UNIVERSITY OF THE WITWATERSRAND

FACULTY OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

FACTORS ASSOCIATED WITH ELEVATED BLOOD LEAD LEVELS IN FIRST GRADE SCHOOL CHILDREN IN CAPE TOWN, SOUTH AFRICA

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfillment of the requirements for the degree of Master of Science (Epidemiology) in the Field of Epidemiology and Biostatistics.

January 31st, 2012

DECLARATION

I, Lisbon Aliraki, declare that this research report is my own work. It is being submitted in partial fulfillment of the requirements for the degree of the Master of Science in Epidemiology in the field of Epidemiology and Biostatistics in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

Signature

On the---------31-----------------day of -----January------------, 2012

DEDICATION

I dedicate this work to my mother, Mrs. Rose Ewang, and my siblings for enduring my being away from home, and encouraging and supporting my quest for knowledge, considering the absence of my father Mr. David Ewang 1950-2005. I also dedicate this work to my best friend Agnes Nakanwagi; you are always very accommodative and supportive.

Last, but not least, this work is as well dedicated to all those who think, work and believe that this world, environment inclusive, deserves a better present and future, serving oneself best by serving others first.

ABSTRACT

Introduction: Lead metal toxicity in children is a major public concern internationally. In South Africa, January 2006 was the date set for the complete phase-out of leaded petrol, a well known major source of environmental lead contamination. Analysis was conducted to describe the distribution of blood in children, to establish proportions of children with elevated blood lead levels (unacceptable blood lead levels of ≥ 10 μg/dl) and to establish factors associated with elevated blood lead levels using data collected in 2007, one year after the phase-out of leaded petrol.

Methods and Materials: An analytical cross-sectional secondary data analysis was conducted on a survey dataset from the Environment and Health Research Unit of the Medical Research Council, South Africa. The primary sampling unit (cluster) was defined as primary schools. Data on first grade children from 13 schools from three suburbs of Cape Town – Woodstock (eight schools), Hout Bay (three schools) and Mitchell's Plain (two schools) – were analyzed using a survey method, calculating design-based robust standard errors. Different weights were applied to schools in the suburbs which formed the stratification variable. The outcome variable was defined as blood lead levels < 10 μg/dl or ≥ 10 μg/dl. A number of background characteristics – health and diet, housing and social aspects – were investigated; odds ratio measurement was calculated and reported.

Results: A total of 532 children were included in the analysis, representing a weighted total of 1 744 children. The children's weighted mean age was 7.40 years (95% CI 7.39 to 7.41). The geometric weighted mean blood lead level was 5.27 μg/dl (95% CI 5.08 to 5.46). The weighted proportion of children with BLLs ≥ 10 μg/dl was 11.81% (95% CI 8.78 to 15.72);

in Woodstock it was (21.0%). In the multivariable logistic regression, several factors were independently associated with higher odds of having BLLs ≥ 10 μg/dl, including use of gas for cooking OR 3.24 (95% CI 2.34 to 4.48) p <0.0001; houses in need of major repairs OR 7.81 (95% CI 1.59 to 38.33) p = 0.017; attending a crèche/preschool OR 15.23 95% CI (3.40 to 68.29) p = 0.003; Others included use of buses or taxis, which increased the odds of a child having a BLLs ≥ 10 μg/dl compared to walking to school by 5.20 times (95% CI 3.00 to 8.99) p < 0.0001 and children who were living in flats (OR 5.55, 95% CI 3.76 to 8.18, p < 0.0001) or in informal/shack dwellings (OR 2.09, 95% CI 1.06 to 4.12, p = 0.037) were at greater odds of having a blood lead ≥ 10 μg/dl than if they lived in free-standing houses. The following factors offered protection against elevated BLLs: Using private cars to transport children to school offered 0.83 lower odds of a child having elevated lead levels (OR 0.17, 95% CI 0.09 to 0.31, p < 0.0001) compared to walking to school, use of plastic water pipes OR 0.60 (95% CI 0.44 to 0.82) p = 0.005 and, domestic cleaning practices, such as cleaning floors with a wet mop (rather than a dry broom) reduced the odds of having blood lead levels ≥ 10 μg/dl by 0.88 (OR 0.12, 95% CI 0.10 to 0.15, p < 0.0001).

Conclusion and Discussion: This analysis indicated that the distribution of blood lead appears similar that determined in the leaded petrol era. The proportion of children with elevated blood lead levels in a Cape Town study was still high. Multiple factors were associated with BLLs ≥ 10 μg/dl. Some factors were protective. The implementation of the phasing out of the leaded petrol should be critically monitored to determine the time period before observing a reductive effect. Preventive measures targeting removal of non petrol sources of lead from the school and home environments should be considered as important.

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NOMENCLATURE

aOR	Adjusted odds ratio
BLLs	Blood lead levels
BMI	Body mass index
CDC	Centers for Disease Control and Prevention
DHHS	Department of Health and Human Services
EHRU	Environment and Health Research Unit
IQ	Intelligence quotient
MRC	Medical Research Council
OR	Odds ratio (crude/unadjusted odds ratio)
PHS	Public Health Services
sd	Standard deviation
US	United States of America
SE	Standard error
μg/dl (μG/DL)	Microgram/decilitre
μg/l (μG/L)	Microgram /litre

CHAPTER 1

1.0 INTRODUCTION AND LITERATURE REVIEW

In this chapter background information about lead and its harmful effects will be given. The problem statement and justification for the study are explained. Literature regarding the distribution of blood lead in children, the proportions of children with elevated blood lead levels and factors associated with elevated blood lead levels is reviewed. The aim and specific objectives of the study are presented at the end of the chapter.

1.1 Background

Lead is a substance that is well known for its toxicity (Harte, Holdren, Schneider & Shirley, 1991). Absorbed primarily through the digestive route and interfering with cellular function and metabolism, lead causes neurological, physiological and behavioral problems in children, ranging from raised hearing threshold and decrease in intelligence quotient (IQ) at low blood lead concentrations, to acute encephalopathy, memory loss and death at high blood lead concentrations (Manser, Khan & Hassan, 1989).

Elevated body lead concentrations also produce harmful effects on the hematopoietic, hepatic, renal, reproductive, and gastrointestinal systems. Acute lead poisoning at blood concentration levels in excess of 100 µg/dl still occurs, such as the outbreak that recently caused over 163 deaths of children in Nigeria (Agencies, 2010).

The harmful effects of lead, at even relatively low levels of exposure, have led the World Health Organisation (WHO) and the US Centers for Disease Control and Prevention (CDC,

1991) to consider lead concentrations in blood equaling or exceeding 10 µg/dl as the level at which action should be taken to remove or reduce sources of lead exposure (Manser et al., 1989). However, there is evidence of harm below this level (von Schirnding and Fuggle, 1984) and there is a global debate about using a lower threshold. The CDC's Advisory Committee on Childhood Lead Poisoning Prevention has initiated a process to evaluate the evidence in this regard (Bernard, 2003). Children in particular are more sensitive and vulnerable to the effects of lead than others. Because of their mouthing behavior and pica tendencies (ingestion of non-food items), as well as the time spent in close contact with the ground, children are usually exposed to considerably more environmental lead than adults (Tuthill, 1996).

The distribution of blood lead levels varies by place, region, population and time depending on local exposures at the time (Thomas, Socolow, Fanelli & Spiro, 1999; von Schirnding, Bradshaw, Fuggle & Stokol, 1991a). This requires periodic surveillance especially in high-risk groups. von Schirnding, Fuggle & Bradshaw, (1991b) found elevated air lead levels in South Africa at a time when petrol lead levels (0.836g/l) in South Africa were among the highest in the world, and lead in petrol was considered the major contributor to elevated levels of lead in the air.

In the past, lead in petrol was the biggest source of lead in the environment (Grosse, Matte, Schwartz & Jackson, 2002; Thomas et al., 1999). Lead may also be found in paint, water, food, cosmetics and lead-glazed ceramics (Brown, 2000, Lanphear, Burgoon, Rust, Eberly & Galke, 1998a). The highest environmental lead concentrations occur most often in highly populated areas (Graber, Asher, Anandaraja, Bopp, Merrill, Cullen, Luboga & Trasande, 2010; Mathee, von Schirnding, Levin, Ismail, Huntley & Cantrell, 2002; Nriagu Jinabhai, Naidoo & Coutsoudis, 1996a). A marked reduction in blood lead levels in Cape Town followed gradual phasing out of leaded petrol (Mathee, Röllin, von Schirnding, Levin & Naik, 2006b), stressing the importance of removing local sources of exposure. The proportion of children who had high lead levels (equal to or greater than 10 µg/dl) also significantly decreased.

In January 2006, leaded petrol was completely phased out in South Africa (Government Gazette, 2003). It is important to monitor the distribution of blood lead levels in children after total removal of leaded petrol, and to establish the proportion of children who are still at increased risk of lead exposure with blood lead levels equal to or greater than 10 µg/dl. This was done for three different suburbs in Cape Town. Ongoing monitoring will also be important to identify new and emerging risk factors in these localities for eventual prevention of elevated blood lead levels in children (Özden, IşSever, GöKçAy & Saner., 2004).

1.2 Problem Statement

South Africa undertook the total phasing out of leaded petrol in 2006. It is hoped this will be followed by reduced blood lead levels in children as was experienced in the US after a similar action (Grosse et al., 2002, Thomas et al, 1999). Currently, little is known about the blood lead distributions in children after 2006.

It is well known that the cause of raised blood lead levels in children is complex: removal of one exposure factor may be insufficient to significantly reduce lead levels in blood, and besides, there is no safe level for lead exposure (Canfield, Henderson, Cory-Slechta, Cox, Jusko & Lanphear, 2003). Available data on non-petrol sources of lead is limited in South Africa (Mathee, Röllin, Levin & Naik, 2006a).

1.3 Justification

Lead plays no beneficial metabolic role in the body (Maresky and Grobler, 1993). It is well known that increased lead in blood, especially in children, causes harmful effects at any concentration and is a major public health concern (Canfield et al., 2003). Identification of those at increased risk of lead exposure is considered one of the first steps in a lead poisoning prevention strategy; this requires periodic surveillance of blood lead levels (Mathee et al., 2006a, Özden et al., 2004).

It is difficult to reverse the effect of elevated lead in the body; yet it is possible to prevent increased blood lead levels by removing the identified local sources of lead exposure (Özden et al., 2004). This public health measure has been shown to work as evidenced by the United States experience (Grosse et al., 2002, Thomas et al., 1999).

1.4 Literature Review

1.4.1 Distribution of blood lead levels among children in Cape Town

Several studies have documented that lead in the blood of children varies from place to place and also with season (von Schirnding et al., 1991b). This is presumed to be due to the different exposure risk factors that may be present at particular times. For example, in 2002, studies carried out in Cape Town found the overall mean blood lead level was 6.4 μ/dl and the distribution of mean blood lead in three suburbs as follows: in Woodstock, Mitchell's

Plain and Hout Bay among children of 5-11 years old were 6.9 µg/dl, 6.9 µg/dl and 4.8 µg/dl, respectively. Also, it was discovered that the mean levels varied among individual schools studied: from 3.3 µg/dl at a Hout Bay school, to 8.1 µg/dl at a school in Woodstock (Mathee et al., 2006b). A study conducted in Jakarta, Indonesia in June, 2001 prior to the leaded petrol phase out found that the geometric mean blood lead levels was 8.6 µg/dl; in this study the arithmetic mean could even have been higher (Albalak, Noonan, Buchanan, Flanders, Gotway-Crawford, Kim, Jones, Sulaiman, Blumenthal, Tan, Curtis, & Mcgeehin, 2003).

