Maternal and fetal blood lead levels

The high observed prevalence of HIV/STD co-infection is troublesome in light of infrequent barrier use, although participants did report a twofold increase in the rate of condom use from 25% to 50% during the study period. Nevertheless, the large number of clients served each week and the continuing low level of condom use contribute to this large burden of sexually transmitted infections.

Overall, the findings from this acceptability study reveal that the product was acceptable and did not compromise the traditional practices of the women. Moreover, an effective microbicide that does not moisten the vagina to a great extent may act as a substitute for other harmful traditional practices. The microbicide appears to be associated with observable colposcopic changes, but not more so than with placebo use. Finally, it is concluded that conditions within this cohort were conducive for a large phase III efficacy trial.

In sum, the sexual behaviours and prevalence of STDs among this cohort, along with the demonstrated safety and acceptability of COL-1492, indicate the appropriateness of a large phase III efficacy trial.

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MATERNAL AND FETAL BLOOD LEAD LEVELS

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Background. Elevated blood lead levels during pregnancy can affect neurological development in the fetus and the child. The extent of this problem has not been well studied in developing countries.

Aim. To assess maternal and fetal blood levels during pregnancy.

Setting. The obstetric units of two hospitals in Durban serving disadvantaged communities.

Results. Maternal and umbilical cord blood levels were analysed in 300 women at time of delivery. The mean maternal blood lead level was 7.3 μg/dl but 18.7% of the samples had values greater than 10 μg/dl (the US Centers for Disease Control cut-off level for raised blood lead level in children and pregnant women). The mean umbilical cord blood level was 6.3 μg/dl and 12% had values greater than 10 μg/dl.

Conclusion. This study indicates that there is a significant risk of maternal and fetal lead exposure in Durban and that public health measures to reduce exposure are needed.

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Lead is an environmental toxin of public health concern throughout the world. In developed countries studies indicate a decreasing trend of lead toxicity;[1] this is attributed to increased public and government awareness leading to effective control measures. In contrast, studies from developing countries[2-5] indicate that lead toxicity is still a major problem, with lead levels similar to those of developed countries in the 1970s.

Epidemiological evidence has shown that blood lead levels as low as 10 μg/dl have deleterious effects on neurological development in children.[6-8] Consequently, in consideration of this evidence, world bodies such as the Centers for Disease

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Control (CDC)[9] and the World Health Organisation (WHO) have revised the threshold levels of blood lead to 10 μg/dl.[10] Studies in pregnant women reveal that elevated blood lead levels (Pb-B) are associated with increased rates of congenital anomalies, abortion, premature labour, and impaired fetal growth.[6,8,11] Although levels between 10 μg/dl and 30 μg/dl may produce no clinical symptoms in the mother, they pose significant risk to the fetus because lead is permeable through the placenta. In addition, the increased turnover of calcium during pregnancy and breast-feeding may increase maternal blood lead levels as 90% of body lead is stored in the skeleton.[11,12]

The major sources of lead exposure come from gasoline emissions, industrial emissions and lead-glazed ceramics. A recent study conducted in Durban[3] in 1996 showed that the average airborne lead concentration ranged from 0.4 μg/m³ to 1.8 μg/m³, with the dominant source of contamination being leaded gasoline. The aim of the study was to determine the extent of elevated blood lead levels in pregnant women and newborns and to evaluate exposure risk factors.

METHODOLOGY

Study area/population

The study was conducted in August 1996 and involved two hospitals in the Durban metropolitan area, namely King Edward VIII (KEH) and RK Khan (RKK) hospitals. Both hospitals serve a large population that is socially and economically disadvantaged.

Durban is one of the leading industrial zones in South Africa with industries that range from small cottage industries to car assembly and ship repair yards. In some areas residential suburbs are located within the industrial areas.

The protocol for the study was approved by the Ethics Committee of the Faculty of Medicine, University of Natal. Informed consent, employing translators where necessary, was obtained from each participant. All the women who delivered in the two institutions between 08h00 and 20h00 during each day of the study period were recruited. Out of 320 mothers 287 agreed to participate. A structured questionnaire was used to obtain sociodemographic and obstetric data.

Blood collection and analysis

After delivery 2.5 ml of maternal venous blood and 2.5 ml of cord blood were collected into a lead-free plastic vacutainer containing dry potassium ethylenediamine trichloroacetic acid. The collected blood was mixed with the anticoagulant and stored in a fridge and all samples were frozen at the end of each day. In September the samples were transported in cooler boxes to the School of Public Health, University of Michigan, USA, where they were analysed. The analysis followed the ultra-clean laboratory procedures developed by Nriagu.[13]

A 1 ml blood sample was digested with 10 ml of trace metal-grade nitric acid in a sealed teflon bomb of a microwave digestion system. This was diluted further to 25 ml with mill-Q water (Millipore Corporation, Bedford, Massachusetts). The digestion was done in batches of 12, with each batch including a reference blood sample (NIST 955a). The digestion of samples in any batch was repeated if the lead content of the reference blood sample deviated from certified value by ± 10%. Lead concentration in each sample was measured by graphite furnace absorption spectrometer (GFAAS) equipped with a Zee-man background corrector. Replicate analysis of several samples showed the range of error to be ± 10% for all blood lead data reported.

