mu\text{mol/l}$ (30 $\mu\text{g}/100\text{ ml}$), inhaled lead might contribute 0.6 $\mu\text{mol/l}$ (12 $\mu\text{g}/100\text{ ml}$). With lead removed from petrol the blood concentration would then presumably be about 0.9 $\mu\text{mol/l}$ (18 $\mu\text{g}/100\text{ ml}$). For children the drop would probably be less. For pregnant women especially such a reduction could be important—though the threshold of harm for the fetus is not known, it is probably lower than for children (see last article, 13 December, p 1624). More screening of people living in possible "hot spots" is clearly needed. In general, however, such raised blood lead concentrations have so far been found in Britain in association with factors other than air pollution—notably industrial lead pollution,² high-lead drinking water as in Glasgow,¹¹ and old houses.³ Nevertheless, besides being inhaled, airborne lead may contaminate food, soil, and dust.

LEAD IN FOOD

No one disputes that airborne lead may contaminate crops; but how far this remains in the lead in food as eaten—and how far it enters the food chain—is less clear.

The average lead content of the British diet has fallen somewhat during the 1970s.¹² The average weekly intake is 790 μg a week, well below the FAO/WHO's provisional "tolerable" intake of 3 mg.¹ The legal limit for the lead concentration in food is 1 ppm and the average for a typical diet is 0.1 ppm. Foods with the higher lead contents tend not to be eaten in large quantities—examples are liver, acid canned fruits, and herbs.¹² An important source of contamination is the lead solder in cans, and though there are stricter standards for infant foods many young children have adult canned foods. Lead-glazed and old pewter containers, moreover, may produce toxic lead concentrations in food and beverages.¹

Young children, with their relatively higher energy intake and greater absorption of lead, take up more lead from their food in proportion to their weight. Furthermore, food is the most important source of lead for most people; so however reassuring

the average figures appear it is important to look for preventable sources of pollution. The Conservation Society argues that airborne lead derived from petrol is the chief source of the lead in food, both through surface contamination and through entry into the food chain.⁵ The Lawther Report concludes that even with heavily contaminated produce from the vicinity of busy roads and factories most of the lead is removed by washing¹; but the Conservation Society cites work showing that lead has a strong affinity for plant surfaces and that normally only about half is so removed. The point is not yet clear; but for most people such foods—especially those grown in polluted areas—form a small proportion of the total diet. Nevertheless, vigilance is called for with local produce in some places. Travelling long distances as it does,¹³ atmospheric lead pollution does, of course, affect food grown in rural areas. Even in the High Sierras, California, much of the lead has been shown to come from industrial sources¹²—becoming bound to soil and deposited on leaves—but air lead concentrations are low away from urban areas. A Danish study of rye grass grown in a rural area showed that nearly all the lead in the green parts was from the air¹⁴; but it is not clear how relevant this is to food as prepared and eaten by people. Uptake of lead in polluted areas varies from species to species, being 15 times greater in oats than lettuce.¹⁵ Though soil lead will also be mainly from the atmosphere in a polluted area, the increase in lead content in vegetables and fruit grown there is not nearly as great as that in the soil.¹²

How important, then, is our generalised lead pollution in the food chain? Though the number of samples was small, cows grazing on a highly polluted pasture produced milk and lean meat with lead concentrations no higher than in control samples; but lead was increased in liver and kidney.^{12 16} In general, only a proportion of the lead is taken up at each point in the food chain and it is not necessarily all bioavailable. Thus the increase in the lead actually absorbed by people eating the food in question is not likely to be great in absolute terms. Nevertheless, we do need more quantitative information about the sources of lead in our diet.¹⁷