1.4.2 Proportion of children with elevated blood lead levels in Cape Town.

Although it has been increasingly recognized that there is no safe threshold for certain effects (Canfield et al., 2003), the internationally accepted blood lead level in children above which action should be taken to reduce the level of risk of lead exposure is 10 µg/dl (CDC, 1991). CDC considers this blood lead levels greater than or equal to 10 µg/dl to be elevated or unacceptably high blood lead level. The proportion of children with blood lead levels greater than or equal to 10 µg/dl in South Africa was very high in the 1980s, with 90% or more children in urban areas being affected (von Schirnding et al., 1991b). At that time South Africa was among the countries with highest level of lead in petrol (0.836 g/l). Later, South Africa reduced the lead content of petrol to 0.6 g/l in 1986, and the petrol lead level was further reduced to 0.4 g/l in 1994. Soon after these changes in the lead content of petrol, research done in Woodstock, Mitchell's Plain and Hout Bay showed that despite these reductions, the proportion of children with lead levels equal to or greater than 10 µg/dl was still well over 90% (von Schirnding, Mathee, Robertson, Strauss & Kibel, 2001). A study of the same areas in Cape Town in 2002, when leaded petrol contributed only 30% of the petrol market share, showed a marked reduction in the proportion of children with high blood lead levels; only 10% for the total sample (Mathee et al., 2006b). But the proportion varied across the three suburbs, with Woodstock having 12%, Mitchell's Plain 12% and Hout Bay 3%. In Jakarta, a study carried out in June, 2001 before leaded gasoline phase-out on July 1st , 2001, it was found that 35% of the children had their blood lead levels ≥ 10µg/dl (Albalak et al., 2003). One study showed that in terms of former South African apartheid-based population groups (used as an indicator of socio-economic status), the mean blood lead level among White children was significantly lower (3.5 µg/dl) than in Coloured children (7 µg/dl) or African Black children (6.0 µg/dl). The proportions of White, Coloured and African Black children with high blood lead levels were 4%, 17% and 9%, respectively (Mathee et al., 2006b).

1.4.3 Factors associated with elevated blood lead levels in Cape Town.

Factors associated with a risk of increased lead exposure are complex. Significant sources of lead vary across places and with time. Besides proximity to a busy road (Albalak et al., 2003; Mathee et al., 2006a; Nriagu, Blankson & Ocran, 1996b), other potential lead sources include paint, batteries, polluted water, contaminated foods and cosmetics. Some traditional medicines and tobacco have been found to contribute to increased blood lead levels in children (Nriagu et al., 1996a). In a study conducted by Mathee and colleagues in Cape Town and in Johannesburg (Mathee et al., 2006a), high blood lead levels were associated with peeling paints in homes and schools, the use of lead solder in cottage industries, and para-occupational lead exposure (when workers transfer lead particles into their homes from workplaces on hair, skin or clothing). Having a single parent, and lack of ownership of a car or telephone, were associated with increased blood lead levels in 13-year-olds. The sex of the child and lack of home ownership were also found to be strong predictors of elevated lead levels in the Birth to Twenty Cohort (Naicker, Norris, Mathee, von Schrinding & Richter, 2010).

1.5 Study Aims and Objectives

1.5.1 General objectives

To carry out an assessment of the risk factors for lead exposure among first grade children in Cape Town, South Africa.

1.5.2 Specific objectives

1. To describe the distribution of blood lead levels in first-grade school children in selected schools in Cape Town.

2. To establish the proportion of children with unacceptable blood lead levels in first-grade school children in selected schools in Cape Town.

3. To determine factors associated with elevated blood lead levels in first-grade school children in selected schools in Cape Town.

CHAPTER 2

2.0 METHODS AND MATERIALS

2.1 Study Design

This was a cross-sectional analysis of secondary data from Cape Town provided by the Environment and Health Research Unit (EHRU) of the Medical Research Council of South Africa in order to describe the distribution of blood lead concentrations, establish the proportion with unacceptable blood lead levels (BLL) of ≥ 10 μg/dl and determine the key factors associated with BLL ≥ 10 μg/dl. The data were collected in the period between 2007 and 2008 as part of a broader South Africa's Schools Environmental Health Survey.

In 2007 the EHRU conducted a blood lead survey of first grade school children in selected parts of South Africa. A single-stage stratified sampling process was used in Cape Town. The three areas (suburbs) of Woodstock, Hout Bay and Mitchell's Plain were chosen. Primary schools formed the primary sampling unit (cluster) in these suburbs. The three areas were known to differ in their traffic densities. In Woodstock all the eight primary schools and in Hout Bay all three primary schools were chosen, while in Mitchell's Plain two out of 26 primary schools were chosen by simple random sampling without replacement. The schools were obtained from the Western Cape Education Department listings. All first-grade children in the selected schools were expected to participate in the original study.

There were 963 children expected to participate, but blood sample were obtained successfully from 532 (55%) children.

2.2 Study Setting

The schools selected for the study are in the suburbs of Woodstock, Mitchell's Plain and Hout Bay. These areas were chosen because of their varying traffic densities. Woodstock is an inner city suburb characterised by mixed residential and commercial development. Mitchell's Plain is an expansive urban housing development area located around 20 km east of central Cape Town. Hout Bay is located around 30 km south of central Cape Town. Most of these schools were also studied in the past (1991 and 2002) as regards blood lead levels in children (Mathee et al., 2006b, von Schirnding et al, 1991b). In total, 13 primary schools were selected.

2.3 Study Population

This comprised all first grade children attending all eight primary schools in Woodstock, all three primary schools at Hout Bay and two primary schools in Mitchell's Plain.

2.4 Eligibility Criteria

All participants had to be primary school children in the first grade.

2.4.1 Inclusion criteria

Children were included in the primary study if their parents consented to participation; and if the child was present on the day of field work, and was not overanxious.

2.4.2 Exclusion criteria for the current study

Participants with incomplete outcome data were to be excluded, but no participant was excluded since all had the outcome (blood lead level) data of interest. Variables with more than 15% missing data were excluded because zero values in some of the categories of blood lead levels implied that multivariate analysis gave no defined result.

2.5 Study Sample and Sample size

All 532 children recorded in the data set were included in the present study. These 532 pupils from 13 schools would provide a precision of ±9% of estimating the proportion of children with blood lead levels $\geq$ 10 μg/dl after taking into account the issue of clustering. The precision was obtained based on the assumptions and calculations below. The precision is given by 2 * standard error (SE), where SE = $\sqrt{[p\ (1-p)\ D/n]}$, p = expected proportion of children with BLL $\geq$ 10 μg/dl, D = the design effect, D = 1 + (m-1) ρ, m = an assumed average number of children per school (cluster) that the team was able to recruit, ρ = intraclass correlation coefficient. Based on the assumption that m = 40, ρ = 0.2, from the above formula D = 8.8. Assuming based on the previous study p = 15%, and with 532 participants, SE is 0.045 and precision is ±9% in this current study (Bennett, Woods, Liyanage & Smith 1991; Hayes and Bennett 1999; Zeger and Liang, 1986).

2.6 Data Sources

Data were provided by the Environment and Health Research Unit of the Medical Research Council of South Africa. Various data were collected, including data on height, weight and blood lead concentration in children. Blood lead concentration was measured in the field by LeadCare blood lead testing system utilizing capillary blood. Environmental sampling from schools and children's homes was done to establish lead concentration in soil, dust and paint. Water lead content was analysed. Self-administered questionnaires were sent to parents to collect essential information on demographic status, health and diet of the child, home and surrounding environmental conditions, children's activities in relation to potential risk factors for lead exposure, and the child's school ability and activity status.

2.7 Measurements

This analysis had planned to make use of the following information: blood lead levels of the children as an outcome variable, height and weight of the child. In the questionnaire the following data were to be used:

Sex of the child, age, language spoken at home by the child, where the child was born, race of the child, type of transport used by child to go to school, area where the child plays most of the time after school, type of surface where the child plays, whether the child attended play school/crèche before going to grade one, whether the child sucks his or her fingers or nails, whether the child puts non-food objects in the mouth, whether the child eats non-food objects, frequency with which child washes his or her hands (before eating, after playing in dirty areas or before going to sleep), administration of home-made medications or remedies for sickness or to improve health, whether the child uses make-up (e.g. eye liners or kohl pencils), and how often the child eats canned or tinned foods.

Housing status, ownership of the home by the parents, type of dwelling, age of the house, distance of the child's home from a busy road, the number of rooms in the house (not counting bathroom, toilet or kitchen), main fuel used for cooking, whether anyone regularly smokes at home, the number of people in the home who smoke at least one cigarette per day, paint peeling from the walls (outside walls, doors or window sills), paint peeling from the indoor walls, doors or window sills, the degree of dustiness of the home, the location of the toilet, main source of water, need for major repairs, history of painting, decoration or renovation in the past year, the number of cars owned by people who permanently live in the house, whether the child plays with pets, adults' involvement with occupations related to lead, work conducted at home that involves lead, and house cleaning practices and methods.

Social aspects: the number of people living in the house, number of siblings, the person taking care of the child, home-based occupational activities, the total monthly household income (See Appendix G for the modified questionnaire).

Note that the questionnaire had been used in previous surveys in the same area (Mathee et al., 2006b). However, variables that had more than 15% missing values were eventually excluded.

2.8 Data Processing Methods and Analysis

In this section all the data processing procedures are explained. The detailed analytical process is also explained.

2.8.1 Data processing methods

The data set, which was entered in Stata Version 10, was transferred into Stata Version 11.1. Data were explored by using inspect and codebook commands to establish missing values.

Missing data on sex of the child were traced back to the names of the children and the right gender entered. Several variables entered as strings were destringed or decoded to numeric variables. Variables that had their responses recorded as separated variables were recombined according to the questionnaire requirement. Responses that needed "1" for Yes and "2" for No were recoded as "1" for No and "2" for Yes in keeping with the coding for the binary outcome definition that require presence of a yes/presence category to be on a higher coding (Vittinghoff, Shiboski & Mccullosch, 2005).

A new variable named crowding, which was defined as the number of persons/room, was generated, with options of < 3people/room (coded 1) and ≥ 3 people/room (coded 2). The age of the children was generated as at 31 Dec 2007, because the actual days of recruitment were not available in the variable list. The BMI-for-age percentiles were calculated taking into account sex of the child: these were categorised as underweight for less than 5^{th} percentile (code = 1); healthy weight for 5^{th} percentile to 85^{th} percentile (code = 2); overweight for 85^{th} to $<95^{th}$ percentile (code = 3) and obese for $\geq 95^{th}$ percentile (code=4), using (CDC, 2010).