STATISTICS

Blood lead levels were summarised by both means and class intervals. The association between lead levels and exposure risk factors as well as obstetric parameters was analysed by chi-square (Fisher's exact) and analysis of variance. The association between maternal and cord lead levels was analysed using Pearson's correlation coefficient and a general linear model to measure the strength of association.

RESULTS

The sociodemographic profile of patients is summarised in Table I. The mean age (SD) was 26 (6) years. The majority of patients were black (75%), followed by Indians (23.0%) and whites (2%). The majority of women were multiparous (69%).

Table I. Sociodemographic profile of study subjects

Characteristics		
Age (yrs) (mean (SD))	25.9 ± (6.2)	
Race		
Black	219	(75.3%)
Indian	67	(23.0%)
White	5	(1.7%)
Education		
None	19	(6.3%)
Primary	127	(41.8%)
Secondary and above	158	(52.0%)
Parity		
1	96	(31.5%)
2 - 4	176	(57.7%)
≥ 5	33	(10.8%)
Vehicle ownership	62	(21.2%)
Residence		
Urban	215	(71.0%)
Proximity to road < 1 km	215	(71.0%)
House painted	206	(67.3%)
Source of water		
Municipal tap water	273	(89.2%)
Ground water	7	(2.3%)
River	26	(8.5%)

The literacy level was unexpectedly high, 93% of the women having had some formal education. The homogeneous nature of this group can be seen from similarities in exposure risk factors, namely the majority were from urban areas (71%), did not own motor vehicles (78%), used municipal tap water (89%), lived in painted houses (67%) and lived close to roads (71%). The maternal blood lead levels (Pb-MB) and fetal cord blood levels (Pb-CB) are summarised in Tables II and III. The mean Pb-MB was 7.32 μg/dl with a range of 0.9 - 32.2 μg/dl, while the mean Pb-CB was 6.46 μg/dl with a range of 1.5 - 21.4 μg/dl. The prevalence of raised lead levels as defined by the CDC (> 10 μg/dl) was 18.2% for mothers and 11.7% for the fetuses.

Table II. Mean maternal blood and cord blood lead levels (μg/dl)

Pb level	*N*	Mean	SD	Minimum	Maximum
Maternal blood	296	7.35	3.85	0.9	32.2
Cord blood	298	6.56	3.1	1.5	21.4

Table III. Frequency distribution of Pb in maternal and cord blood

Class intervals of lead levels	Maternal blood (μg/dl)			Cord blood (μg/dl)		
	N	%	CT (%)	*N*	%	CT (%)
< 10	242	81.8	81.8	26.3	88.3	88.3
10.0 - 14.9	43	14.5	96.3	30	10.1	98.3
15.0 - 19.9	8	2.7	99.0	2	0.7	99.0
≥ 20	3	1.0	100.0	3	1.0	100.0

CT = cumulative total.

Racial differences in blood lead levels were evident between blacks and Indians. Mean Pb-MB for the black patients was 7.1 μg/dl, while for the Indian patients it was 8 μg/dl. The prevalence of elevated blood lead levels for the Indian mothers was 30.8% while the corresponding value for black mothers was 14.2%. This was statistically significant ($P = 0.01$). The mean Pb-CB for black patients was 6.58 μg/dl, while for the Indian patients it was 6.18 μg/dl, not a statistically significant difference.

There was a positive relationship between Pb-MB > 10 μg/dl and low birth weight, previous pregnancy losses and congenital abnormalities (Table IV). However, this was not statistically significant. Preterm delivery and low Apgar score were associated with low Pb-MB, which was unexpected but not statistically significant (Table IV).

Table V summarises the relationship between various socio-demographic variables and maternal blood lead levels. Apart from race the other risk factors did not show any statistically significant difference with regard to blood lead levels.

Table IV. Obstetric variables v. maternal blood lead levels

Outcome	*N*	Mean (SD)	Mothers with Pb > 10 μg/dl *N*	Mothers with Pb > 10 μg/dl %
Birth weight (g)				
< 2 500	52	7.4 (3.8)	11	21.1
≥ 2 500	238	7.3 (3.8)	42	17.6
Apgar score				
< 8	35	7.2 (3.7)	6	17.1
> 8	259	7.4 (3.8)	48	18.5
Previous pregnancy loss				
Yes	51	7.5 (4.2)	11	21.6
No	235	7.3 (3.7)	40	17.0
Congenital abnormalities				
Yes	8	7.1 (2.8)	2	25.0
No	286	7.3 (3.8)	52	18.2
Outcome				
Alive	294	7.3 (3.7)	2	25.0
Stillbirth	2	8.9 (8.6)	52	18.2
Preterm				
Preterm	91	7.0 (3.5)	15	16.5
Full term	205	7.5 (3.9)	39	19

