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Environmental health aspects of lead

Die gesundheitlichen Aspekte der Umweltverschmutzung durch Blei

Les problèmes sanitaires posés par le plomb présent dans l'environnement

SOURCES AND SIGNIFICANCE OF ENVIRONMENTAL LEAD FOR CHILDREN

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Summary

The potential sources of lead in the child's environment are numerous but their availability reflects the physiological and behavioural characteristics of this population group. Permissible intakes of lead should take account of the metabolic and nutritional requirements of different age groups. It is suggested that the permitted lead content of foodstuffs should be based on the needs of young children rather than adults. The lead content of paints and soils may make substantial contributions to intake compared with air, water and foodstuffs. The priorities for environmental control measures should be revised to take account of the major sources of lead for children with respect to distribution and the frequency with which they are associated with symptomatic lead poisoning.

Introduction

Numerous sources of lead are available to the child in the domestic environment in addition to foodstuffs, water and air. The degree to which individual sources of lead contribute to the child's intake will vary according to their availability in particular environmental circumstances and to the physical and mental development of the child (1).

Two factors in childhood have a particular influence on the intake of lead and its significance for the child, namely growth and behaviour.

Much of the dose/response data for individuals is based on data derived from adults, for example in the early studies of Kehoe (2) and this is not necessarily directly applicable to children. Growth results in changes in stature and in the relations of individual tissues to each other in a non-uniform manner and this may be relevant of the sites of action or storage of an absorbed toxic material, such as lead. It also results in increased metabolic needs for nutriments and for oxygen during early life which in turn increases the intake of lead in the atmosphere or in the diet. It has been pointed out that a 2-year-old child may weigh only 20% of the average adult body weight but nevertheless ingests 50% of the calories in the adult diet. A similar increase for respired air is observed so that lead derived from these sources is proportionately increased (3). It can be shown that lead actually absorbed, as opposed to intake, is provided principally by the diet and a much smaller component is derived from the atmosphere.

Few attempts have been made to relate the intake of lead in the diet to the known variations in the metabolic activity of children. In paediatric practice it has long been recognised that the major variable determining oxygen consumption, fluid requirements and drug dosage, is the surface area rather than the body weight (4). This is reflected in the proportionately greater food intakes per unit body weight in young children. Conversely, it could be argued that as with drug dosages used in therapy, a proportionately greater absorption of lead might be required to produce a given toxic effect in young children although this may not apply to chronic cumulative substances as opposed to those with shorter soft-tissue biological half lives.

The calorie requirements of children are related to the changing growth pattern with age although the rates are not identical. Determination of the metabolic requirements on a surface area basis shows that this is not a constant entity throughout development. The calorie requirements of the newborn per unit surface area are greater than those of the adult but increase to reach a peak value by the first year of life and subside progressively thereafter until the adult value is attained (Table 1). It is suggested, therefore, that until reliable dose-response data becomes available for each age group of children, dietary standards ought to be based on the requirements of the one-year-old child rather than the adult.

The determination of permissible limits of intake at different ages can be approached by scaling down acceptable limits for adults. For this purpose, an acceptable upper limit of dietary ingestion of lead of 600 μg/day (340 $\mu g/m^2$) has been assumed, since this value is known not to result in significant changes in the adult and is probably 2-3 times the mean intake of lead (2). The resultant values for permissible lead intake reflect the growth changes during childhood and for a 2-year-old child gives a value of 180 μg/day (Table 1). This value is similar to that for the upper limit of normal derived for this age group from faecal lead studies (5, 6) so that this would seem to be a reasonable approach.

Since the metabolic requirements of children themselves change per unit surface area, a further correction should be applied to take this into account. The results in a small but relatively constant reduction in the permissible lead intake so that the proportionate reduction in the younger age groups is relatively large compared with older children. The revised value for a 2-year-old child then becomes 133 μg per day which is greater than the mean lead intake for this age group but less than the upper limit of normal. Such a limitation could be achieved by relatively modest tightening of food standards legislation. Recently, in the United Kingdom, it was found that canned infant foods contained twice as much lead on average as in the National diet (7) and a reduction to a quarter of the present value has been envisaged in a new specification.

The above data have been based on an assumed permissible maximum intake of 600 μg/day for the adult and this would have to be increased to about 800 μg/day to attain the existing upper limit of normal. If the recent suggestion that a "tolerable" intake of lead in the adult diet was 3 mg/week (8) equivalent to 430 μg per day is accepted, then this would imply a decrease in the permissible limit for 2-year-old children to 93 μg lead per day, which although greater than the present mean value, might be more difficult to achieve in practice.