LEAD IN WATER

A national survey showed that over 4% (16% in Scotland) of households have lead concentrations over 100 $\mu\text{g}/\text{l}$ in their drinking water—that is, in daytime unflushed samples¹⁸; flushing is likely to reduce the concentration.¹⁹ Moreover, using the hot tap for cooking and filling the kettle may result in a high lead intake even where there is no lead plumbing since hot water can leach lead from solder.¹ The WHO limit is 100 $\mu\text{g}/\text{l}$, and an EEC directive is expected to recommend 50 $\mu\text{g}/\text{l}$ after flushing as a desirable limit even for lead-plumbed houses. With a lead concentration of 100 $\mu\text{g}/\text{l}$ people consuming the "maximum" amount of water, 2.9 l a day (including cooking), would have nearly 300 μg of lead daily from this source alone, and at 200 $\mu\text{g}/\text{l}$ 580 μg . The bottle-fed baby is at obvious risk,¹ and the fetus perhaps even more.²⁰ The contribution from cooked food could in fact be underestimated in some cases as cooking may result in a greater uptake of lead than the uptake of water would suggest—though salt may modify this process.²¹ Even at the modest water lead concentration of 20.7 $\mu\text{g}/\text{l}$, it has been argued, people could easily exceed the "tolerable" weekly intake of 3 mg recommended by FAO/WHO.²¹

Blood lead concentrations do not appear to rise in proportion to water lead concentrations—they are possibly related to the cube root of the concentration in water.^{11 19} Nevertheless, high-lead water raises the risk of having a high blood concentration¹¹; among the children on a Welsh estate with lead plumbing the median was 1.8 $\mu\text{mol/l}$ (37 $\mu\text{g}/100\text{ ml}$).¹⁹ A linear increase in blood lead concentration with age was found in one study of men drinking high-lead water, who (unlike controls) did not reach equilibrium before the age of 60.²² Toxic symptoms attributable to lead have occurred even in adults drinking water with a very high lead content.²³ Lead has also been suggested

as a factor in the higher infant mortality associated with soft water.²⁴

The combination of lead plumbing and soft, acid water gives a high chance that water lead content will exceed 100 µg/l.²⁵ In the Welsh estate replacement of the lead plumbing reduced blood lead concentrations by half on average within six months¹⁹; a 30% drop, in soft water areas, is predicted on the basis of a national survey.²⁵ The cheaper expedient of raising the pH of the water could produce a 20% fall in mean blood lead concentration (from 1.2 µmol/l (24 µg/100 ml) to 0.9 µmol/l (19 µg/100 ml)) in the people affected; a combination of the two measures would be the ideal.²⁵

LEAD IN DUST AND SOIL

In an American study near a lead smelter the air lead concentration best predicted blood lead values in children.²⁶ High values were most strongly correlated, however, with dusty homes in the under-2s and high-lead topsoil in the 2-7-year-olds, so that ingestion of dust and soil contaminated by airborne lead was probably the most important factor in these children. Dust is also carried home on workers' clothing, and even washing may not entirely remove it. The Health and Safety Executive's recent more stringent regulations about clothing should now improve matters.²⁷

Dust has a much higher lead content in cities than in the country,²⁸ and away from lead-emitting factories the lead probably comes mainly from traffic and from paint, depending on circumstances. Indoor concentrations of lead in dust appear to reflect those outdoors on the whole,²⁸ though this would not apply where old, high-lead paint is the main source. In the recent Birmingham study of preschool children nearly all the "high-lead" children lived in houses with a high lead content in dust samples, but under two-thirds of the others; so this may have been a contributory factor in susceptible children.⁴ A study of Derbyshire villages, some of which had soil with a high lead content, found children's blood lead concentrations to increase with the lead content of the soil, though not proportionately.²⁹ The lead in dust and soil may not in fact all be bioavailable; but in American inner-city children aged 1½-6 years there was a strong correlation between high levels of lead in household dust and on the children's hands and raised blood lead concentrations.³⁰ These children were more likely than others to suck their fingers and put things in their mouths; but this did not appear to be a factor in the Derbyshire children.²⁹ One study, however, suggested that a child could ingest 100 µg lead a day simply from contamination of sweets with average urban dust.³¹

In children lead in dust, one review concludes, could lead to an increment in blood lead concentration of the order of 0.2 µmol/l (5 µg/100 ml) for each 1000 ppm—though the values suggested by the various studies differ widely.²⁸ If even a portion is fallout from the atmosphere, airborne lead becomes more important—for exposed and susceptible children in the worst environments—than if it were just inhaled, though dust seems to be a minor hazard for most children.

