The current lead pollution problem

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In the past few years, pollution of the environment by lead has received considerable attention and evoked a variety of responses the more extreme of which have been readily accepted for publication in the National Press.

The manifold purposes that man has found for the utilization of lead in the past and at the present time have caused its dissemination into the environment which, in some instances, has resulted in undesirable effects. However, in order to determine those situations which require attention, an approach based upon scientific principles is essential. Other considerations of an emotive or political nature can only cause confusion and lead to unsatisfactory resolutions.

A great deal of investigatory work has been undertaken in recent times relating to sources of lead in the environment and their effects upon populations.

The sources that have received most attention may be categorized as shown in Table 1.

TABLE 1. Sources of lead absorption

Food and beverages	} Ingestion
Drinking water	
Paint	
Factory emissions	} Inhalation
Automobile exhausts	

The work done by Kehoe (1933, 1961) demonstrated that lead is inescapably present in body tissues by virtue of the ubiquitous distribution of the metal on the surface of the earth. Most of the lead absorbed into the body arrives via the intestinal tract from food, water and other beverages. Man's own contribution to his daily ingestion, over and above that which forms an inevitable background, has been from food products packaged in metal containers, sealed by the use of solder, a practice which is far less prevalent at the present time, with the result that tinned foods contain less lead than before. Also the use of lead arsenate as an insecticide has been markedly reduced, resulting in a reduction of the contamination by lead of certain food products, particularly of those in the fruit range.

Some beverages with an acid pH, such as fruit

juices, cider and wine may also contain excessive amounts of lead if improperly prepared or held for storage in poor quality lead glazed vessels. In some districts of the wine drinking countries of Europe, in particular Yugoslavia, high concentrations of lead are still found in wine which, if drunk regularly, can give rise to overt clinical lead poisoning.

Drinking-water supplies may also be contaminated by lead, particularly in older house properties where the installation of lead pipes is widespread. These are no longer used in modern house construction, but they still remain in many of the older houses. The pH value of water is of material significance. Soft waters with acid pH will readily take up lead into solution, whereas hard waters of alkaline pH will not. For the most part the lead content of drinking water in the U.K. lies within the WHO recommended standard of 0.1 p.p.m., but in some soft water areas the lead content has exceeded this limit.

Lead was used in paint almost universally for many years for its weathering and preservative properties. It continues to be so used for much outdoor application but has been largely replaced for indoor use by titanium. Lead in paint from the surfaces of old, dilapidated buildings has been shown to be a major source of excessive intake, resulting in poisoning among children, as evidenced by the work of investigators in Australia (Nye, 1929; Henderson, 1954; Emmerson, 1963), in the U.S.A. (Chisolm, 1971; Guinee, 1972; Sachs, 1973), and by Barltrop (1972) in the U.K.

The excess intake of lead in children is often associated with the habit of pica. It is perhaps of interest to mention that medical authorities in France deny that lead poisoning is a serious problem among French children as apparently they do not exhibit the habit of pica as do the children of other countries. Nevertheless, in those countries where lead poisoning and excessive blood lead levels are prevalent among children living under conditions of poor socio-economic circumstances, the prime cause has been attributed to the ingestion of peeling flecks of lead-based paint from the surfaces of old, dilapidated buildings.

The incidence of lead poisoning among industrial

lead workers has decreased markedly over the past 40 years. It is, however, only in the past few weeks that attention has been drawn to the possible effects of lead emissions from factories on local populations. The lead smelter at Avonmouth and factories in London and other parts of the country are cases in point where blood lead levels have been shown to be raised in population groups living within the immediate vicinity, although no overt cases of lead poisoning have been detected (Martin, 1974). The inhabitants of the Meza valley in Yugoslavia, who for many years have been subjected to excessive lead exposure from a lead smelter, estimated at ten to twenty times the concentrations of lead in air in the busy streets of a large town, have been shown to exhibit the biological changes indicative of elevated exposure to lead, but with no clinical symptoms (Fugas, 1974). This investigation is continuing with a view to a possible determination of the biological significance of lead at such atmospheric concentrations to the population so exposed.

