Blood Lead Levels Among Schoolchildren Living in the Pattani River Basin: Two Contamination Scenarios?

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ABSTRACT
The levels of lead contamination among primary schoolchildren living in Pattani River basin, a region reported to have a high environmental lead content, were determined in this cross-sectional study. During the period Feb-Mar 1995, random samples schoolchildren were assembled from Amphur Bannang Sta, Changwat Yala (Site A) - a region of exposed tin-mine waste at the headwaters of the river, Amphur Yala, Changwat Yala (Site B) - a region in the mid-reaches of the river where mine waste had been removed some 20 years previously, and Tambol Sabarak, Muang Pattani (Site C) situated at the mouth of the river. Information on residence and play behaviour was obtained by interview and venous blood specimens were taken for assay of total blood lead (PbB) concentration using atomic absorption spectrometry. At Site C, specimens of household soil and dust were collected from each household for analysis of total lead content. Distributions of PbB concentration for each school and area of residence were examined and factors associated with elevated PbB identified. Geometric mean PbB concentration in the schools ranged from 8.0 to 13.9 µg/dl and prevalence of PbB > 10 µg/dl ranged from 22 to 98 percent. PbB concentrations at Sites A and C were very significantly higher than those at Site B. At Site A, mean PbB was higher in villages containing extensive mine waste dumps, while at Site C, a marked spatial pattern in mean PbB was evident, closely paralleling lead content of household dust and soil, with increasing levels occurring with closer proximity to a boat-repair yard where extensive use of plumboplastbic oxide is made. Other factors associated with PbB concentration differed between Sites A and C. The findings suggest that lead contamination of children in the mining area and at the mouth of Pattani River represent two distinct contamination scenarios. The PbB concentrations of primary schoolchildren living in both sites are high compared with international standards and should be regarded as a matter of public health concern.

Key Words: blood lead level, schoolchildren, Pattani river basin

Introduction
High concentrations of lead in the water\textsuperscript{1,3}, sediments\textsuperscript{2,4,5} and soil\textsuperscript{6} reported in parts of the Pattani River basin, on the eastern coast of southern Thailand, have raised concern over the potential or actual threat to the health of local residents through the uptake of lead into the body which can give rise, especially in children, to neurological and haematological defects.
Pattani river and its tributaries flow past several tin-mining areas in the hills of Yala Province before entering the Pattani plain and running into the Gulf of Thailand at Pattani Bay. Until the falling price of tin forced closure of the mines in recent years, mining operations had been undertaken in Yala Province for over 50 years. Several investigations have revealed evidence of contamination of the river and surrounding areas with heavy metals from these mines\(^1\). High lead levels have also been reported in sediment and animals taken from the mouth of Pattani River\(^2\). For communities living in the Pattani River basin contaminated drinking water and food together with direct, if unintentional, ingestion of contaminated soil are likely mechanisms by which human exposure could occur. However, in spite of the potential for human contamination, there were no data previously available on levels of human contamination in these areas. This investigation was designed to examine the distributions of whole blood lead concentrations among schoolchildren residing at selected sites along the Pattani River basin to determine if a problem exists and, if so, to identify the conditions under which childhood blood lead was elevated.

**Subjects and Methods**

Three study sites, 2 rural and 1 urban, located within the Pattani River basin were selected for study on the basis of known or suspected high levels of environmental lead contamination and/or their history of tin-mining, and the sample population drawn from children attending primary schools in these sites (Figure 1).

Site A, located at Tambol Thamthalu, Bannang

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![Map of Pattani River Basin](image)

**Fig. 1** Map of Pattani River Basin, showing the location of the study sites, A, B and C.
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Sta District of Yala Province at the headwaters of Pattani River, is a rural tambol containing several tin mines abandoned approximately 7 years prior to the study. The mines themselves as well as extensive areas of mine-waste have been left exposed following the mine closures.

Site B, located at Tambol Tachi, Yaha District of Yala Province in the mid-reaches of the Pattani River basin, is a rural tambol formerly containing a tin mine which was permanently closed about 20 years prior to the study and the mine waste almost entirely cleared.

Site C was centred at Tambol Sabarang, which forms part of Pattani Municipality in Muang District, Pattani Province. The tambol is situated at the mouth of Pattani River, where high lead contamination of river sediments has been reported, although there are no mining activities in the district.

Five primary schools, 2 in each of sites A and C and one in site B, provided the study base of schoolchildren, who were aged 6-15 and resident locally for at least 1 years.

Data collection and blood sampling were undertaken in Feb-Mar, 1995. Information regarding age, sex, and place and duration of residence of each child was obtained from the school records using a questionnaire completed by the class teacher, and details of play behaviour and type of residence obtained by interviewing the child.

A 5 cm³ sample of venous blood was drawn from each child for analysis of whole blood lead concentration (PbB) using a Hitachi Polarized Zeeman Atomic Absorption Spectrometer at the Faculty of Tropical Medicine, Mahidol University, Bangkok. Internal validation of the assay was performed using standards provided by the Division of Toxicology, Department of Medical Science, Ministry of Science and Technology, Bangkok.

From the household of each child in Site C, specimens of household dust and the top 2 cm of soil were collected. Soil and dust samples were analyzed by atomic absorption spectrophotometry at the Department of Mineral Resources, Ministry of Industry, Songkhla, and Division of Environmental Health, Department of Health, Ministry of Public Health, Bangkok, respectively.

Distributions of PbB's among the sample of primary school children at each school were examined, and factors associated with PbB explored using multivariate modelling methods. No adjustment of PbB for haematocrit was made.

