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SHORT REPORT

Yearly measurements of blood lead in Swedish children since 1978: an update focusing on the petrol lead free period 1995–2001

U Strömberg, T Lundh, A Schütz, S Skerfving

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Background and Aims: To assess blood lead concentrations (B-Pb) in children not exposed to petrol lead. In a previous paper we reported the results for the period 1978–94 (2441 children measured). A substantial decrease of B-Pb was found, which reflected a beneficial effect of gradual banning of petrol lead. Since 1994, petrol sold in Sweden has not contained lead.

Methods: In the south of Sweden, each year from 1995 to 2001, B-Pb was measured in 329 boys and 345 girls, aged 7–11 years.

Results: The geometric mean (GM) of B-Pb was 21 (range 6–80) $\mu\text{g/l}$. There was no consistent change of B-Pb from 1995 to 2001. Children living near a lead smelter had raised B-Pb (GM 24 $\mu\text{g/l}$, range 11–80). Passive smoking, but not age and sex, influenced B-Pb significantly.

Conclusions: B-Pb in Swedish children, no longer exposed to petrol lead, seems to have stabilised at an average level close to 20 $\mu\text{g/l}$ (provided there is no nearby industrial lead emission).

Main message

- Blood lead concentrations in Swedish children, no longer environmentally exposed to petrol lead, have stabilised at an average level close to 20 $\mu\text{g/l}$.

Policy implications

- Banning of petrol lead has had a substantial beneficial effect on children's blood lead concentrations.
- Results indicate that blood lead levels in children could fall to 20 $\mu\text{g/l}$ on average, if known sources of lead exposure were removed.

Lead (Pb) from petrol has been the major source of exposure in most countries. There is also exposure from other sources, including industrial ones.

Yearly since 1978, blood Pb concentrations (B-Pb) have been measured in children living in the municipalities of Landskrona and Trelleborg, located in southern Sweden. We have reported the results up to 1994.¹ Children from the urban areas had about 10% higher levels than those from the rural areas. In addition, living near a Pb smelter caused an approximate 10% increase.

During the period 1978–94 there was a dramatic decrease of B-Pb, which reflected the gradual reduction of Pb in petrol. We did not observe any clear levelling off in the B-Pb time trend. Petrol sold in Sweden since 1994 has not contained lead (National Swedish Environment Protection Agency; Swedish Petroleum Institute).

We have continued to follow the B-Pb in the same manner. We here report the complete data, with focus on the period 1995–2001.

MATERIALS AND METHODS

Children studied

At the end of May or beginning of June each year, blood samples were obtained from children in schools in the urban and the surrounding rural areas of Landskrona (population: 37 728 in 2000) or Trelleborg (38 427). All children in the selected school classes were invited, and about 60% participated in the period 1995–2001. Blood was drawn from the cubital vein into evacuated, heparinised 10 ml Venoject (Terumo Europé, NV, Leuven, Belgium) tubes, which had been

checked for absence of Pb contamination. Altogether 3115 children have been studied. During the period 1995–2001, results on B-Pb were obtained for 674 children (329 boys and 345 girls), aged 7–11 years (median 9). In Trelleborg, the numbers of children measured were: $n = 93$ in 1995, $n = 84$ in 1997, $n = 53$ in 1999, and $n = 85$ in 2001; and in Landskrona, $n = 116$ in 1996, $n = 128$ in 1998, and $n = 115$ in 2000.

Lead exposure

The environments in Landskrona and Trelleborg have been described previously, with reference to lead exposure from traffic and industry.¹ In the town of Landskrona there are two secondary Pb smelters. Some of the children lived 0.5–1 km from the smelters, referred to as the near smelter area.

