Factors associated with elevated blood lead levels in inner city Cape Town children

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Summary

A cross-sectional analytical study was carried out to determine risk factors for childhood lead exposure. Blood lead levels of inner-city Sub A coloured children living in Woodstock were examined in relation to information obtained by questionnaire on environmental and social factors. The mean blood lead concentration of the population was 18 μg/dl. Thirteen per cent of children had blood lead levels ⩾ 25 μg/dl, the present USA 'action' level. Dusty homes and homes in a poor state of repair, over-crowding, low parental education and income, and other aspects related to family structure and socio-economic status, were associated with raised blood lead levels.

It is suggested that social factors assume importance in predisposing children to lead in the environment. In particular, the over-crowded nature of the homes could have a direct bearing on the quality of the care-giving environment, providing opportunity for children's activities to go unsupervised. This could lead young children to be more exposed to accessible sources of lead associated with poor housing conditions. More attention needs to be given to examining the interaction of social and environmental factors in studies of childhood lead exposure.

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Childhood lead poisoning is one of the 20th century's most insidious environmental health problems associated with urbanisation and inner city decay. For example, a nation-wide health and nutrition survey in the USA showed a clear association between the prevalence of raised blood lead levels and the degree of urbanisation of the population.[1]

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The first community-based epidemiological study designed to determine the extent of increased lead absorption among children in South Africa was completed in 1982.[2] In the study of 1 234 coloured Sub A and Sub B children attending schools in the Cape Peninsula, it was found that among children from urban areas there was an approximate two-fold increase in the prevalence of raised zinc protoporphyrin (ZPP) and blood lead levels compared with children from suburban areas.[2,3] This suggested that South African children from urban areas are at increased risk of exposure to lead. This finding was confirmed in a preliminary hospital and clinic-based study carried out by White *et al.*[4]

There have been few comprehensive studies carried out in this country to determine the risk factors for lead exposure among young urban children.[5] The determinants of childhood lead exposure are multifactorial and may include factors such as exposure to lead-based paint, petrol-derived aerosols and lead plumbing. In Cape Town, the role of factors associated with housing in childhood lead exposure was explored in a cross-sectional study carried out in the inner city area of Woodstock. Blood lead levels of coloured children were examined in relation to environmental and social risk factors.

Subjects and methods

Woodstock is located in the 'twilight zone' of Cape Town's inner city. While it is primarily a working-class suburb, extremes of wealth exist and the community is diverse in respect to culture and religion.

Schools formed the primary sampling units for the study, and selection of pupils within schools was restricted to one age group to eliminate age bias. As younger children are at greater risk than older children, the study population was defined as all Sub A pupils living and attending schools in the Greater Woodstock area. All principals of the 5 coloured primary schools with pupils living in the area gave permission for children to be tested at school.

Collection and analysis of blood samples

Following parental permission (by 90% of parents), 5 ml of blood were obtained by venepuncture from each child (104 children altogether) and stored in tubes containing heparin.

Children not wishing to comply (< 5%) were excluded. Duplicate blood samples were obtained from 20% of the population in order to measure intra- and inter-laboratory variation.

Blood lead analyses were carried out using standard methods.[6] Following preparation and centrifugation, an atomic absorption spectrophotometer (Beckman 1272, M Model) was used to perform lead analyses. With each batch of samples a reagent blank and set of working standards were run simultaneously. The lowest accurately measurable concentration of lead in blood was found to be 5 μg/dl. Routine blood lead measurements on samples were performed by the Institute of Child Health, Red Cross War Memorial Children's Hospital, Cape Town. This laboratory participates in the national quality control programme.[6]

Questionnaire data

In order to identify particular risk factors that could have a bearing on the community's exposure to lead, a questionnaire covering a broad range of items was designed and pre-tested. To reduce the possibility of language bias, the questionnaire was translated into English and Afrikaans.

The questionnaire contained items of interest that fell into three main content areas: (*i*) sources of mechanisms of exposure to lead; (*ii*) socio-demographic and economic factors; and (*iii*) potential ill-effects associated with increased exposure.

Statistical analysis

Univariate analyses were carried out to examine the relationship between individual variables and blood lead concentrations. For the discrete variables, if the distribution of blood lead levels was approximately normal for the two or more categories of the variable, a *t*-test (for two categories) or a one-way analysis of variance (for more than two categories) was performed. If the distribution of blood lead levels was skewed but the variances for the categories were not significantly different, a Mann-Whitney *U*-test (for two categories) or a Kruskal-Wallis test (for more than two categories) was performed. If the variances were significantly different, a median test was performed.

Spearman correlation coefficients were determined for continuous variables to see if an association with blood lead levels existed. In addition, multivariate analyses on questionnaire data were carried out. A series of multi-way contingency tables were formed and log linear models used to analyse them.[7]

Results

Blood lead levels

The median blood lead concentration of the population was 18 μg/dl (SD 6 μg/dl). No difference in blood lead concentration occurred with respect to gender. Thirteen per cent of children had blood lead levels ⩾ 25 μg/dl, the present USA 'action' levels.[8]

Descriptive profile of population

Analysis of the questionnaire data (for which there was an 80% response rate) revealed that the average age of the children's homes was 52 years; 32% of houses were reported to have significant amounts of flaking paint outside, while 23% had paint flaking on inside surfaces. Of the respondents, 32% reported that their homes needed major repairs, and 29% reported that their homes were excessively dusty.