PAINT

High-lead paint is a well-established cause of lead poisoning and of raised blood lead concentrations in children, often in association with pica.³² Its contribution to dust is also important. Several of the day nurseries studied in Birmingham had old, flaking paint with a very high lead content.⁴ One flake of paint weighing 10 mg, scarcely bigger than a match head, can easily contain 1 mg lead³²—over 10 times a child's daily intake from food¹—and a child who regularly eats such paint flakes is likely to be poisoned in a few months. Despite the current limitation of lead in domestic paint, high-lead paint may still be used inappropriately and old paint remains a hazard. More stringent monitoring in children's environments seems essential.

Hampstead's Heath Street (London NW3), where the airborne lead concentration was 5.7 µg/m³ outside a first-floor flat and 3.8 µg/m³ inside.¹ The slow-moving traffic and hilly terrain probably contribute to the raised concentrations. (Reproduced by courtesy of the MRC Toxicology Unit, Clinical Section.)

The future

In an ideal world the aim would be to eliminate petrol lead immediately, as recommended by the Conservation Society,⁵ as well as other sources of lead, since even small amounts derived from the atmosphere by the various routes may sometimes be important in otherwise vulnerable people. The feasibility and the economics of doing this at present in Britain—where petrol lead has just been reduced to 0.40 g/l—are a matter of dispute.⁵ Arguing that there would be higher costs and energy consumption, the Fellowship of Engineering (unpublished report) would prefer lead filters to be fitted to vehicles, reducing lead emissions by up to a half, if any further measure is to be introduced in the near future, with consideration of methanol as a petrol additive in place of lead later.

Part of the Conservation Society's case rests on the belief that "most UK children, in common with those of many other countries, are now suffering an epidemic, even a pandemic, of low-grade lead intoxication for which the addition of lead to petrol is largely, though not wholly, to blame." The evidence cited in the report does not, however, appear to lead to this conclusion. Nevertheless, there are some children and mothers with raised blood concentrations who may well be at risk. Considerable immediate benefits are likely to come from much more rigorous attention to the sources of lead thought to be important—especially industrial pollution, lead plumbing, lead paint, black spots for air pollution, contaminated dust and soil, and certain cosmetic preparations, with continued checks on food and food containers. More comprehensive monitoring of young children and pregnant women and of the environment, with investigations on the origins of environmental lead, could result in a large measure of protection. But, in view of the uncertainties, a child's or pregnant woman's living conditions should surely be scrutinised at somewhat lower blood concentrations than the present limit of 1.69 µmol/l (35 µg/100 ml) set by the EEC.

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Medicine and Mathematics

Statistics and ethics in medical research

VIII—Improving the quality of statistics in medical journals

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Publication of a paper implies that the work is both sound and worth while. As I pointed out in my first article, it bestows both respectability and credibility on the work—a “seal of approval.” Once a paper has been published the results may influence both medical practice and further research by other scientists, and if the subject is of general interest the “mass media” may report the findings.

The ultimate responsibility for the general standard of published research rests with the medical journals. Perhaps unwillingly, the journals have the role of guardians of quality. This is particularly important with regard to statistical methods, which the majority of readers of medical papers are not able to judge for themselves and so must take on trust. The system of appraisal by independent referees is not ideal, but it is probably

the most practical method of quality control. Referees are usually selected, however, for their expertise in the relevant medical topic; their ability to assess the statistical aspects is left somewhat to chance. The result is that the statistical methods used in many research papers do not receive adequate scrutiny, with the consequences described in the previous articles.

The poor quality of statistics in published papers has been a cause of concern for many years, and is not confined to medical research. In 1964 Yates and Healy¹ wrote: “It is depressing to find how much good biological work is in danger of being wasted through incompetent and misleading analysis of numerical results.” Concern should be particularly great in the medical field because of the ethical implications, but the medical journals have generally been slow to appreciate that the statistical aspects can be fundamental to the validity of research.

Statistics in medical papers

Probably as a reflection of widespread unease, there have been several reviews of the quality of statistics in published papers

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