The sample weight was generated: schools from Woodstock were weighted 1 (eight out of eight schools), Hout Bay schools were weighted 1 (three out of three schools) and Mitchell's Plain schools were weighted 13 (two out of 26 eligible primary schools). Finite population corrections were provided for since the schools were chosen without replacement: in Stata these were entered as the total number of possible primary schools in each suburb. The suburbs were treated as the stratification variables and the primary schools were the primary sampling unit or Cluster. Sub-population variables representing the suburbs of Woodstock, Hout Bay and Mitchell's Plain were generated.

The outcome variable was defined as a child having blood lead levels < 10 µg/dl and ≥ 10 µg/dl (code = 0 and code = 1 respectively).

Some socioeconomic status/position indicators which may themselves be possible risk factors for lead rather than confounders were analysed individually, not as composite indicators. The socioeconomic indicators to be analysed were housing ownership, home amenities, household conditions and monthly household income. Owning a house, having an inside toilet, living in a flat or house, having a monthly household income of ≥ R5000 and no overcrowding (< 3 persons/room) were considered high socioeconomic position. On the other hand, renting a house, having an outside toilet, living in a shack or informal house, having monthly household income of < R5000 and overcrowding (≥ 3 persons/room) were considered low socioeconomic status/position (Galobardes, Shaw, Lawlor, Lynch & Smith, 2006a; Galobardes, Shaw, Lawlor, Lynch & Smith, 2006b; Liberatos, Link & Kelsey, 1988).

2.8.2 Data analysis

To cater for the design characteristics of clustering in school and weight, the 'svyset' command of Stata Software was used to set the parameters. Blood lead concentration in children was found to be markedly positively skewed (skewness 1.65, $p < 0.0001$; kurtosis 7.17, $p < 0.0001$ and overall $p < 0.0001$) (Figure A 1). A natural log transformation rendered blood lead concentration normally distributed for purposes of accurately obtaining the mean blood lead levels. The mean of the transformed blood lead levels was antilogged (exponentiated) to obtain the geometric mean (Figure A 2). The survey characteristics were defined using the svyset command in Stata. Descriptive statistics were obtained using the “svy: tab” and “svy: mean” commands in Stata and results reported have been as weighted proportions or weighted mean (Table 3.1, Table 3.2 and Table 3.3; Figure 3.1 and Figure 3.2, Figure 3.3). Cross tabulation was carried out using the “svy: tab outcome variable response variable” command to compare characteristics between those with BLLs < 10 μg/dl and those with BLLs ≥ 10 μg/dl; weighted number of children, weighted proportions and design-based Pearson Chi square (χ^2) and p values have been reported (Table 3.4). A “svy, subpop (variable)” command was employed to analyse variables in terms of the suburbs (areas) of Cape Town.

Logistic regression techniques using “svy: logistic” commands that take into account the design characteristics were used to examine the variable factors for their associations with blood lead level ≥ 10 μg/dl and to calculate design-based (linearlized) robust standard error. Since exploration of the variables was of prime interest, all the variables that were associated with blood lead levels ≥ 10 μg/dl at p value of less than 0.2 in univariable model were included into a multivariable model (Table 3.5). This approach was found to rule out confounding most effectively (Maldonado and Greenland, 1993). In the exploratory stage of analysis, the selected variables when entered into multivariable analysis showed multicollinearity, and the model was unable to converge because of zero values in the categories of blood lead levels. Because of all this, variables with more than 15% missing values were removed from the analysis; categories of variable that contained too few responses were combined; and other responses that didn’t make sense, such as not being aware of where the latrine was located, were set to missing. Results from unweighted and weighted analysis were compared as recommended by David, (2008). The weighted analysis has been reported because it revealed substantial difference from the unweighted results thereby improving the robustness of the standard errors.

The final selected variables were checked for multicollinearity before running the final multivariable model using the "pwcorr" command and cross checked using "collin" command. There was no significant multicollinearity found: the highest coefficient was 0.6083 (Figure B 1). A logistic diagnostic test on the final model was performed. Using the linktest command showed that there was marginal misspecification error (hatsq coefficient 0.08, 95% CI 0.00 to 0.16, p = 0.051) and the logistic regression technique was still appropriate for the data (Figure C 1). The effective sample size used in the multivariable model was 396 children.

Applying the "svylogitgof" command for a survey design recommended by Hosmer and Lemeshow (Archer, Lemeshow & Hosmer , 2007), the overall goodness of fit had no evidence of lack of fit; hence the model explained the variables well (Figure C 2). The decision on whether to retain marginally significant factors in the model was examined by Wald's test using the "test" command. It was found that individually, the variables still remained marginally significant; hence the variables were maintained in the final model based on prior knowledge of their importance (Figure D 1). But collectively, all could be removed safely from the model (Figure C 3).

2.9 Ethical Considerations

The ethical clearance to carry out secondary data analysis was obtained from the University of the Witwatersrand Human Research Ethics Committee (appendix F) and permission to use the data was granted by the head of the Environment Health and Research Unit at the MRC, Prof. Angela Mathee (appendix E).

The original study received approval from University of the Witwatersrand Human Research Ethics Committee (Ethics Certificate Number: M070458)**.** Permission to conduct the primary study was granted from the Western Cape Provincial Department of Education and the principals of the schools. Written informed consent was obtained from the parents of participating children during primary data collection. Confidentiality was assured through allocation of unique identification numbers to the participants. Individual results were provided to parents on request. The parents of children found to have high blood lead levels (more than 20 μg/dl) were contacted and offered a home interview and assessment of potential sources of lead together with appropriate counselling and provision of lead hazard information material. Children were referred for further medical investigation. In the current analysis, results will be presented at conferences and key stakeholder feedback sessions without revealing the identity of study participants.

The data set provided has been kept confidential and used only for the stated intentions. Results have been presented as a summary without revealing the identity of the individuals or the names of the schools.

CHAPTER 3

3.0 RESULTS

3.1 Description of Study Sample

A total of 532 first grade children, which translates to a weighted total of 1 744 first grade children from 13 primary schools, were obtained from the primary data; all were included in the analysis. The suburb of Woodstock had a total of 219 children from eight schools, Hout Bay 212 children from three schools and Mitchell's Plain 101 from two schools (translating to a weighted value of 1 313).

With respect to the total sample, data were available on the age of 145 (27.63%) of the children: the weighted mean age of the children as of December 31, 2007, was 7.40 years (95% CI 7.39 to 7.41) and age ranged from 5.22 to 10.00 years. In the weighted sample, boys constituted 938 out of 1 728 gender recorded, representing 54.28% (95% CI 53.13 to 54.3). English was the most spoken language at home with (820/1603) (51.15%, 95% CI 33.26 to 68.76); the majority of the children were of Coloured race at (1 143/1606) (71.48%, 95% CI 20.86 to 95.97). And only (249/1602) (15.55%, 95% CI 9.09 to 25.33) could afford to be taken to school in private cars. Knowledge of lead health effects in children= (747/1452) 51.45% (95% 46.46-56.4)

3.2 Distribution of Blood Lead

From Table 3. 1, it is observed that geometric mean blood level for the total sample was 5.27 µg/dl (95% CI 5.08 to 5.46) and the range was from 1.00 µg/dl to 30.40 µg/dl. The geometric mean value for Woodstock was 6.75 μg/dl, Hout Bay 6.29 μg/dl and Mitchell's Plain 4.92 μg/dl.

Table 3. 1 Mean blood lead levels by area

	N(number of cluster)	N(number of children)	N1(number of children weighted)	Arithmetic mean (sd) in μg/dl ††	Weighted geometric mean (sd) in μg/dl
Woodstock	8	219	219	7.70 (4.29)	6.75 (2.51)
Hout Bay	3	212	212	7.15 (3.74)	6.29 (2.56)
Mitchell's Plain	2	101	1 313	5.43 (2.59)	4.92 (1.26)*
Total	13	532	1 744	7.05 (3.88)	5.27 (1.62)**

* Linearised (robust) standard error 1.05, 95% CI 2.65 to 9.12 (design based)

** Linearised (robust) standard error 1.02, 95% CI 5.08 to 5.46 (design based)

†† obtained when weights for the schools were not considered and the high positively skewed distribution of blood lead concentration was not accounted for.

Since all the schools in Woodstock and Hout Bay were included in the study, a design-based standard error could not be obtained; hence the standard deviations are reported.

In figure 3.1 it can be shown that the cases of children having high blood lead levels ≥ 25 μg/dl were from those that were studying in schools that were in the areas of Woodstock and Hout Bay.

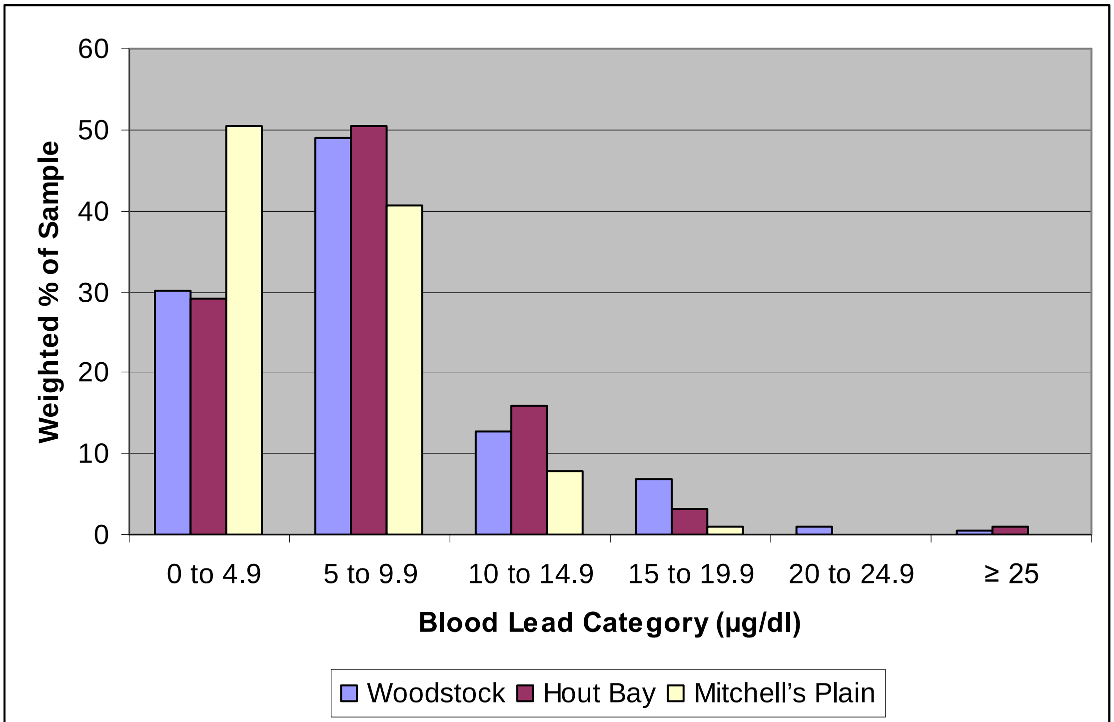

Figure 3. 1 Blood lead distribution by area

With regard to the total sample of children studied it can be deduced that very few had blood lead levels ≥ 25 μg/dl, however quite a large proportion of children had blood lead levels ≥ 5 μg/dl (figure 3.2).