Questionnaire

Each child was questioned about, inter alia, parents' smoking habits and own hobbies, in particular those involving Pb exposures (for example, shooting air guns).¹

Blood lead analyses

Flame atomic absorption spectrometry (AAS) and electrothermal atomisation AAS were employed in 1978–94,¹ and inductively induced plasma-mass spectrometry (ICP-MS; PlasmaQuad 2+, Fison Instruments, Winsford, UK) in 1995–2001.² Detection limits were ≤ 0.5 $\mu\text{g/l}$. Quality control was strict, especially at method changes (ETA-AAS ν ICP-MS, $r = 0.98$, $n = 29$). Accuracy was checked by control blood samples (35 $\mu\text{g/l}$; batches 205052 and 404107, Nycomed, Oslo, Norway): our mean accuracy in 1995–2001 was 92% and relative SD $\leq 5\%$. We produced good results in the UK National External Quality Assessment Service (Birmingham, UK).

Abbreviations: B-Pb, blood lead; GM, geometric mean

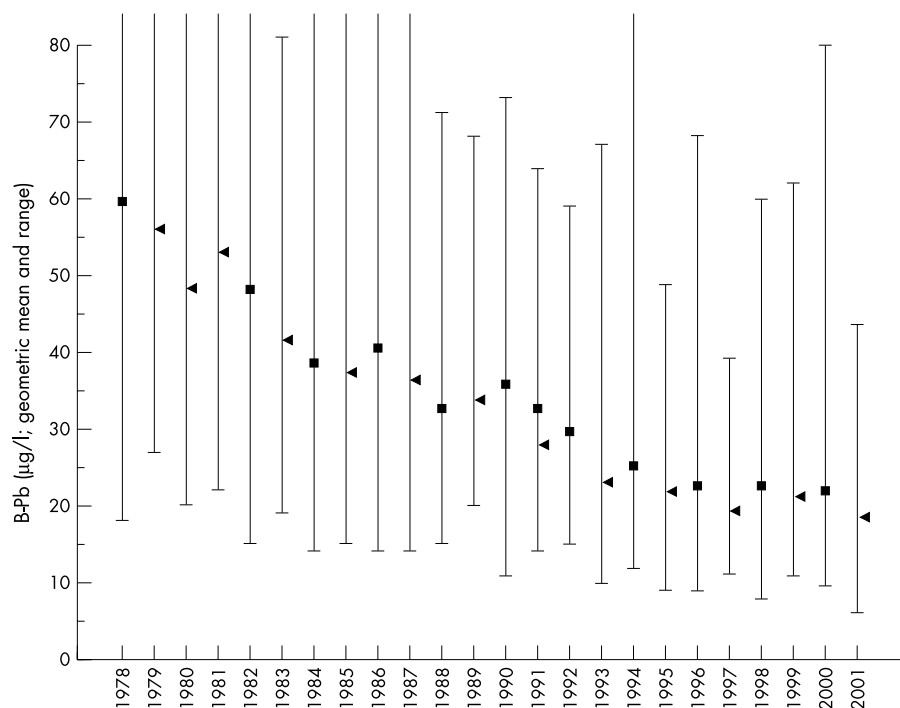


Figure 1 Blood lead concentrations in Swedish children from the municipalities Landskrona (geometric means represented by squares) and Trelleborg (triangles) during the period 1978–2001. Notice that for several years before 1995, the range of B-Pb is truncated at 83 µg/l (the complete ranges have been reported previously¹) and, in 1991, children from both municipalities were measured.

Statistics

Individual B-Pbs were log transformed. The influence of sample year, residential area, age, and sex on B-Pb was examined by analysis of variance techniques. Post hoc analyses of multiple factors, with adjustments for multiple comparisons, were performed according to Scheffé's method.³ Furthermore, the impact of parents' smoking habits (non-smokers *v* at least one smoker) and Pb exposing hobbies (no *v* yes) was evaluated.

RESULTS

Figure 1 shows the substantial decrease of the geometric means (GMs) of B-Pb in the children measured each year from 1978 to 2001. The ranges of B-Pb are also shown. The upper quartiles of B-Pb proportionally followed the decreasing trend of the GMs (upper quartile 74 µg/l in 1978; 24 µg/l in 2001). B-Pb measured in the 674 children during 1995–2001 had a GM of 21 (upper quartile 26; range 6–80) µg/l. Children from the near smelter, urban, and rural areas of Landskrona had B-Pb of 24 (31; 11–80), 22 (27; 9–56), and 21 (26; 8–68) µg/l, respectively; those from the urban and rural areas of Trelleborg had B-Pb of 20 (24; 6–62) and 21 (26; 9–49) µg/l.