Similarly in the U.S.A., lead factories have been investigated for lead emissions. In particular I would mention a lead smelter at El Paso, Texas, which over many years had been emitting particulate lead among a small community living within 200 yards of the factory's boundary fence. A detailed investigation of 138 children, all of whom had elevated blood lead levels, revealed no evidence of lead poisoning nor of unusual response to psychometric tests, as compared with an unexposed control group (McNeil and Ptasnik, 1974).

An association between blood lead levels in excess of 25 $\mu\text{g}/100\text{ g}$ blood and hyperactivity in children has been suggested by David *et al.* (1972). This was not confirmed by the El Paso study, or by a recent report of an investigation involving 476 children living in the vicinity of a lead factory on the Isle of Dogs, London (Lansdown *et al.*, 1974).

A source of contamination of the home environment has been shown to emanate from the clothing and shoes of lead workers. To prevent the spread of lead contamination to the home, adequate washing facilities should be provided at the place of work. In addition, lead workers should be issued with works clothing which should be kept at all times within the confines of the factory and separate from their own clothing; special laundry facilities for works clothing need to be provided.

Emissions from lead factories have been, and still remain, point sources of environmental lead contamination which may involve populations living within the immediate vicinity of a works. Efforts are being made at the present time to reduce such emissions, with the aim of eradicating any clinical or biological effects which may have been noted in the past.

Speculation on the health effects of lead from motor car exhausts has been widespread for a number of years. Lead in the form of organo-tetraethyl lead was introduced into petrol over 50 years ago. At a concentration of about 2.5 g Pb/gal, equivalent to 2 ml of lead alkyl, the efficiency of a given fuel can be raised by 6–10 octane numbers, thus providing oil refineries with flexibility of operation and the ability to produce petrol of high efficiency at lower cost. Tetramethyl lead, with a higher vapour pressure than tetraethyl lead, was introduced into petrol in the late nineteen fifties for its ability to remain with the more volatile hydrocarbon fractions. Under certain conditions of engine operation, e.g. rapid acceleration, the lighter hydrocarbon fractions, which are inherently poor in octane number, would pass into the combustion chamber deficient in lead content if tetraethyl lead alone was used. Tetramethyl lead and tetraethyl lead are usually added to petrol in combination as a mixture.

Recent legislation in the U.K. requires that as of 1st November 1974 the lead content of petrol must not exceed 0.55 g/l, as opposed to the previous maximum of 0.64 g/l, equivalent to a reduction from 2.9 to 2.5 g Pb/Imp. gal.

Ethylene dibromide and ethylene dichloride are included with the lead alkyl compounds. Their purpose is to act as scavengers by combining with the inorganic lead that is formed on combustion and so aid in its removal from the engine via the exhaust system. The ratio of the lead alkyl compounds to the organo-halides is about 3 : 2 by volume.

In the course of the lifetime of a car approximately 70% of the lead used in the petrol will be emitted through the tail pipe and the remainder retained within the exhaust system and lubricating oil. Of the lead emitted, the bulk is deposited within about 100 m of the road surface.

A considerable number of investigations have been undertaken in recent years to determine the contribution of auto exhaust lead to the human body burden. It has been shown that city populations generally have higher blood lead levels than rural groups, but no definite relationship between air lead levels and blood lead levels has been demonstrated.

The results of a survey of female populations in seven cities in the U.S.A. (Tepper and Levin, 1972), reported in 1972, showed no correlation between blood leads and air leads in comparisons between cities (Fig. 1). The blood lead values of residents in the country town of Los Alamos, with the lowest air lead levels, were similar to those of the group investigated in Pasadena, Los Angeles, with the highest air lead levels.

Jones, Commings and Cernik (1972) could find no difference in blood lead concentrations in two groups of day and night taxi drivers in London, although

FIG. 1. The seven city study results. Figures in parentheses represent the number of people.

carboxy haemoglobin levels were higher in the day-time drivers. Azar, Snee and Habibi (1972), also were unable to find any difference in blood lead concentrations between taxi drivers in Philadelphia and those in Los Angeles, although the air lead concentrations in Los Angeles were 2.5 times greater than those recorded in Philadelphia.