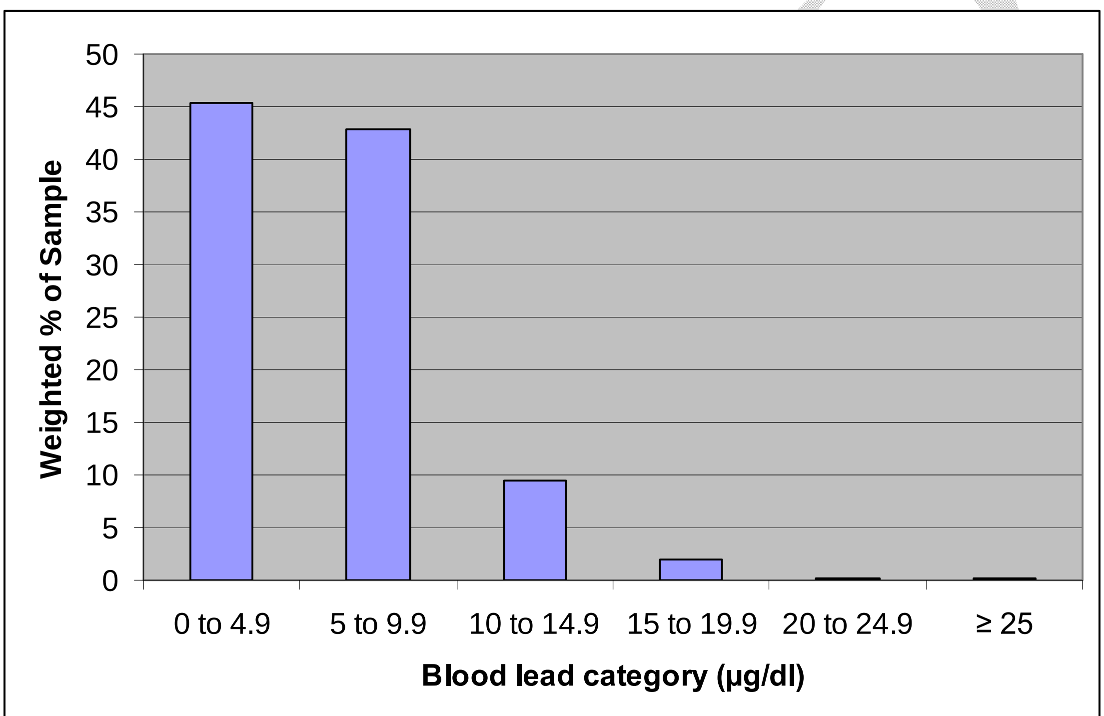

Figure 3. 2 Blood lead level distribution for the total sample

In terms of population groups, Black Africans had a weighted geometric mean BLL of 5.73 μg/dl. This was followed by the Coloured group with 5.16 μg/dl, while Whites had a lower mean of 4.98 μg/dl and Asians combined with others had the lowest mean of 3.25 μg/dl (Table 3. 2). The geometric mean value of blood lead in children in each of the schools varied from 4.44 μg/dl to 9.21 μg/dl (Table 3.3).

Table 3. 2 Comparison of blood lead levels by year, area and race

	2002		2007		
	Unweighted Arithmetic Mean ±	% ≥ 10 μg/dl †	Weighted geometric mean	Weighted % ≥ 10 μg/dl	% ≥ 10 μg/dl †
Area					
Woodstock	6.9	12	6.75	21.00	21.00
Hout Bay	4.8	3	6.29	20.28	20.28
Mitchell's Plain	6.9	12	4.92	8.91	8.91
Population groups					
African Black	6.0	9	5.73	13.67	17.46
Coloured	7.0	17	5.16	11.81	20.00
White	3.5	4	4.98	15.79	15.79
Asian	≠	≠	3.25	0	0
Total	6.4	10	5.27	11.81	18.42

† Unweighted proportions

± The arithmetic mean is always higher than the geometric mean. Arithmetic means are in inaccurate for skewed data such as lead blood distributions (Kirkwood, 2003).

≠ Values not available

3.3 Proportions of Children with Elevated Blood Lead Levels ≥ 10 μg/dl

The proportion of children with high blood lead levels ≥ 10 μg/dl was 11.81% (95% CI 8.78 to 15.71%). Disregarding the survey design, 18.42% of the children studied would have blood lead levels ≥ 10 μg/dl without extrapolating to all the children in the population. The proportions with different blood lead levels are displayed in Figure 3. 1 and Figure 3. 2. The figures represent the distributions by suburbs and distributions among the study samples.

The proportions of children with BLLs ≥ 10 μg/dl were significantly different between the schools ($p < 0.0001$). They ranged from as low as 0% to 40% in one of the schools in Woodstock (Figure 3.3 and Table 3.3).

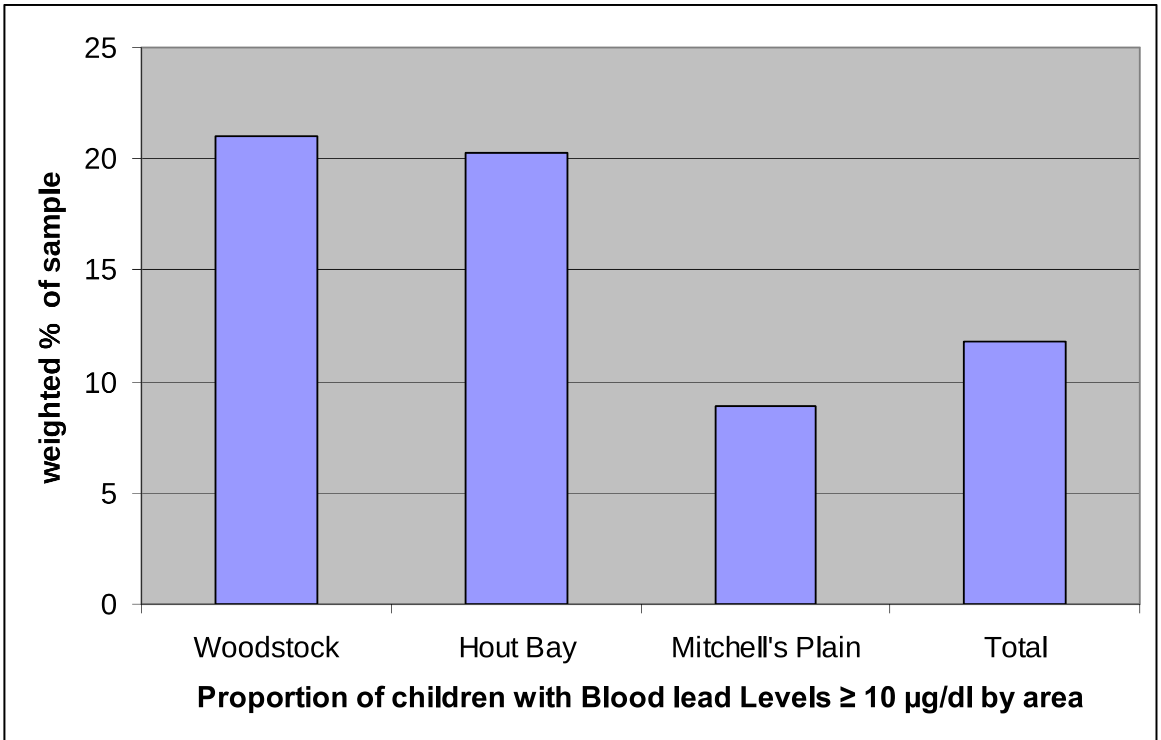

Figure 3. 3 Proportion of children with blood lead levels ≥ 10 μg/ dl by area and total.

Table 3.3 Distribution of blood lead levels by school

Schools	N	Weighted N	Geometric mean	Standard deviation	% ≥ 5 μg/dl	% ≥ 10 μg/dl
Woodstock						
Woodstock A	51	51	7.54	2.53	82.35	29.41
Woodstock B	26	26	4.44	1.77	38.46	0.0
Woodstock C	25	25	9.21	2.20	92.0	40.0
Woodstock D	17	17	8.50	2.16	88.24	29.41
Woodstock E	25	25	6.89	2.08	72.0	16.0
Woodstock F	14	14	6.62	1.99	64.29	21.43
Woodstock G	21	21	6.17	2.48	57.14	14.29
Woodstock H	40	40	5.99	2.69	60.0	15.0
Hout Bay						
Hout Bay A	84	84	5.53	2.53	60.71	14.29
Hout Bay B	102	102	7.46	2.14	83.33	27.45
Hout Bay C	26	26	4.95	3.25	53.85	11.54
Mitchell's Plain						
Mitchell's Plain A	71	923	5.10	1.26*	50.70	11.27
Mitchell's Plain B	30	390	4.53	1.23**	46.67	3.33

* Linearised (robust) standard error 7.89 $\times 10^{-16}$, 95% CI 1.26 to 1.26

** Linearised (robust) standard error 9.17 $\times 10^{-15}$, 95% CI 1.23 to 1.23

Among those who had blood lead levels ≥ 10 μg/dl girls made up 55.6 %, a majority spoke English (46.9%), and as expected, most were born in South Africa (97.0%). Most of them walked to school (72.8%); see Table 3.4.