The majority of respondents (93%) had electricity in the home, but 21% used paraffin regularly, 47% used gas and 11% coal. Of the respondents, 57% lived in homes with an outside toilet.

There were on average 2 smokers per home. The median number of people per household was 6, while the median number of rooms per household was 3. Over 70% of parents had completed 6 or more years of schooling, and 26% of respondents owned their homes. Thirty per cent of the children lived in single parent families.

English was spoken at home by 48% of children, 24% spoke Afrikaans, and 27% both languages. Thirty-seven per cent of children were of the Christian faith, while the rest were of Islamic faith.

Risk factors

A number of environmental and sociodemographic factors were significantly related to children's blood lead levels (Table I). Among the environmental variables, raised blood lead levels in children were associated with residence in dusty homes and homes in a poor state of repair. Water pipes were not a significant factor in the exposure of children to lead — the majority of homes had copper pipes; in only 2 homes was the presence of lead pipes reported.

TABLE I. RISK FACTORS

Variable	Mean blood lead level (μg/dl)	Significance level (*P*-value)
House dust present		
Yes	**21**	
No	**16**	**0,0280**
Major repairs needed		
Yes	**20**	
No	**16**	**0,0305**
Home owned		
Yes	**19**	
No	**14**	**0,0090**
Home language		
Afrikaans	**22**	
English	**16**	**0,0011**
Religion		
Christian	**20**	
Islam	**15**	**0,0018**
Fathers schooling		
< 6 yrs	**20**	**0,0011**
> 6 yrs	**15**	
Mothers schooling		
< 6 yrs	**21**	**0,0062**
> 6 yrs	**15**	
Single parent		
Yes	**21**	**0,0255**
No	**16**	
Crèche attended		
Yes	**16**	
No	**19**	**0,0358**
	Correlation coefficients*	
Family income	**– 0,48046**	**0,0015**
Occ. density	**0,45786**	**0,0001**
No. of siblings	**0,24012**	**0,0319**

* Spearman rank correlation coefficient between blood lead and the variable of interest.

There were significant differences in the blood lead levels between English and Afrikaans speakers, as well as between children of different religions. For example, being Afrikaans

speaking and of the Christian faith (rather than of Islamic faith) were associated with increased blood lead levels. In this community, both these factors have been documented to be associated with lower socio-economic status.[9] Other sociodemographic factors associated with increased risk included occupational density (overcrowding), having many siblings, living with a single parent, low parental education and family income, and non-ownership of a home. Also, children who had attended a crèche had significantly lower blood lead levels than those who had not.

There was a high degree of confounding between social and environmental factors, and environmental factors, such as the level of dust and the state of repair of the home, were not significant when socio-economic factors were taken into account in the multivariate analyses.

Discussion

While sources of lead in the home environment were not quantitatively determined in this cross-sectional study, qualitative information indicated that several environmental factors associated with the home environment, as well as sociodemographic factors, were related to blood lead levels.

Social factors that were important in influencing children's blood lead levels included those directly related to socio-economic status (for example the relative level of affluence of the family, and the educational level of the child's parents) and other associated factors relating to family structure (for example single-parent families, number of siblings) as well as occupational density.

Studies in other parts of the world have found blood lead levels to be correlated directly or indirectly with socio-economic status. In the USA, for example,[1] low socio-economic groups have been found to have higher blood lead levels than higher socio-economic groups. In the NHANES II study[1] there was a very strong inverse relationship between social class and blood lead levels across all age groups in the population. This relationship was most marked in children under 6 years of age.[1]

Deveaux *et al.*'s[10] failure to find a relationship between socio-economic status and blood lead levels in another Cape study could relate in part to the fact that the children studied were those attending crèches, who are likely to be of higher socio-economic status than non-crèche attenders. In this study, crèche attendance was shown to have a protective effect on blood lead levels.

It is often assumed that children of lower socio-economic status are at higher risk because they are more likely to reside in inner city areas where there is old housing with leaded paint, high density traffic or lead water pipes. In the present study, children from homes in a poor state of repair and children from dusty homes had higher blood lead levels than others, although these factors did not remain significant in the multivariate analyses. Houses in a deteriorating state have greater amounts of dust than well-maintained homes, and increased levels of lead in dust could derive from old flaking lead-based paint and atmospheric lead deposition.

Some studies,[11,12] however, have found that social factors associated specifically with the quality of the care-giving environment may be of more significance than environmental factors *per se*. While the role of environmental factors has subsequently been extensively studied,[13] this analysis has shown that demographic factors, such as overcrowding, are likely to play a role. Overcrowding is associated with other negative social and economic factors, which in turn may impact on the parents' ability to supervise children.

It is suggested here that social factors assume importance in predisposing children to lead in the environment. Should significant quantities of lead be present in the environment (for example lead in dust), this study shows that coloured children from poor social circumstances are at highest risk. While elevated levels of lead in the environment are a necessary prerequisite for exposure to occur, homes in good state of repair (associated with higher socio-economic status) present fewer opportunities for potential sources, such as leaded paintwork, to become accessible. The overcrowded nature of the homes could have a direct bearing on the quality of the care-giving environment, providing opportunity for childen's activities to go unsupervised, and for them to be more exposed to accessible sources of lead. The interaction of social and environmental risk factors is of importance in childhood lead exposure and needs further detailed study.

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