DISTRIBUTION OF BLOOD LEAD LEVELS IN SCHOOLCHILDREN IN SELECTED CAPE PENINSULA SUBURBS SUBSEQUENT TO REDUCTIONS IN PETROL LEAD

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Objective. To determine blood lead levels among children attending schools in selected Cape Peninsula suburbs, and to assess the impact of a reduction in the lead content of petrol.

Design. A cross-sectional analytical study of children's blood lead levels and associated risk factors.

Setting. Selected inner city, suburban, and peri-urban schools in the Cape Peninsula, expected to have differing levels of environmental exposure to lead.

Subjects. Grade 1 schoolchildren for whom prior written parental consent had been obtained, and who were present at school on the day of the study.

Outcome measures. Blood lead levels (µg/dl), associated with a wide range of potential risk factors.

Results. Median blood lead levels in suburbs varied from 14 to 16 µg/dl, the lowest levels occurring in the peri-urban suburb and the highest in the inner city suburb. Within the inner city suburb of Woodstock, variations in mean blood lead concentrations among schools were substantial, varying from 13 to 19 µg/dl. Overall, no change occurred in blood lead levels in this suburb subsequent to the lowering of the lead content of petrol.

Conclusion. Every effort should be made in South Africa to control sources of lead in the urban environment. The study will serve as a useful baseline against which to measure the impact on blood lead levels of further actions which have been taken to promote the use of lead-free petrol in South Africa.

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In South Africa, relatively little is known about the extent of childhood lead exposure nationwide. In general, it is well established that children are at higher risk of lead poisoning compared with adults, and there is firm evidence of biochemical, haematological and neuropsychological effects in children at increasingly lower lead levels.[1] Results from studies conducted around the world have shown a relationship between lead exposure during fetal development and deficits in neurobehavioural performance. At blood lead levels around 10 - 15 micrograms per decilitre (µg/dl) and below, effects such as impaired neurobehavioural development, reduced gestational age and lowered birth weight may occur.[2] In the USA, evidence on the toxic effects of low level lead exposure prompted the Centers for Disease Control to lower the action level for lead in children to 10 µg/dl.[3]

There have been no national blood lead surveys carried out in South Africa, but studies on lead exposure among children in the greater Cape Town area indicate that urban children may be at particular risk.[4-11] School-aged, as well as preschool children in the Cape Town area have been found to have median blood lead levels around 16 µg/dl. In 1984, 8% of children living in the inner city Woodstock suburb of Cape Town were found to have blood lead levels greater than or equal to 25 µg/dl, the previous USA action level.[9] Traffic was found to influence blood lead levels of children attending schools on heavily travelled roads.[11] At such schools in the Woodstock area blood lead levels averaged between 18 and 21 µg/dl. This was at a time when the maximum permissible lead level in petrol was 0.836 g/l. Children living in old, deteriorating housing in Woodstock were also found to be at risk of increased lead exposure.[11]

In light of the fact that in parts of Europe and the USA blood lead levels have been falling over the past years,[12-16] it was decided to do a survey of blood lead levels among schoolchildren living in selected suburbs of Cape Town, where previous surveys conducted had indicated that certain groups of children were over-exposed to lead. The main goal of the study was to determine the distribution of blood lead levels in groups of schoolchildren living in inner city, suburban and peri-urban areas of the Cape Peninsula. A second objective was to determine whether there was any measurable impact on children's blood lead levels following the phased lowering of the lead content in petrol. A third objective of the study was to establish a baseline against which the impact of any further reductions in the lead content of petrol could be measured.

METHODS

Study design

A cross-sectional, analytical study was conducted, and schools in selected areas of the Cape Peninsula expected to have differing degrees of exposure to environmental lead were

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selected. This included children attending schools sampled previously in the inner city suburbs of Woodstock (situated 3 - 5 km east of Cape Town's central business district) and Schotcheskloof, as well as children attending schools in the suburban and peri-urban areas of Mitchell's Plain and Hout Bay respectively. In Woodstock, Schotcheskloof and Hout Bay all primary schools in the suburb were selected, whereas in Mitchell's Plain a primary school was randomly selected. The study population comprised first grade pupils attending the selected schools in the study areas who had written parental permission to participate in the survey.