Table 3.4 Comparing the characteristics of the study sample population between lead category of < 10 μg/dl and ≥ 10 μg/dl

Variable	Category of variable	Category of lead concentration		
		< 10 μg/dl	≥ 10 μg/dl	
		Weighted: N (%)	Weighted: N (%)	P value†
Gender:	Boy	847 (55.6)	91 (44.4)	< 0.0001
	Girl	676 (44.4)	114 (55.6)	
Language spoken at home:	English	728 (51.7)	92 (46.9)	0.7244
	Afrikaans	342 (24.3)	54 (27.6)	
	African	337 (24.0)	50 (25.5)	
Place of birth:	South Africa	1 378 (99.1)	192 (97.0)	<0.0001
	Other African	13 (0.9)	6 (3.0)	
Child's race:	African Black	360 (25.6)	57 (29.2)	0.6448
	Coloured	1 008 (71.8)	135 (69.2)	
	Asian	20 (1.4)	0 (0.0)	
	White	16 (1.1)	3 (1.5)	
Transport used to school:	Walk	938 (66.7)	142 (72.8)	0.3250
	Bus/taxi	156 (11.1)	14 (7.2)	
	Private	225 (16.0)	24 (12.3)	
	School/contract	87 (6.2)	15 (7.7)	

† refers the design- based Pearson chi square p values

Table 3.4 Continued

Variable	Category of variable	Category of lead concentration		
		< 10 µg/dl	≥ 10 µg/dl	
		Weighted: N (%)	Weighted: N (%)	P value†
Where child plays most:	Inside house	542 (38.5)	65 (32.8)	0.0002
	Outside house	727 (51.6)	112 (56.6)	
	Street	93 (6.6)	4 (2.0)	
	Other places	47 (3.3)	17 (8.6)	
Surface child plays most:	Grass	245 (17.8)	40 (22.4)	<0.0001
	Tar, tile or brick paving	722 (52.3)	59 (33.0)	
	Sand	413 (29.9)	80 (44.6)	
Child having attended crèche/ play school:	No	273 (19.4)	30 (15.2)	<0.0001
	Yes	1 134 (80.6)	168 (84.8)	
Sucking of fingers or chewing nails :	No	1 083 (77.0)	119 (60.7)	0.0226
	Yes	323 (23.0)	77 (39.3)	
Eating of non food items:	No	1 230 (89.1)	156 (80.0)	0.0017
	Yes	138 (10.0)	22 (11.3)	
	Don't know	13 (0.9)	17 (8.7)	
Use of home remedies:	No	995 (74.6)	122 (62.2)	0.1078
	Yes	339 (25.4)	74 (37.8)	

Table 3.4 Continued

Variable	Category of variable	Category of lead concentration		
		< 10 μg/dl	≥ 10 μg/dl	
		Weighted: N (%)	Weighted: N (%)	P value†
Use of pottery, ceramics or china:	No	783 (57.7)	147 (77.0)	0.1094
	Yes	573 (42.3)	44 (23.0)	
Frequency of washing of hands (before eating):	Always	846 (63.1)	137 (75.7)	<0.0001
	Sometimes	495 (36.9)	44 (24.3)	
	Never	0	0	
Use of make-up	No	1 285 (93.9)	144 (85.7)	0.0782
	Yes	84 (6.1)	24 (14.3)	
Ownership of home:	Owned	1 003 (72.2)	126 (65.9)	0.4088
	Rented	386 (27.8)	65 (34.1)	
Type of home:	House	978 (71.8)	124 (63.3)	0.0297
	Flat	117 (8.5)	38 (19.4)	
	Backyard dwelling	77 (5.6)	2 (1.0)	
	Shack	200 (14.6)	32 (16.3)	
Proximity to the busy road(within one block):	No	616 (44.3)	111 (57.5)	<0.0001
	Yes	775 (55.7)	82 (42.5)	

Table 3.4 Continued

Variable	Category of variable	Category of lead concentration		
		< 10 µg/dl	≥ 10 µg/dl	
		Weighted: N (%)	Weighted: N (%)	P value†
Fuel most used for cooking:	Electricity	1 308 (92.8)	188 (95.0)	0.3789
	Paraffin	40 (2.8)	2 (1.0)	
	Gas	61 (4.3)	8 (4.0)	
Presence of regular smoker in the house:	No	580 (41.2)	89 (45.2)	0.4995
	Yes	828 (58.8)	108 (54.8)	
Level of dust in the house:	Not dusty	358 (25.7)	72 (36.4)	0.0120
	Slightly dusty	899 (64.5)	117 (59.1)	
	Very dusty	136 (9.8)	9 (4.5)	
Location of toilet:	Inside the house	1 076 (77.2)	160 (82.1)	0.7353
	Outside the house	317 (22.8)	37 (17.9)	
Most common water source for the home:	Tap inside house	1 124 (79.8)	168 (85.7)	0.6473
	Tap on the property (outside house)	252 (17.9)	25 (12.8)	
	Communal tap	33 (2.3)	3 (1.5)	
Type of water pipes:	Metal	538 (39.2)	109 (56.8)	0.0036
	Plastic	782 (57.0)	81 (42.2)	
	Other	51 (3.7)	2 (1.0)	

Table 3.4 Continued

Variable	Category of variable	Category of lead concentration		
		< 10 µg/dl	≥ 10 µg/dl	
		Weighted: N (%)	Weighted: N (%)	P value†
Paint peeling inside house:	No	990 (71.3)	104 (53.9)	0.1554
	Yes	398 (28.7)	89 (46.1)	
Paint peeling outside house:	No	1 026 (74.2)	104 (54.2)	0.2236
	Yes	357 (25.8)	88 (45.8)	
House needing major repair:	No	906 (65.7)	100 (54.6)	0.4266
	Yes	384 (27.8)	80 (43.7)	
	Don't know	90 (6.5)	3 (1.4)	
History of painting, decoration or renovation in last year	No	693 (50.2)	82 (45.3)	0.5920
	Yes	688 (49.8)	99 (54.7)	
Playing with pets	No	802 (57.3)	99 (50.5)	0.0118
	Yes	597 (42.7)	97 (49.5)	
What is used when dusting the house	Dry cloth	295 (21.0)	69 (35.0)	0.0722
	Damp cloth (water)	345 (24.5)	32 (16.2)	
	Damp cloth (water + solution)	766 (54.5)	96 (48.7)	

Table 3.4 Continued

Variable	Category of variable	Category of lead concentration		
		< 10 µg/dl	≥ 10 µg/dl	
		Weighted: N (%)	Weighted: N (%)	P value†
What is used when sweeping the house	Dry broom	1 145 (82.4)	150 (76.1)	0.0341
	Wet mop (water)	11 (0.8)	3 (1.5)	
	Wet mop (water + solution)	233 (16.8)	44 (22.3)	
Person taking care of the child	Mother and father	733 (55.5)	129 (66.2)	0.3517
	One parent only	424 (32.1)	30 (15.4)	
	Relative/ Other	163 (12.4)	36 (18.4)	
Anyone living in house and working from home:	No	1 133 (82.8)	173 (88.3)	0.6165
	Yes	235 (17.2)	23 (11.7)	
Knowledge of lead hazard	No	297 (23.2)	25 (14.4)	<0.0001
	Yes	628 (49.1)	119 (68.4)	
	Don't know	353 (27.6)	30 (17.2)	
Crowding in homes	No crowding (< 3 persons/room)	974 (73.4)	128 (65.6)	0.0153
	Crowding present (≥ 3 persons/room)	353 (26.6)	67 (34.4)	

3.4 Factors Associated with Elevated Blood Lead Levels ≥ 10 μg/dl

Several characteristics and environmental factors were associated with elevated lead levels above the action level at 5% level. The results has been presented under univariable models and multivariable models after controlling for possible confounders as shown below.

3.4.1 Univariable model

In univariable logistic regression, girls were significantly associated with having BLLs ≥ 10 μg/dl. Girls had 1.57 higher odds of having BLLs ≥ 10 μg/dl than boys (odds ratio (OR) 1.57, 95% CI 1.52 to 1.62, $p < 0.0001$). Being born in another African country (not South Africa) was significantly associated with having BLLs ≥ 10 μg/dl (OR 3.31, 95% CI 2.17 to 5.06, $p < 0.0001$); children that were transported to school by taking a bus or taxi were associated with 0.41 lower odds of having BLLs ≥ 10 μg/dl than the children that walked to school (OR 0.59, 95% CI 0.39 to 0.89, $p = 0.018$). However, relative to walking to school, children who used trains were significantly 3.30 times as large odds of having BLLs ≥ 10 μg/dl (95% CI 1.11 to 9.80, $p = 0.035$).

Children who played outside the house, on the street, and places other than inside the house were statistically associated with elevated blood lead levels. Playing outside the house was associated with BLLs ≥ 10 μg/dl (OR 1.29; 95% CI 1.23 to 1.34, $p < 0.0001$); the odds of having BLLs ≥ 10 μg/dl for children who played in other places was 3.02 times the odds for playing inside the house. On the other hand, children who played on the street had 0.64 lower odds of having BLLs ≥ 10 μg/dl (OR 0.36, 95% CI 0.16 to 0.79, $p = 0.017$) than if they played inside the house.

Race, language spoken at home and owning a home were not associated with BLLs ≥ 10 μg/dl (Table 3.5). Playing on tar, tiles or brick paving was significantly more associated with BLLs ≥ 10 μg/dl (OR 0.50, 95% CI 0.43 to 0.58, $p < 0.0001$) than playing on grass. A child that reported attending crèche or preschool was more likely to have BLLs ≥ 10 μg/dl than if the child had not attended a crèche or preschool (OR 1.35, 95% CI 1.22 to 1.49, $p < 0.0001$). Chewing of nails or sucking of fingers was significantly associated with BLLs ≥ 10 μg/dl (OR 2.17, 95% CI 1.13 to 4.15, $p = 0.024$). Washing hands sometimes before eating food was associated with 0.45 lower odds of having BLLs ≥ 10 μg/dl compared to children who always washed hands before eating food (OR 0.55, 95% CI 0.49 to 0.61, $p < 0.0001$). The type of housing was significantly associated with the BLLs ≥ 10 μg/dl. Children living in a flat were 2.56 times higher odds of having BLLs ≥ 10 μg/dl than those living in a stand alone house (95% CI 1.60 to 4.11, $p = 0.001$). Living in a backyard dwelling was significantly associated with being 0.80 lower odds of having BLLs ≥ 10 μg/dl (OR 0.20, 95% CI 0.14 to 0.31, $p < 0.0001$).

The odds of having BLLs ≥ 10 μg/dl for children living within one block of a busy road was significantly 0.41 lower than the odds of living away more than one block from a busy road (OR 0.59; 95% CI 0.05 to 0.69, $p < 0.0001$). Children whose homes were described as very dusty had 0.67 lower odds of having BLLs ≥ 10 μg/dl than the odds of having BLLs ≥ 10 μg/dl if the house was not dusty (OR 0.33, 95% CI 0.19 to 0.58, $p = 0.002$). Use of a communal tap as a source of water resulted in lowering by 0.37 of the odds of a child having BLLs ≥ 10 μg/dl than if the taps were inside the house (OR 0.63, 95% CI 0.55 to 0.71, $p < 0.0001$). For children whose parents could not tell whether the house was in need of a major repair, the odds of having BLLs ≥ 10 μg/dl was 0.70 lower than the odds for those who lived in houses that needed major repairs having BLLs ≥ 10 μg/dl (OR 0.30, 95% CI 0.13 to 0.71, p = 0.012). For playing with pets, the odds of having blood lead level $\geq$ 10 μg/dl was 1.32 times as large than the odds of not playing with pets having BLLs $\geq$ 10 μg/dl (95% CI 1.08 to 1.60, p = 0.012).

Children who lived in houses where a damp cloth was used in mopping had 0.60 lower odds of having BLLs $\geq$ 10 μg/dl than those in houses where a dry cloth was used (OR 0.40; 95% CI 0.16 to 0.97, p = 0.043). Children in homes where three or more people shared a room had 1.44 times higher odds of having elevated blood lead level than the odds for those families where fewer than three people shared a room. The odds of having elevated BLLs for those with knowledge of lead hazards was 2.25 higher than the odds for those who believe that lead poses no hazard (OR 2.25, 95% CI 2.08 to 2.43, p <0.0001).