Table V. Risk factors v. maternal lead levels

Risk factor	*N*	Mean (SD)	Mothers with Pb ≥ 10 μg/dl *N*	Mothers with Pb ≥ 10 μg/dl %
Race				
Black	211	7.1 (3.5)	30	14.2
Indian	65	8.3 (4.3)	20	30.8*
White	5	6.8 (4.2)	1	20.0
Education				
None	18	7.8 (4.2)	3	16.7
Primary	124	7.2 (3.7)	22	17.7
Secondary and above	153	7.4 (3.8)	29	19.0
Vehicle				
Yes	59	7.5 (3.9)	12	20.3
No	224	7.3 (3.9)	41	18.3
Residence				
Urban	207	7.5 (3.9)	43	20.8
Rural	87	6.9 (3.5)	11	12.6
Proximity of residence to main road				
≤ 1 km	208	7.6 (3.9)	40	19.2
≥ 1 km	86	6.8 (3.7)	14	16.3
House				
Painted	201	7.6 (3.9)	38	18.9
Unpainted	95	7.4 (3.5)	16	16.8
Source of water				
Municipal tap water	264	7.2 (3.7)	46	17.4
Ground water	7	8.7 (3.0)	2	28.6
River	25	7.9 (4.2)	6	24.0
Water storage				
Plastic container	169	7.5 (3.7)	29	17.2
Metal drum	9	8.0 (3.6)	2	22.2
Not stored	106	7.0 (3.8)	19	17.9

* $P < 0.01$.

The correlation between Pb-MB and Pb-CB was moderate ($r = 0.45$). The linear model, with fetal cord lead levels as the dependable variables, showed a significant association between fetal and maternal blood lead levels ($P = 0.0001$). According to this model maternal increase of 1 $\mu g/dl$ increased fetal cord lead levels by 0.37 $\mu g/dl$.

DISCUSSION

In this study the mean Pb-MB and Pb-CB lead levels were within the currently accepted threshold levels of 10 $\mu g/dl$ (Pb-MB = 7.35 $\mu g/dl$, Pb-CB = 6.56 $\mu g/dl$). They are significantly lower than previously noted in a pilot study[5] conducted at KEH in 1996 where the Pb-MB and Pb-CB were 21.9 $\mu g/dl$ and 15.93 $\mu g/dl$, respectively. The levels in this study are also lower than those reported from India,[10] where the mean Pb-MB was approximately 20 $\mu g/dl$ and Pb-CB was approximately 16 $\mu g/dl$. The decrease in lead content as well as the introduction of unleaded gasoline in South Africa in 1996[4] may have contributed to the lower levels noted in this study. However studies on childhood lead toxicity from Durban[13] as well as from other areas of South Africa[14] indicate that blood lead levels are still high in spite of reduced lead gasoline content. These differences may be due to different sources of exposure in adults and children, but there is a need to confirm our finding using a larger group.

In spite of the acceptable mean blood lead levels, 18.7% of maternal and 11.2% of umbilical cord sample lead levels were greater than 10 $\mu g/dl$, but all were below 32 $\mu g/dl$. For adults such levels (10 - 30 $\mu g/dl$) produce mild clinical problems and are largely asymptomatic.[11] Their significance in pregnant women is the risk they pose to the fetus which is much more sensitive to lower levels, as has been noted in various studies.[6,7] The placenta barrier is permeable to lead, as noted by the positive correlation coefficient in this study ($r = 0.45$), and depending on factors such as iron and calcium metabolism, fetal blood levels may approximate maternal levels.

As noted in previous studies in Durban,[3,13] the following exposure risk factors were not significant, namely water storage containers, painting of houses, water sources and education status. Living close to tarred roads was found to be a significant exposure risk in these studies, but was not found to be significant in our study. Various possible explanations could account for these findings. The majority of the study population obtained their water from municipal sources that have minimal lead contamination. Most of the houses were unpainted, making this an unlikely source of contamination. However it is also possible that other significant exposure risk factors were not investigated. In particular, use of herbal medications and the practice of cottage industries were reported by Nriagu *et al.*[3,13] to be significant exposure risk factors. Atmospheric lead pollution was not directly assessed in this study, and it is likely to have been a significant exposure source. A study undertaken in Durban[3] found that atmospheric lead concentration in industrial areas exceeded 1.5 $\mu g/m^3$, the recommended threshold of the Environmental Protection Agency (EPA). This environmental lead pollution would also explain the finding in this study that Indian mothers whose residential areas were close to industrial areas had a higher prevalence of elevated lead levels compared with black mothers. Among Indian mothers 30.8% had values greater than 10 $\mu g/dl$ compared with 14.3% of black mothers.

In conclusion, this study indicates that there is still significant exposure to lead pollution in Durban. There is a need to identify and control exposure sources, as well as to educate people about the impact of lead pollution, especially in children and pregnant women. The significantly lower blood lead levels noted in this study compared with other studies in the same area need to be confirmed using a larger study.

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