Daines *et al.* (1972) have reported that people living in close proximity to a busy highway, i.e. 12 feet away, had higher blood lead concentrations than people living further away. Caprio, Margulis and Joselow (1974) reported similar findings among children living within 100 ft of busy roadways in Newark, New Jersey. These authors imputed that the inhalation of automobile exhaust lead was an important factor in the aetiology of childhood lead poisoning in urban areas. In neither study was the state of repair of the housing given, or an indication of the socio-economic circumstances of the families. No evidence of parental occupation was provided and in the study by Caprio *et al.* no information as to race, sex or details of age breakdown were given. In the absence of the contributory support of negative data from other known sources of lead exposure, it was not possible to conclude that the lead in car exhausts was the cause of the elevated blood lead levels found in the populations under investigation.

Guinee (1972), in a study covering a period of 3 years and involving 263,000 children in New York, of which 231,400 were aged 1–6 years, largely composed of Black and Puerto Rican children living in the less fortunate socio-economic areas of the city, found that in 90% or more of those with an elevated blood lead level the cause was due to the ingestion of

peeling flecks of lead-based paint from the surfaces of old dilapidated buildings. In addition, Black children had a higher incidence of elevated blood lead concentrations than Puerto Rican children.

Chisolm (1971) in Baltimore, Sachs (1973) in Chicago and Fine *et al.* (1972) in Illinois, have also found that the ingestion of lead-based paint was the principal cause of elevated blood lead in children in those cities. They did not find that the lead from automobile exhausts was a contributory source that could account for excessive intake among children. In a two-part study in Detroit, Ter Haar and Aronow (1974) were able to show that the source of lead in soil and dust around homes in the City area and in a rural area away from traffic was principally from house paint and not from airborne lead which had settled to the ground. The studies of Barltrop (1972) in the U.K. support the findings of the American investigators. A recently reported investigation by Barltrop *et al.* (1973) of children and their mothers living in a high soil lead area (of 10,000 p.p.m.) and in a low soil lead area (of 500 p.p.m.) indicated a difference in blood lead concentrations between the two populations of about 3–4 µg. This would suggest that the ingestion by children of soil and dust does not contribute greatly to their overall lead intake.

A recent report (S.A.M.O., 1974) of the results of an investigation of blood lead levels in a population living in the vicinity of the Gravelly Hill motorway interchange at Birmingham (Spaghetti Junction) indicated an increase of average blood lead levels, from a figure of 12.2 µg/100 ml of blood before the opening of the motorway interchange to 26.3 µg/100 ml of blood some 20 months after the interchange came into use. Nine-hundred and two people were involved in the investigation, comprising 443 female adults, 361 male adults and 98 children under the age of 10 years. The population was assessed geographically in distances from the motorway of less than 100 m, 100–300 m and 300–600 m. Blood samples were obtained about two months before the opening of the motorway in March and April 1972, again between October 1972 and March 1973 and yet again between October 1973 and January 1974.

The variables introduced into the investigation as it proceeded virtually precluded any comparison of results which might reasonably have been made between the series. Capillary blood samples were used in the first series, before the opening of the motorway. As difficulties were experienced with the collection of capillary samples, venous samples were collected in the second series. In the third series venous samples were collected, but analysed at a laboratory different from that used in the first and second series. These anomalies apart, no consistent

difference was apparent in blood lead concentrations between areas in relation to distance from the motorway which might have been expected if lead from traffic using the motorway had been a significant source of uptake.

Male adults usually show higher blood lead values than female adults, probably by virtue of occupation and larger intake of food and beverages. This was shown in the results of the Gravelly Hill investigation in which the ratio difference of blood lead between the sexes did not alter through the three series. If the lead emitted by motorway traffic was responsible for the increase observed in blood leads, then it would have been reasonable to have expected the ratio difference between the male and female adults to have diminished, as the male population would have been less exposed to the daytime traffic by virtue of their absence at their places of work.