Table 3.5 Odds ratios and 95% confidence interval for factors associated with blood lead levels ≥ 10 µg/dl

Explanatory variables	Categories of explanatory variables	Univariable analysis			Multivariable analysis (effective sample size 396)		
		Crude odds ratio	95%CI (lower-upper)	P value	Adjusted odds ratio	95%CI (lower- upper)	P value
Gender:	Male	1.00			1.00		
	Female	1.57	1.52-1.62	< 0.0001	0.80	0.60-1.07	0.112
Language spoken at home (recoded):	English	1.00					
	Afrikaans	1.25	0.42-3.73	0.656			
	African	1.17	0.69-2.01	0.517			
Place of birth:	South Africa	1.00			1.00		
	Other African	3.31	2.17-5.06	< 0.0001	84.53	46.92-152.28	< 0.0001
	Outside Africa	-	-	-			
Child's race:	African Black	1.00					
	Coloured	0.85	0.33-2.15	0.695			
	Asian	-	-	-			
	White	1.18	0.41-3.41	0.726			
	other	-	-	-			
Transport used to school:	Walk	1.00			1.00		
	Bus/taxi	0.59	0.39-0.89	0.018	5.20	3.00- 8.99	< 0.0001
	Train	3.30	1.11-9.80	0.035	-	-	-
	Private cars	0.71	0.30-1.63	0.370	0.17	0.09-0.31	< 0.0001
	Other	-	-	-			
	School/contract	1.14	0.51-2.55	0.723	5.81	4.07-8.30	< 0.0001
Where child plays most:	Inside house	1.00			1.00		
	Outside house	1.29	1.23-1.34	< 0.0001	1.01	0.74-1.37	0.949
	Street	0.36	0.16-0.79	0.017	4.23	1.48-12.09	0.013
	Other places	3.02	2.10-4.33	< 0.0001	5.14	1.28-20.60	0.026

Note (-): the numbers were too few that Stata excluded them from the analysis automatically

Table 3.5 continued

Explanatory variables	Categories of explanatory variables	Univariable analysis			Multivariable analysis		
		Crude odds ratio	95%CI (lower- upper)	P value	Adjusted odds ratio	95%CI (lower- upper)	P value
Surface child plays most:	Grass	1.00			1.00		
	Tar, tile or brick paving	0.50	0.43-0.58	< 0.0001	0.35	0.12-1.02	0.053
	Sand	1.19	0.95-1.48	0.116	0.79	0.34-1.83	0.538
Child having attended crèche/ play school:	No	1.00			1.00		
	Yes	1.35	1.22-1.49	< 0.0001	15.23	3.40-68.29	0.003
Sucking of fingers or chewing nails :	No	1.00			1.00		
	Yes	2.17	1.13-4.15	0.024	2.98	1.20-7.40	0.024
Eating of non food items:	No	1.00			1.00		
	Yes	1.26	0.98-1.61	0.065	0.97	0.38-2.47	0.945
Use of pottery, ceramics or china:	No	1.00			1.00		
	Yes	0.41	0.13-1.31	0.117	1.06	0.82-1.38	0.623
Frequency of washing of hands (before eating):	Always	1.00			1.00		
	Sometimes	0.55	0.49-0.61	< 0.0001	1.45	0.68-3.10	0.298
	never	0.56	0.18-1.73	0.274	-	-	-
Use of home remedies:	No	1.00			1.00		
	Yes	1.78	0.85-3.72	0.111	0.48	0.26-0.88	0.022
Use of make-up:	No	1.00	1.00		1.00		
	Yes	2.55	0.85-7.66	0.086	4.29	1.88-9.78	0.003

Table 3.5 continued

Explanatory variables	Categories of explanatory variables	Univariable analysis			Multivariable analysis		
		Crude odds ratio	95%CI (lower-upper)	P value	Adjusted odds ratio	95%CI (lower-upper)	P value
Ownership of home:	Owned	1.00					
	Rented	1.34	0.62-2.89	0.410			
Type of home:	House	1.00			1.00		
	Flat	2.56	1.60-4.11	0.001	5.55	3.76-8.18	< 0.0001
	Backyard dwelling	0.20	0.14-0.31	< 0.0001	-	-	
	Shack	1.26	0.58-2.76	0.519	2.09	1.06-4.12	0.037
Proximity to the busy road(with in one block):	No	1.00			1.00		
	Yes	0.59	0.50-0.69	< 0.0001	0.16	0.11-0.24	< 0.0001
Fuel most used for cooking:	Electricity	1.00			1.00		
	Paraffin	0.35	0.11-1.15	0.077	-	-	
	Gas	0.91	0.26-3.21	0.873	3.24	2.34-4.48	< 0.0001
Presence of regular smoker in the house:	No	1.00					
	Yes	0.85	0.50-1.43	0.500			
Location of toilet:	Inside the house	1.00					
	Outside the house	0.74	0.11-5.15	0.736			
Level of dust in the house:	Not dusty	1.00			1.00		
	Slightly dusty	0.65	0.43-0.97	0.038	0.99	0.66-1.50	0.974
	Very dusty	0.33	0.19-0.58	0.002	2.04	1.36-3.04	0.003

Table 3.5 continued

Explanatory variables	Categories of explanatory variables	Univariable analysis			Multivariable analysis		
		Crude odds ratio	95%CI (lower-upper)	P value	Adjusted odds ratio	95%CI (lower-upper)	P value
Most common water source for the home:	Tap inside house	1.00			1.00		
	Tap on the property (outside house)	0.66	0.08-5.42	0.669	0.05	0.01-0.26	0.002
	Communal tap	0.63	0.55-0.71	< 0.0001	0.12	0.03-0.44	0.005
Type of water pipes:	Metal	1.00			1.00		
	Plastic	0.51	0.38-0.69	0.001	0.60	0.44-0.82	0.005
	Other	0.19	0.04-0.98	0.048	0.24	0.04-1.34	0.093
Paint peeling inside house:	No	1.00			1.00		
	Yes	2.12	0.69-6.52	0.161	5.03	1.07-23.78	0.43
Paint peeling outside house:	No	1.00					
	Yes	2.43	0.51-11.72	0.233			
History of painting, decoration or renovation in last year	No	1.00					
	Yes	1.22	0.55-2.70	0.592			
Playing with pets	No	1.00			1.00		
	Yes	1.32	1.08-1.60	0.012	4.07	2.66-6.22	< 0.0001
House needing major repair:	No	1.00			1.00		
	Yes	1.89	0.24-14.92	0.505	7.81	1.59-38.33	0.017

Table 3.5 continued

Explanatory variables	Categories of explanatory variables	Univariable analysis			Multivariable analysis		
		Crude odds ratio	95%CI (lower-upper)	P value	Adjusted odds ratio	95%CI (lower-upper)	P value
What is used when dusting the house:	Dry cloth	1.00			1.00		
	Damp cloth(water)	0.40	0.16-0.97	0.043	0.12	0.10-0.15	< 0.0001
	Damp cloth(water+ solution)	0.54	0.24-1.21	0.116	0.34	0.24-0.48	< 0.0001
What is used when sweeping the house:	Dry broom	1.00			1.00		
	Wet mop (water)	2.08	1.42-3.05	0.002	10.07	6.48-15.67	< 0.0001
	Wet mop (water+ solution)	1.44	1.00-2.08	0.051	2.18	0.84-5.68	0.098
Person taking care of the child:	Mother and father	1.00			1.00		
	One parent only	0.40	0.21-0.77	0.011	0.40	0.14-1.18	0.086
	Relative	1.26	0.12-12.97	0.831	8.61	4.68-15.82	< 0.0001
	Guardian	-	-	-			
Anyone living in house and working from home:	No	1.00					
	Yes	0.64	0.09-4.52	0.619			
Knowledge of lead hazard	No	1.00			1.00		
	Yes	2.25	2.08-2.43	< 0.0001	0.77	0.44-1.35	0.316
Crowding in homes	No crowding (< 3 persons/room)	1.00			1.00		
	Crowding present (≥ 3 persons/room)	1.44	1.09-1.91	0.016	0.43	0.19-1.00	0.051

3.4.2 Multivariable model

Variables that had p values less than 0.2 in the univariable models were included in the multivariable model. This approach has been shown to adequately cater for possibility of negative confounders.

In the multivariable logistic regression, several factors were independently associated with the unacceptable blood lead level (≥ 10 μg/dl) at 5% levels. In the overall sample, being born in an African country other than South Africa was independently associated with BLLs ≥ 10 μg/dl (adjusted odds ratio (aOR) 84.53, 95% CI 46.92 to 152.28, p < 0.0001). Children who were transported to school using a bus/taxi were more likely to have a BLL ≥ 10 μg/dl than those who walked to school (aOR 5.20, 95% CI 3.00 to 8.99, p < 0.0001). Similarly, the odds of having unacceptably high BLLs when children used school/contract vehicles were 5.81 times the odds of walking to school (95% CI 4.07 to 8.30, p < 0.0001). However, children transported in private cars to school had 0.83 lower odds of having BLLs ≥ 10 μg/dl compared to those that walked to school (aOR 0.17, 95% CI 0.09 to 0.31, p < 0.0001). Children who played on the street or other places had significantly higher odds of having elevated blood lead levels than those who mainly played inside the house. Playing on the street was significantly associated with unacceptable blood lead levels; (aOR 4.23, 95% CI 1.48 to 12.09, p = 0.013), while playing in other places, children's odds of having BLLs ≥ 10 μg/dl was 5.14 times the odds of playing inside the house (95% CI 1.28 to 20.60, p = 0.026).

Having attended a crèche was statistically significantly associated with a child having BLLs ≥ 10 μg/dl in comparison with never attending a crèche (aOR 15.23, 95% CI 3.40 to 68.29, p

= 0.003). Children who suck their fingers or chew their nails were more likely to have elevated blood lead levels compared to those children who did not (95% CI 1.20 to 7.40, $p = 0.024$). The odds of having BLLs ≥ 10 μg/dl for children using make-up was 4.29 times the odds for those children who didn't, and this was statistically significant (95% CI 1.88 to 9.78, $p = 0.003$). Children whose parents used gas for cooking at home instead of electricity were more likely to have blood lead levels ≥ 10 μg/dl (aOR 3.24, 95%CI 2.34 to 4.48, $p < 0.0001$). BLLs ≥ 10 μg/dl was also significantly associated with the level of dust in the house. The odds of having elevated blood lead levels for children living in houses described as being very dusty was 2.04 (95% CI 1.36 to 3.04, $p = 0.003$) times the odds of not dusty houses. In the same line, children in houses described as in need of major repairs were more likely to have blood lead levels ≥ 10 μg/dl compared to those houses not in need of major repairs (aOR 7.81, 95% CI 1.59 to 38.33, $p = 0.017$). Playing with pets increased the child's odds of having BLLs ≥ 10 μg/dl by 4.07 times compared with not playing with pets (95% CI 2.66 to 6.22, $p < 0.0001$). Living in a house where a wet mop was used to sweep the house was significantly associated with having BLLs ≥ 10 μg/dl (aOR 10.07, 95% CI 6.48 to 15.67, and $p < 0.0001$).