Data collection

Venous blood samples (5 ml) were obtained from 510 schoolchildren with parental permission (the overall response rate was 90%), present at school on the day of the study. Samples for blood lead analyses were stored on ice in heparin-containing tubes, and further samples for full blood counts were stored in tubes containing ethylene-diamine-tetra-acetate anticoagulant. The blood lead concentrations were determined by the Institute for Child Health Laboratory at the Red Cross War Memorial Children's Hospital in Cape Town, using atomic absorption spectrophotometry. An atomic absorption spectrophotometer (Pye-Unicam SP9 model), equipped with automatic sampler, graphite furnace, SP9 computer and a deuterium arc background corrector (Unicam Chromatography, Cambridge, UK), was used to perform lead analyses on blood samples, prepared according to standard methods. The laboratory participates in the national quality control programme. The coefficient of variation in blood lead samples was 5.8%.

RESULTS

Table I gives the mean and median blood lead levels by area (suburb), as well as the percentage of children with blood lead levels ≥ 10, 15 and 25 µg/dl respectively by suburb. As can be seen, blood lead levels were lower in children from schools in the suburban areas of Mitchell's Plain and Hout Bay, compared with the inner city areas of Woodstock and Schotcheskloof. For example, in Hout Bay a significantly lower percentage of children had blood lead levels ≥ 15 µg/dl than in inner city Woodstock (34% versus 62%) (Table I).

Table II. Mean and median blood lead levels (µg/dl), by school, 1991

School	No. of children	Median	Mean
Woodstock			
1	19	17	17
2	37	16	17
3	68	16.5	16
4	43	13	13
5	14	15	16
6	37	19	19
7	25	15	16
Schotcheskloof			
9	48	15	15
Mitchell's Plain			
13	104	15	15
Hout Bay			
10	20	14	14
11	70	13.5	13
12	25	14	14

Table II gives a breakdown of blood lead levels by school. It is evident that substantial variations in blood lead concentrations occurred between individual schools in the inner city suburb of Woodstock, where median school blood lead levels ranged from 13 to 19 µg/dl. At school 6, situated in the immediate proximity of a busy highway, the highest blood lead levels were registered, with 78% of children having blood lead levels equal to or greater than 15 µg/dl.

Comparing overall blood lead levels in the Woodstock area before and after the reduction in the lead content of petrol, both in 1984 and 1991, median blood lead levels of 16 µg/dl were measured in Woodstock. In 1984, as was the case in 1991, school 6 registered one of the highest blood lead levels. The lowest blood lead levels (13 µg/dl) were measured at school 4, which similarly registered the lowest blood lead levels in the 1984 survey. Differences in blood lead concentration at the schools were significant at the 5% level, both in 1991 and 1984.

Blood lead levels measured at school 9 in the inner city suburb of Schotcheskloof were lower in 1991 (averaging 15 µg/dl) than in 1984 (19 µg/dl); this was the only school to have shown a significant drop in blood lead levels subsequent to the reduction of lead in petrol. Blood lead levels measured

Table I. Blood lead distribution by area (µg/dl), 1991

		Blood lead level				
Area	No. of children	Median	Mean	% > 10	% > 15	% > 25
Woodstock	243	16	16	99	62	2
Schotcheskloof	48	16	16	100	71	2
Mitchell's Plain	104	15	15	93	57	1
Hout Bay	115	14	14	95	34	0

at school 10, situated in suburban Hout Bay, were substantially higher in 1991 than in a previous 1982 survey, when blood lead levels averaged 11 µg/dl. This may reflect urbanisation trends and increased traffic densities in the area over the past 10 years.

Discussion

In general, differences between suburbs were less than expected in this study, illustrating that environmental lead is now a widespread problem in Cape Town. Of interest was the fact that blood lead levels had not changed significantly in the Woodstock inner city area subsequent to the lowering of the lead content in petrol. It is possible that while lead levels in petrol in South Africa were significantly reduced, in phases, from 0.836 to 0.4 g/l during 1989, levels were still too high to make a measurable impact on blood lead levels overall. It is also possible that reductions in the level of lead in petrol were offset by increases in traffic volume that may have occurred in the area over this period. Also, the impact on dust lead concentrations in the area may not yet have been measurable, even if reductions in air lead concentrations had occurred. Alternatively, significant changes in the socio-demographic profile of the population may have occurred. However, a full background study was not within the scope of this phase of the project.