Standards in general should be devised so that the greatest possible number of individuals in a population are safeguarded. It is suggested, therefore, that a new approach to food standards might be made to take account of the increased metabolic needs of young children. This should be based on the year-old child as the norm rather than the adult since it is at this age group that the caloric requirements per unit/surface area are maximal. The most extreme situation for a given foodstuff would be that it formed the staple diet for a particular child so that it satisfied the calorie requirement. The calorie content of most foodstuffs is available in tables and by taking the previously derived limit of 104 μg/day, the maximum permissible content of lead of each foodstuff can be calculated. This has been done for a limited range of foodstuffs (Table 2) and the findings have been compared with the observed range of lead contents in the United Kingdom National Diet (9). Although the values obtained are comparable with the observed values, they are exceeded in every example by a proportion of the analyses. Similar calculations could be made with respect to the intake of lead in air and water.

Although these environmental sources of lead are in a sense obligatory, there are numerous alternative sources in the domestic environment but they have in common the property that there is an element of choice available to the parents, if not the child, in respect of some of these substances. Thus although the child has little choice in manifesting pica, the family may have some choice in the type of paint accessible to the child or the type of vessel used for the preparation of foodstuffs. Pica is a common activity in young children and the range of objects ingested may be large. When this involves paint considerable intakes of lead may result from the ingestion of flakes only a few mms diameter. Similarly soils and domestic dusts may make substantial contributions to the lead intake of the child, either by direct ingestion or by contamination of the diet. Although ingestion is a familiary problem in connection with lead paint, it has also occurred in connection with contaminated garden soils although the number of cases of poisoning due to soil must be few.

Industrial clothing may serve to transport lead from work to the home but although raised blood leads in children have been attributed to this, symptomatic poisoning is probably rare. Some of these other sources of lead have been listed (Table 3) and their potential

daily contribution compared with food, water and atmosphere. It is evident that intakes from these sources may be large and 3-6 fold increase over and above the dietary intake can be achieved without difficulty.

The hazard that various materials containing lead provide for the child depends upon the interplay of several factors and is not necessarily solely dependent on lead content.

It would seem appropriate to concentrate control measures in those areas where there is greatest need but even this may be difficult to define since there is little reliable information concerning the prevalence of lead intoxication arising from particular sources. Equally, some weight should be given frequency of exposure of the population to particular sources since a material which rarely causes poisoning may have greater overall significance if the entire population is exposed to it compared with a highly toxic material to which few children are exposed. It is difficult to assign relative weight to these factors; however, an attempt can be made by applying arbitrary scales to the prevalence of exposure of the population and the frequency with which symptomatic lead poisoning is thought to occur. It is suggested that the produce of these two values in each case might be taken as an index of the priority which should be assigned to the devising and implementation of control measures. Such a scheme would necessarily be tentative and would need to be modified as sources of lead are identified with greater certainty and to meet the needs of particular situations. Applying these criteria it would seem that the control of lead paint accessible to children is the most pressing need at the present time and that control of lead in diet and atmosphere are perhaps the least important with regard to symptomatic poisoning.

It is recognized that long term low grade exposures to lead may have biological significance but this remains essentially unproven and must be regarded as secondary to the occurrence of symptomatic poisoning. Although it is suggested that priority be given to selected control measures, it is not implied that they should be restricted to these fields since the individual's lead burden must reflect the summated intake from all sources. It is argued, however, that the relative significance of various sources of lead should be recognized and that the interests of the more vulnerable members of the community should be taken into account.

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TABLE 1

Calorie requirements and permissible dietary intake of lead

Age	Calories/kg	Calories/m^2	Pb.µg/m^2	Pb.µg/m^2 (calorie corrected)
Birth	120	1943	72	59
1	100	2296	150	104
2	95	2199	184	133
3	90	2154	208	154
6	80	2086	286	218
9	70	1963	365	297
12	60	1809	433	380
15	50	1706	345	509
Adult	40	1590	600	600

TABLE 2

Maximum lead content of foods for a 1-year-old child

Food	Calories/100 g	Lead ppm	Observed Range (U.K.) * ppm
Cereals:			
Cornflakes	359	0.37	-
Bread	275	0.28	0.01 - 0.81
Vegetables:			
Cabbage	25	0.03	0.01 - 0.51
Potato	85	0.09	0.01 - 0.14
Meat:			
Beef sirloin	297	0.31	0.01 - 0.50
Beef liver	136	0.76	-
Fruit:			
Apple	58	0.14	0.01 - 0.60
Melon	32	0.03	-
Milk:			
Cow's	65	0.07	0.01 - 0.08

* Ref.7

TABLE 3

Sources of lead for a 2-year-old child

Source	Lead Content	Potential Intake µg/day
Food	0.13 ppm	135
Water	0.01 ppm	15
Air	2 $\mu g/m^3$	6
Paint	5%	1,000
Glazed vessels	7 ppm leach in 100 ml	700
Batteries (fuel)	-	1,000 *
Soils and dusts	0.5%	500 *
Industrial clothing	5 g *	500 *

* Tentative figures

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