On the social front, a child living with a relative other than both parents significantly had increased the odds of having BLLs ≥ 10 μg/dl by 8.61 times (95% CI 4.68 to 15.82, $p < 0.0001$). Children living within one block off a busy road significantly had 0.84 lower odds of having elevated blood lead than those who lived more than one block off a busy road (aOR 0.16, 95% CI 0.11 to 0.24, $p < 0.0001$). Relative to having tap water inside the house, children whose home used a tap that was located on the property but outside were less likely to have elevated blood lead levels (aOR 0.05, 95% CI 0.01 to 0.26, $p = 0.002$). Similarly, children whose family used a communal tap as a source of water were less likely to have elevated blood lead levels (aOR 0.12, 95% CI 0.03 to 0.44, $p = 0.005$). Homes using plastic or other plumbing types compared to having a metallic pipe meant the children living there had 0.40 lower odds of having BLLs ≥ 10 μg /dl (aOR 0.60, 95% CI 0.44 to 0.82, $p < 0.005$). Using other types of plumbing, the child was 0.76 less at odds of elevated blood lead, although this was marginally significant (aOR 0.24, 95% CI 0.04 to 1.34, $p = 0.093$).

Dusting a house using a damp cloth with or without a solution reduced the odds of BLLs ≥ 10 μg/dl compared with using a dry cloth. For children whose homes used a damp cloth with water alone, the odds were 0.88 lower for having elevated blood lead (aOR 0.12, 95% CI 0.10 to 0.15, $p < 0.0001$), while using a wet mop with solution, the odds were 0.66 less (aOR 0.34, 95% CI 0.24 to 0.48, $p < 0.0001$) compared to the odds of using a dry mop.

It was ironical that children who lived in homes where caretakers didn't know whether lead substance could cause health hazard compared to those who thought lead poses no health hazard, were significantly less likely to have BLLs ≥ 10 μg/dl (aOR 0.27, 95% CI 0.09 to 0.79, $p = 0.023$). While being aware of the health hazard poised by lead reduced the likelihood of having BLLs ≥ 10 μg/dl compared to having knowledge that lead has no health hazard, but this was not statistically significant (aOR 0.77, 95% CI 0.44 to 1.35). Paint peeling from inside the house was not significantly associated with elevated blood lead level (aOR 5.03, 95% CI 1.07 to 23.78, $p = 0.43$). The type of housing was significantly associated with blood lead levels ≥ 10 μg/dl. Living in a flat significantly increased the odds of a child having BLLs ≥ 10 μg/dl compared to living in a free standing house (aOR 5.55; 95% CI 3.76 to 8.18, $p < 0.0001$); living in an informal house or shack likewise increased the child's odds of BLLs ≥ 10 μg/dl by 2.09 times, 95% CI 1.06 to 4.12, $p = 0.037$).

CHAPTER 4

4.0 DISCUSSION

The objectives of the study was to describe the distribution of blood lead among the first grade children, establish the proportion of children with elevated blood lead levels and to determine the factors associated with elevated blood lead levels in first grade children in Cape Town, South Africa.

As noted from the results, children in the suburbs of Cape Town had significant differences in the distribution of blood lead levels. In general, these blood levels are still high, similar to those countries still using leaded petrol. The research has also shown that children's school and home environments are their major sites of lead exposure.

4.1 Distribution of Blood Lead Levels

Overall, the weighted geometric mean blood lead level of the children was 5.27 µg/dl (95% CI 5.08 to 5.46). In the suburbs, the geometric mean blood levels differed, with Woodstock having 6.75 µg/dl, Hout Bay at 6.29 µg/dl and Mitchell's Plain at 4.92 µg/dl. The significant differences in the blood lead between the suburbs in the current study can be attributed to the differences in the exposure factors in these areas and activities these children may be engaged in.

In the 2002 study (Mathee et al., 2006b), the mean blood lead concentration for the total sample was 6.4 µg/dl with the suburbs of Woodstock, Hout Bay and Mitchell's Plain reported to have had mean blood lead concentration of 7.3 µg/dl, 5.2 µg/dl and 6.9 µg/dl, respectively; but these were probably arithmetic means, which tends to be larger.

In comparison to other places, this study was similar to a study carried out in a developing country Jakarta, Indonesia in June, 2001. The result of the survey carried out among 6 to 12 years old children from a nationally representative sample of schools (rural and urban) of Indonesia showed that the geometric mean blood lead levels was 8.6 µg/dl (Albalak et al., 2003). It is important to note that the study was carried out just a month before Indonesia undertook phasing out of leaded petrol in July, 2001. In Uganda another developing country, following the phase-out of leaded petrol in 2005, a survey that employed a stratified cross-sectional design to study the distribution of blood lead levels among 4 to 8 year old children was conducted in Kiteezi, a peri-urban area of Kampala City. The findings of the study revealed that the mean blood lead level was 7.15 µg/dl (Graber et al., 2010).

In a study conducted on 6 year old children in both rural and urban settings in 1991 after leaded petrol was phased-out, the results showed that in West Germany blood lead levels were generally lower with a geometric mean between 3.93 µg/dl and 5.08µg/dl, while in East Germany the geometric mean was between 4.23 µg/dl and 6.81 µg/dl (Begerow et al., 1994). This difference between the current study and the Germany study could be explained in part by the fact that Germany is a developed country and South Africa is a developing country and therefore of different socioeconomic status. This may also reflect on the other local sources of lead that may be different in these countries, hence removal of leaded petrol may not necessarily follow the same path to reduction in BLLs. When compared to US findings (Thomas et al., 1999; Grosse et al., 2002; Jones et al., 2009), the distribution of blood lead levels in the current study are still high after phasing out leaded petrol. Jones et al, (2009) established that in the US, the geometric mean blood lead levels was 3.6 µg/dl (95% CI 3.2 to

3.9) among children aged between 1 to 5 years in the season 1988-1991, that was 10 years after phasing out leaded petrol.

Examples above tend to suggest that sufficient time is needed between the phase-out of leaded petrol and a noticeable decline in blood lead distribution. A study conducted for three consecutive years in the high-traffic city of Shantou, China showed that it takes a while for blood lead levels to begin to drop (Luo et al., 2003). In their study in 1999, one year after banning the use of leaded petrol the geometric mean blood lead level was 9.7 μg/dl and the proportion with blood lead level ≥ 10 μg/dl was 10.4%.

In terms of the population groups, the weighted geometric means for African Blacks (5.73 μg/dl) and Coloureds (5.16 μg/dl) were high compared to Whites (4.98 μg/dl) and Asian children (3.25 μg/dl) had the lowest mean blood lead, but these differences were not statistically significant. A study in 2002 had found the mean lead blood concentration to be 6.0 μg/dl, 7.0 μg/dl and 3.5 μg/dl for Black Africans, Coloured and White race respectively. Asian race was not reported in that study.

There were significant differences in the mean blood lead levels between schools in this current study. The geometric mean blood lead levels were as low as 4.44 μg/dl at a school in Woodstock and as high as 9.21 μg/dl at a school in Woodstock as well. Schools in Hout Bay and Woodstock tended to have the highest levels. The findings in the 2002 study showed that the mean blood lead levels in the schools ranged from 3.3 μg/dl at a Hout Bay school to 8.1 μg/dl at a Woodstock school.

4.2 Proportions with Unacceptable (Elevated) Blood Lead Levels (≥ 10 μg/dl)

Much as individual blood lead concentration are important in order to determine whether treatment of lead poisoning may be warranted, the proportion of those children with blood lead levels ≥ 10 μg/dl is an indication of the need for public action to identify and remove the offending source(s) of exposure. The proportion of children with blood lead levels ≥ 10 μg/dl also acts as an indicator to show whether the removal of exposure source has been effective. In the current analysis, a weighted proportion of 11.81% (95% CI 8.78 to 15.71%) of children had unacceptable blood lead levels. This proportion varied significantly across the three suburbs: in Woodstock it was 21.0%, in Hout Bay 20.28% and in Mitchell's Plain 8.91%. In 2002, the overall proportions with BLLs ≥ 10 μg/dl 10% while these proportions were found to be as follows in the suburbs: Woodstock 12.0%, Hout Bay 3.0% and Mitchell's Plain 12.0%.

A study carried out in Uganda after the phase-out of leaded petrol reported that as many as 20.5% of the children had blood lead levels ≥ 10 μg/dl (Graber et al., 2010). The 2007 study reported unweighted proportions (Table 3.2), but evidently there has been an increase in the number of children with unacceptable blood lead levels, bearing in mind that the major source of environmental lead exposure (leaded petrol) should have been lower in 2007.

When individual schools are considered, the proportion of children with blood lead levels ≥ 10 μg/dl was high, with some schools in Woodstock having 40.0% of the children with unacceptable blood lead levels. In the 2002 study, the school with the highest proportion was in Woodstock with 24% of the children having BLLs ≥ 10 μg/dl. If the discussion regarding lowering the threshold for public health action is considered, there requires a lot of work to be done since in one of the school at Woodstock there were as many as 92.0% of the children who had blood lead levels ≥ 5 µg/dl. This current finding is similar to the percentage obtained at a school in Woodstock in the 2002 study where as many as 88% of children had BLLs ≥ 5 µg/dl.

4.3 Comparisons Between 2002 And 2007 Blood Lead Distributions

Previous study in the same areas of Cape Town had demonstrated that there was significant reduction in the blood lead distributions in these areas in the 2002 (Mathee et al., 2006b) compared to studies done in the 1990s (von Schirnding et al., 1991b). The reduction in the blood lead concentration was attributed to the partial removal of leaded petrol and the introduction of lead free petrol into South Africa in 1996. Their finding was shown to be similar to the trends observed in places where leaded petrol had been phased out.

With the complete phase-out of leaded petrol from South Africa in 2006, further decline in the concentration of lead in children's blood and the reduction in the proportion of children with BLLs ≥ 10 µg/dl was expected since the decline has been demonstrated by some countries that have phase-out leaded petrol. Some of the countries that have recorded this decline in blood lead concentration following a complete phase-out of leaded petrol include China and the United States of America among others.

In China a study had shown that following complete banning of the use of leaded petrol in 1998, the geometric mean blood lead concentration among 1-5 years old children in a highly traffic City area of Shantou gradually decline over a three year period. The geometric mean blood lead level was found to be 9.7 µg/dl in 1999, which declined to 8.5 µg/dl in 2000 and

7.1 μg/dl in 2001. The proportions of children with BLLs ≥ 10 μg/dl was 44.3%, 35.8% and 23.0% in 1999, 2000 and 2001 respectively (Luo, Zhang & Li, 2003). In earlier survey of a nationally representative sample of 1-5 year old children in the US had demonstrated a marked decline in blood lead levels over a 10 year period. In that study, the geometric mean blood lead levels for all the children was 15.0 μg/dl in 1976- 1980 data and in 1988-1991 data the geometric mean was 3.6 μg/dl. In the same study periods the proportion of children with BLLs ≥ 10 μg/dl declined from 88.2% to 8.9% in 1976-1980 and 1988-1991 periods respectively (Pirkle et al., 1994). This decline in blood lead concentration has continued in the US, in 1999-2004 data where analysis by Jones and colleagues showed that the geometric mean and the proportion of children with BLLs ≥ 10 μg/dl among 1-5 year old children was 1.9 μg/dl and 1.4% respectively (Jones et al., 2009).