The factors sample year, age, and sex did not indicate a significant effect on B-Pb, either for the children from any of the three residential areas of Landskrona, or in the rural area of Trelleborg (all $p > 0.1$). There was no significant difference in B-Pb between the children from the urban and rural areas of Landskrona and the rural area of Trelleborg, respectively ($p = 0.17$), whereas the children from the near smelter area of Landskrona had significantly higher B-Pb than observed in the two rural areas. In the urban area of Trelleborg, sample year ($p < 0.001$), but not age and sex, had a significant impact; the post hoc analysis implied that the B-Pb measurements in 2001 (GM = 16 µg/l) were significantly lower than in both 1995 and 1999 (GMs = 22 µg/l).

Considering each residential area separately, neither the prevalence of at least one parental smoker nor the prevalence of children with a Pb exposing hobby changed markedly in the period 1995–2001. However, the prevalence of at least one

parental smoker varied significantly between the residential areas (34% in both rural areas, 56–58% in the urban areas, and 67% in the near smelter area; χ^2 test $p < 0.001$). A significant effect of parental smoking habits on B-Pb was found for the near smelter area (on average 18% higher B-Pb if at least one parent was a smoker, $p = 0.02$; a similar result was obtained when adjusted for sample year, age, and sex) and for the urban area of Landskrona (14% higher B-Pb, $p = 0.007$; adjusted result similar). Furthermore, the frequency of children with a Pb exposing hobby was highest in the near smelter area (24% compared to 12–19% in the other areas; $p = 0.11$), but no effect on B-Pb was found within the areas.

DISCUSSION

Our data show a dramatic decrease of B-Pb in children during the period 1978–2001. In prospective studies from other geographical areas, similar relative decrease rates, though on much higher absolute B-Pb levels, have been recorded.^{4,5}

Up to 1994, there was a gradual decrease of Pb in petrol.¹ There was no clearly consistent change of B-Pb in the period 1995–2001—that is, after the total disappearance of Pb from petrol. The role of Pb in petrol as a main source of Pb exposure was also indicated by the presence of a difference between urban and rural areas at the beginning of the period, but not at the end. A clear association between petrol Pb and B-Pb has been seen in several studies in different countries.⁶

There was an effect on B-Pb by living near the smelters, but the impact was small. In recent years, all children had B-Pb far below the community intervention level of 100 µg/l used in the USA,⁷ certainly because the emissions were limited and mainly occurred several years ago.¹ However, there might be remaining Pb contamination of the soil. Furthermore, the current B-Pb should, to some extent, be influenced by earlier absorption in the children, resulting in endogenous exposure from deposits in the skeleton.⁸ Furthermore, the prevalence of parental smoker(s) was highest in the near smelter area. The present data indicated that parental smoking affected children's B-Pb, an effect that has been addressed previously.⁹

Age and sex did not significantly influence B-Pb in the children studied in the period 1995–2001. Previously, we found lower B-Pb in girls than in boys.¹ One should bear in mind, however, that the earlier years also included children who were older than 12 years, and the sex difference was most pronounced for such children, particularly in the beginning of the period when the Pb exposure was higher.

The children in the non-smelter areas seem to have stabilised their B-Pb at an average level close to 20 µg/l. This value is low in an international perspective,¹⁰ and definitely lower than the intercept of about 30 µg/l, as petrol Pb is reduced to zero, estimated in populations from different parts of the world after phasing out petrol Pb.⁶ The reasons for the low value observed in the present study might be the small size of the towns⁶ and—more importantly—the lack of significant Pb exposure from sources known to be important in other parts of the world, such as Pb contaminated drinking water, Pb based paint, and Pb soldered cans.

In the urban area of Trelleborg, but not in the other residential areas, a significant decrease in B-Pb was observed in the most recent years. Naturally one should expect some year to year fluctuations in B-Pb, which may not necessarily reflect actual fluctuations in exposures.¹¹ However, the situation will be followed; we shall study whether there might be any further general decrease of the exposure in the population.

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