While it is difficult to make valid comparisons with blood lead levels of children in other countries, it can nevertheless be said that overall blood lead levels of the Cape urban children measured in this study appear to be considerably higher than those of urban Australian and European children, where blood lead levels now average well below 10 µg/dl.[13,17] Results from the Third National Health and Nutrition Examination Survey (NHANES) study[18] in the USA also indicate that blood lead levels are now averaging around 3 µg/dl. In certain European countries and the USA, where blood lead levels have been steadily decreasing over time,[19] in some instances in direct proportion to decreases in the lead concentration of petrol,[12,14] a larger impact may have been observed because of the lower baseline against which levels of lead in petrol were lowered and eventually removed, but also because the role of other confounding factors would have been less significant in a nationwide population survey of the magnitude of the NHANES surveys in the USA.[12]

In the inner city environment sources of lead are ubiquitous, with elevated levels being found in air, dust, paint, in the environment at large and in the home environment in particular. In light of other contributing factors associated with raised blood lead levels in these inner city children,[11] which may not necessarily have remained constant over time, it is possible that more measurable impacts on blood lead levels in South African children will be seen in outlying areas, where there are fewer competing sources of exposure. In this respect, the blood lead levels of the suburban children will serve as a useful baseline against which to measure the current situation regarding lead in petrol in South Africa.

Conclusions

In light of overwhelming evidence linking lead at increasingly lower levels to adverse effects in children, every effort should be made in South Africa to lower the baseline of children's blood lead levels. Blood lead levels in these children remained significantly high over the period studied. Intensified, vigilant control of all sources of lead in the urban environment is vitally necessary in South Africa.

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References

1. Environmental Protection Agency. *Air Quality Criteria for Lead*. Vols I - IV, EPA-600/8-83/028a-dF. North Carolina, USA: Environmental Criteria and Assessment office, 1986.
2. Davis JM, Svensgaard PJ. Lead and child development. *Nature* 1987; **329:** 297-300.
3. Centers for Disease Control. Preventing lead poisoning in young children: a statement by the Centers for Disease Control — October 1991. Atlanta, Georgia: US Department of Health and Human Services, 1991.
4. von Schirnding YER. A study of the impact of lead in the environment on school children in the Cape Town area. MSc thesis, University of Cape Town, 1982.
5. White NW, Dempster WS, Pocock F, Kibel MA. Lead absorption in Cape children: A preliminary report. *S Afr Med J* 1982; **62:** 799 - 802.
6. von Schirnding YER, Fuggle RF. Zinc protoporphyrin levels and lead absorption in children attending schools in the Cape Peninsula, South Africa. *S Afr J Epidemiol Infect* 1986; **1:** 11 - 15.
7. von Schirnding YER, Fuggle RF. A study of the relationship between low level lead exposure and classroom performance in South African children. *Int J Biosoc Res* 1986; **6**(2): 97 - 106.
8. Deveaux P *et al.* Blood lead levels in pre-school children in Cape Town. *S Afr Med J* 1986; **69:** 421 - 424.
9. von Schirnding YER. Environmental lead exposure among inner-city Cape Town children: A study of associated risk factors. PhD thesis, University of Cape Town, 1988.
10. von Schirnding YER, Bradshaw D, Fuggle R, Stokol M. Blood lead levels in South African inner-city children. *Environ Health Perspect* 1991; **94:** 125 - 130.
11. von Schirnding YER, Fuggle RF, Bradshaw D. Factors associated with elevated blood lead levels in inner-city Cape Town children. *S Afr Med J* 1991; **79:** 454 - 456.
12. Annest JL, Pirkel JL, Matuc D, Neese JW, Bayse DD, Kovar MG. Chronological trend in blood lead levels between 1976 and 1980. *N Engl J Med* 1983; **308:** 1373 - 1377.
13. Schutz A, Attewell R, Skerfving S. Decreasing blood lead in Swedish children, 1978 - 1988. *Arch Environ Health* 1989; **44:** 391 - 394.
14. Skerfving S, Schutz A, Ranstam J. Decreasing lead exposure in Swedish children, 1978 - 1984. *Science of the Total Environment* 1986; **58:** 225 - 229.
15. Brunekreef BD. The relationship between air lead and blood lead in children : a critical review. *Science of the Total Environment* 1984; **38:** 79 -123.
16. Environmental Protection Agency. *Strategy for Reducing Lead Exposures*. Washington, DC: US Environmental Protection Agency, 1991.
17. Cowie C, Black D, Fraser I. Blood lead levels in preschool children in eastern Sydney. *Aust N Z J Public Health* 1997; **21:** 755 - 761.
18. Brody DJ, Pirkle JL, Kramer RA, *et al.* Blood lead levels in the US population. Phase 1 of the Third National Health and Nutrition Examination Survey. *JAMA* 1994; **272:** 277 - 283.
19. Maravelias C, Athansalelis S, Dona A, Chatzioanou A, Priftis C, Koutselinis A. Reduction of lead pollution in Greece during the past two decades. *Arch Environ Health* 1998; **53:** 424 - 426.

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