Results

The distributions of PbB in samples of children from each school are displayed in Figure 2. Overall range of PbB is wide, 2.9-28.3 μg/dl, with many

![Fig. 2 Distribution of PbB by school. Each circle represents the PbB of one child. The broken vertical line marks the concentration of 10 μg/dl, the minimum level for concern.](image-url)
children having PbB in excess of 10 µg/dl (defined by the Centers for Disease Control, USA, as the minimum level for concern).

There are clear differences in the distributions of PbB among the 5 schools - these are summarized numerically in Table 1. Children at Ban Tachi School (Site B) had PbB's generally much lower than those from the other schools, but there were also marked differences in the distributions of PbB between each of the two schools in both Tambol Thamthalu (Site A) and Tambol Sabarang (Site C). Within each of these sites, the two schools are located close together (approximately 3 km at Site A and 1 km at Site C), so that these marked differences were unexpected. Mean-adjustment techniques revealed that these inter-school differences were due almost entirely to differences in the areas of residence of children at the two schools in each site, suggesting that geographic area of residence may be one of the major determinants of PbB.

To identify the independent associations of geographic, demographic, home-condition and play-behaviour factors with childhood contamination levels, multiple linear regression modelling of logarithm-transformed PbB was performed.

Both at Site A and at Site C, area of residence was the most important factor accounting for variation in PbB. However, in other respects factors differed markedly between sites A and C. At Site A, sex, and in the case of females, also age, strongly influenced PbB. PbB's of girls decreased steadily with increasing age between 6 and 15, whereas no such decrease was evident for boys. At Site C, no age and sex effects were evident. Play behaviour which brought children into close contact with soil and water was associated with increased PbB at Site A, but not at Site C. On the other hand, type of housing and water use influenced PbB at Site C but not at Site A.

Spatial distributions of PbB at Site A showed mean PbB levels elevated by approximately 25 percent among children resident in villages containing extensive mine-waste dumps compared with those in other villages. At Site C, a very distinct spatial distribution of mean PbB levels was evident, and this distribution was closely mirrored by the distributions of soil and dust lead content (Figure 3). Levels of all three parameters peaked in the same area, which turned out to be the location of a boat-repair yard. Inspection of this yard revealed that plumbobplumic oxide, in powder form, was being used extensively in the process of caulking wooden boats.

**DISCUSSION**

The high proportions of children with PbB in excess of 10 µg/dl in two of the three sites and in excess of 20 µg/dl in one of the sites suggest that the problem is of sufficient magnitude to be of public health concern.

At the third site (Site B), PbB's were relatively low. It is not currently known to what extent this represents the beneficial effects of environmental remediation following mine closure or the lack of significant lead contamination at the original mine site.

Environmental contamination at Sites A has been reported in a number of studies. At the mouth of Pattani River - the location of Site C - high levels of lead had been reported in the river sediments and in parts of the food chain, although the source

<table>
<thead>
<tr>
<th>School</th>
<th>No. of children</th>
<th>PbB (µg/dl)</th>
<th>No. of children</th>
<th>No. of children</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Geometric Mean</td>
<td>Geometric Std dev</td>
<td>≥10 µg/dl (%)</td>
</tr>
<tr>
<td>Ban Thamthalu</td>
<td>46</td>
<td>15.91</td>
<td>1.30</td>
<td>44 (96)</td>
</tr>
<tr>
<td>Ban Tangkadeng</td>
<td>127</td>
<td>12.39</td>
<td>1.36</td>
<td>94 (74)</td>
</tr>
<tr>
<td>Ban Tachi</td>
<td>105</td>
<td>7.96</td>
<td>1.51</td>
<td>23 (22)</td>
</tr>
<tr>
<td>Tesabal 3</td>
<td>61</td>
<td>14.76</td>
<td>1.23</td>
<td>60 (98)</td>
</tr>
<tr>
<td>Ban Sabarang</td>
<td>57</td>
<td>10.92</td>
<td>1.28</td>
<td>37 (65)</td>
</tr>
</tbody>
</table>
That this industry is a likely major source of childhood contamination in the study site is further reinforced by unpublished data of one of the authors (SC), of PbB of various groups of workers in Pattani municipality. Boat-yard workers in general had relatively high PbB’s but those employed as caulkers, handling the plumbomutlic oxide, had the highest PbB’s of all manual workers studied (arithmetic mean 45.3 μg/dl, standard deviation 14.6 μg/dl).

It should be noted that this study does not provide a direct indication the overall prevalence of childhood lead contamination within the Pattani River basin. The findings do, however, have several important public health implications. Tin-mining operations are not confined to the Pattani River region, but scattered throughout southern Thailand. In many of these mine sites, either active or abandoned, similar problems of contamination may exist. Similarly, boat-building and repair yards are located in many coastal towns in southern Thailand. It is likely that all of these yards use plumbomutlic oxide in the caulking process. Many are located close to residential communities, which may therefore be at high risk of lead contamination.

The high prevalence of elevated PbB’s with potentially adverse health effects among children living close to the sources of lead contamination suggests a need for intervention to reduce the exposure levels. Two possible approaches are a) to remove or isolate the ultimate source of contamination and b) to reduce child contact with the contaminant. The extent to which the former approach is politically and economically feasible needs to be explored, while the second approach still requires more information on the precise pathways by which children are being contaminated in each of the settings covered in this study.

CONCLUSION

Blood lead concentrations of primary school children living in the Pattani River basin are high compared with international standards. Two contamination scenarios appear to exist, one in the headwaters of Pattani River, where blood lead concentrations are highest among children living in villages containing mine-waste dumps, and the other at the...
mouth of the river associated with proximity to a boat-repair yard where plumboplatinum oxide is used.

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