The Gravelly Hill study is an example of how erroneous results can show an alarming trend and be advertised widely in the National Press to the unnecessary disquiet of the public mind. As opposed to other sources of lead exposure, lead from motor car exhausts, despite intensive research and widespread public interest, has not been shown to have been responsible for any cases of overt lead poisoning over the past 50 years.

Governmental action has been proposed in a number of countries to reduce the lead content of petrol, on the basis that an increasing car population will add inevitably to the escape of lead to the atmosphere, but the present situation of crude oil supplies has caused government circles to hesitate in the promulgation of legislation which might intensify an already difficult position. If it is considered advisable to reduce the emission of lead from car exhausts, an alternative to the reduction of lead in petrol would be the prevention of its escape at the point of exhaust. With this end in view lead filters have been undergoing test at the Government Warren Springs Laboratory. The device consists of an alumina coated steel wire mesh which can be fitted to replace the conventional silencer. It has been shown to be effective to a 90% level in reducing emissions of lead and other particulate matter, and at the same time to operate satisfactorily as a silencer. The device has been designed to operate effectively for at least as long as the average life span of a conventional silencer system of about 2 years, or 25,000–30,000 miles. The additional cost would be minimal, some few pounds over the conventional system. A possible bonus might be a subsequent recovery of the lead retained within the filter.

The U.S.A. and countries of the European Community are actively engaged at the present time in evaluating the effectiveness of the lead filter device for use in current and future cars. Although the

evidence does not indicate that lead from motor vehicle exhausts is a material cause for concern in relation to the public health, a reduction of lead emissions would nevertheless be apposite, especially in view of the minimal cost that would be involved by the use of lead filters, as opposed to the much higher penalty that would be imposed if a marked reduction of lead in petrol were to be implemented.

Conclusion

Lead in the environment, its sources and its intake by man, has been studied over the years in very considerable detail. Lead by ingestion, in food, water and beverages, would seem to provide the largest source of intake. The intake of lead by inhalation, except in the case of occupational exposure, would appear to subscribe only a relatively small part of the total intake. The WHO study of 1968 of blood lead concentrations in populations from different countries (Table 2) showed how these vary from country

TABLE 2. Blood lead values by country

Country	$\mu\text{g}/100 \text{ ml blood}$			
	Sample size	Range	Mean	S.D.
Argentina	49	5.50	14	8
Chile	35	5.30	17	6
Czechoslovakia	20	0.50	20	8
Egypt	28	0.50	20	13
Finland	46	10.60	26	12
Israel	67	5.40	15	5
Italy	26	5.40	13	10
Japan	40	5.60	20	8
Holland	60	0.45	15	7
Peru	32	0.35	7	5
Poland	76	0.35	12	6
Sweden	30	5.25	10	3
Yugoslavia	46	5.60	24	16
United Kingdom	30	0.45	23	13
United States:				
California	33	10.27	17	17
New York City	105	0.10	21	18
Ohio	40	10.53	16	8
New Guinea	38	10.40	22	5
Total	801			
Aggregate			17	11

to country, with little to suggest that air lead concentrations formed a significant contribution to the total lead intake. The mean values ranged from a low of 7 $\mu\text{g Pb}/100 \text{ ml}$ of blood in Peru to a high of 26 $\mu\text{g Pb}/100 \text{ ml}$ of blood in Finland. New Guinea natives, with a mean value of 22 $\mu\text{g Pb}/100 \text{ ml}$ blood, compared closely with U.K. natives, with 23 $\mu\text{g Pb}/100 \text{ ml}$ of blood. Blood sample sizes were small and as such perhaps were not wholly representative of the populations in each country. However, air lead concentrations, as these may be related

to automobile exhaust emissions, could not have played a big part in the intake of lead by New Guinea natives, by virtue of a dearth of motor vehicles in that part of the world.

Point sources of concern, which may lead to a high and serious level of lead intake, have been shown to be from the ingestion of old leaded paint among children living in poor socio-economic circumstances, from the drinking of lead-contaminated beverages, in particular wine, and from the exposure of local populations to uncontrolled emissions from lead factories. If these sources can be reduced or eliminated, then the major causes for possible concern in respect to health will have been removed.

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