Although the blood lead concentration in 2007 was determined using the LeadCare method and study in 2002 utilised Model Perkin-Elmer Analyst 300 with HGA 850 and may raise comparability issues, these methods have been shown to correlate well with each other (Bischoff, Gaskill, Erb & Hillebrandt, 2010; McMillin and Bornhorst, 2008; Parsons, Reilly, Esernio-Jenssen, Werk, Mofenson, Stanton & Matte, 2001).

Despite the different analytic methods in this current study in which all the study design characteristics were considered and the methods in the previous study in which some features of the study design were not considered and reporting slightly different parameters such as the previous studies had reported an arithmetic mean, which is always higher than the geometric mean. In this current analysis as shown (Table 3. 1), the arithmetic mean was higher than the geometric mean. Arithmetic mean in a skewed data such as blood lead concentration is not an accurate measure.

This analysis has shown that the blood lead levels in the first grade children in Cape Town in 2007 has not changed from the values in a study done in 2002, to the contrary the blood lead concentrations and the proportion with elevated blood lead levels have increased.

The lack of reduction of blood lead concentration and the proportion of children with elevated blood lead levels in the area of Cape Town may be attributed to several factors. Firstly, insufficient time had passed before lead deposited in environments where children play. The lead particles may take longer than one year to diminish and secondly the phase-out of leaded petrol did not start smoothly as was expected, there seems to have been significant amounts of leaded petrol in circulation in 2006. In an article titled "Slow Progress on Phase-out of Leaded Fuel SADC" the South African Petroleum Industry Association was reported to have made an arrangement with the South African Government to allow the industry until June 2006 to flush out all the leaded fuel that was still in circulation then (Patson, 2006). Thirdly, there could have been immigration from some areas of the country where exposures were much higher; hence diluting the expected decline in blood lead concentration. A lower socioeconomic status (known risk factor for elevated blood lead) of immigrants living in these areas may partially explain this (Mathee et al., 2006b; von Schirnding et al., 1991b). The socioeconomic variables were not fully investigated due to significant missing values in the data. But it is also possible that a new local source of contamination was at play. This would need further investigation. Because of the above the full impact in reducing blood lead concentration in children after a total phase-out of leaded petrol may be expected to manifest after 2007.

By the time of 2002 research, leaded petrol constituted only 30% of the fuel market in South Africa and by the time of the 2007 research, the percentage contributed by leaded petrol could have been less than 30%. In regards to the above, while it is expected that further reduction in blood lead concentration would be expected after 2007, a much significant reduction can only be achieved if other non petrol lead sources are identified and removed.

However in order to realise significant reduction in blood lead distribution , Needleman emphasises that strict policy aimed at removing the sources of lead exposure should be enforced consistently. He warns that there is the danger of deviation from achieving this goal if these principles are not strictly adhered to (Needleman, 1998). In relation to the above statement, by statistical modelling, it has been shown that having delayed or no policy on removal of lead sources in the community can have a profound effect of failing to reduce the level of lead exposure in children or it has the effect of increasing blood lead levels in children (von Storch and Hagner, 2004).

4.4 Factors Associated with Elevated (Unacceptable) Blood Lead Levels (≥ 10 µg/dl)

Several factors were identified that were grouped into three categories. Firstly, those factors that increased the odds of having an elevated blood lead level that included: being born in other African countries, using taxis, buses and school contract transport, playing in the streets or in other places, attending a crèche, sucking fingers or chewing nails, children using make-up, using gas for cooking, houses described as very dusty, playing with pets, if a house was in need of major repair, children living with relatives or guardians, and the type of houses amongst others.

Secondly, those factors which were associated with elevated lead levels in the sense that they reduced the odds of having an elevated blood lead level. These factors included transporting children to school using private cars, living within one block of a busy road, when the tap used as a water source is located outside but on the property and when a communal tap is used, and when plumbing was made of plastic or other materials other than metal. Dusting a house using a damp mop with or without a cleaning solution and knowing the hazardous effect of lead were all significantly associated with reducing the odds of an elevated blood lead level.

The third category were those factors that were marginally significant and therefore inconclusive in its relationship to having BLLs ≥ 10 μg/dl such as, playing on tar, tile or brick paving, other types of plumbing, and the use of wet mops for sweeping the house when a mixture of water and solutions such as washing powder or Handy Andy.

In this study, the race of the child, the language spoken at home, paint peeling outside the house or inside the house, and the presence of someone working from home did not have any significant relationship with elevated blood lead level.

4.4.1 Place of birth

In this analysis, a child born outside South Africa was more likely to have an elevated blood lead level. In the US Pirkle and colleagues also found Mexican migrants tended to be more at risk than the Native Americans (Pirkle, Brody, Gunter, Kramer, Paschal, Flegal & Matte, 1994). In Germany Turkish migrants were found to have very high blood lead distributions such that they would be treated in their own subgroup for analysis (Begerow, Freier, Turfeld, Krämer & Dunemann, 1994). It is tempting to suggest that these children might have come from other areas where they were much more exposed to lead. It is also possible that looking for work by the father may have been a reason for them to stay in these areas of Cape Town. Such work may have been related to lead; unfortunately, because of a great deal of missing values, parent work type could not be analysed. It would be rewarding to study these children in order to understand their socioeconomic condition, housing condition, and the nature of work done by their parents, or specifically try to study isolated local factors responsible for high lead exposure. The confidence interval was quite large because of smaller numbers.

4.4.2 Means of transport to school

Children that were using some form of public transport compared to walking were significantly more likely to have blood lead levels ≥ 10 μg/dl. For example, children using a bus or taxi transport to school were highly more likely to have elevated blood lead levels than those who walked to school. Similarly, children using a school/contract vehicle were 5.81 times the odds of walking to school for having an elevated blood lead level. In contrast, those children transported to school using private vehicles were less likely to have blood lead levels ≥ 10 μg/dl. This was statistically significant. Two explanations could be advanced for these findings. Children transported to school using private cars are economically more privileged and were of socially higher class than the ones using public transport. It has been shown that exposure to lead was related to poverty (Mathee et al., 2006b, Lanphear et al., 1998b). On the other hand, the type of fuel these vehicles were using then might also be a factor. There are some suggestions that at the beginning of the total phase-out there was still some leaded petrol. Public transporters tended to use more leaded petrol than private car owners who switched much faster and earlier to unleaded petrol because they could afford the cost of unleaded fuel (Patson, 2006). The old containers may still have been contaminated with leaded petrol. The flushing of the tanks were expected to be completed in June 2006 (Patson, 2006). Besides, public transport tends to be in poor mechanical condition, hence emitting much more incompletely burnt leaded fuel to the environment. Some of the engines of these old cars needed modification in order to use unleaded petrol. This stresses further the contribution of leaded petrol to environmental lead contamination.

4.4.3 Places where children play

This study has shown that playing in the street and other places compared to playing inside the house was significantly associated with elevated blood lead levels. Children who played most of the time on the street were significantly more likely to have blood lead levels $\geq$ 10 μg/dl. When a child played in other places, the odds of having blood lead level $\geq$ 10 μg/dl were 5.14 times higher compared to playing inside the house. The main pathway of exposure to lead in children is through the oral route; playing on the street is obviously more dangerous since most of the lead particles in exhaust fumes of lead are deposited to the soil around the streets. This was previously documented in earlier studies (von Schirnding et al., 1991b; Mathee et al., 2006).

4.4.4 Schooling at a crèche or preschool

Having attended a crèche or preschool was among the most significant factors associated with blood lead levels ≥ 10 μg/dl with regards to the strength of association. Attending a crèche/ preschool was associated with 15.23 times the odds for having blood lead levels ≥ 10 μg/dl compared to if a child had not attended. To the contrary, previous studies in the same areas had found that attending a crèche/ preschool was significantly associated with a protective effect against elevated blood lead levels (Mathee et al., 2006b, von Schirnding et al.,1991b). The authors attributed their findings to the fact that children attending the crèche/ preschool were from homes with higher socioeconomic status and elevated blood lead levels were associated with lower socioeconomic status.

The difference observed could be related to the analytical approaches used, the degree and the extent to which possible confounders were controlled (McNamee, 2005).

Allowing for entry in a multivariable models for variables with p value less than 0.2 might have controlled for more potential confounders than using p values less than 0.15 used in previous studies . Negative confounders that were not properly controlled for would allowed attending crèche to show no effect or even to show protective effect when actually attending a crèche school could have been a risk factor for elevated blood lead levels (Maldonado and Greenland, 1993). In addition the study published in 1991 reported on only 5 schools with Coloured race in Woodstock area. While in the study reported in 2006, 11 schools from Woodstock, Hout Bay and Mitchell's Plain with mixed race were studied. In this study the few socioeconomic variables investigated were not significantly associated with blood lead levels ≥ 10 μg/dl.

Despite the above discussions, this finding raises the question of the nature of school environments in terms of lead exposure factors. Coupled with mouthing behavior at these ages, the sources of lead in this environment should rather be investigated and removed if found, however small they may be. Previous studies had demonstrated that children's toys and furniture had high lead content from the paints used to colour them. There were also significant proportion of paints that were leaded as found in Johannesburg (Montgomery and Mathee, 2005). It was recommended then that such toys be removed and that the furniture be repainted with non-lead-based paints (Mathee et al., 2006b). Investigating the school environment in Cape Town (building, furniture and children's toys) for lead concentration in paints to colour them would be worthwhile.

4.4.5 Use of make-up

Using make-up was found to be associated with a 4.29 times increase in the odds of a child having blood lead levels ≥ 10 μg/dl than those children who did not use makeup. It is well known that some eye liners or pencils contain lead (Moore, 1987). This finding is therefore not a surprise, as other studies in the past had demonstrated this already.

4.4.6 Fuel for cooking

Regarding fuel used for cooking, children coming from homes that used gas at home for cooking were significantly associated with a 2.08 times increase in the odds of a child having blood lead levels ≥ 10 μg/dl than when electricity was used. Liquefied petroleum gas is the common cooking gas in South Africa. Why it is associated with elevated blood is not clear, but probably it means that the gas containers were contaminated with lead at petrol stations. The use of electricity is more likely to be associated with higher socioeconomic status compared to using gas. Using electricity should be encouraged; where this is impossible, non-contaminated gas cylinders may be used.

4.4.7 Housing conditions

Several aspects of housing had significant associations with blood lead levels ≥ 10 μg/dl. A child coming from a very dusty house was 2.04 times increase in the odds of having elevated blood lead levels compared to relatively dust-free dwellings. This suggests that children may be exposed to lead-rich dust inside the home environment. The most likely source could be paints peeling indoors. This is similar to what other studies have found (von Schirnding et al., 1991b, Montgomery and Mathee, 2005).

This study has also demonstrated that routine home activities may lessen the exposure level. In a home where a damp cloth using water alone was used a child's odd of having BLLs ≥ 10 μg/dl was reduced by 0.88 compared to using a dry mop.

Closely related to the above discussion, houses that needed major repairs were significantly associated with increased odds of having blood lead levels ≥ 10 μg/dl (aOR 7.81, 95 % CI 1.59 to 38.33). A similar finding was documented in an earlier study in the same areas (von Schirnding et al., 1991b). Although the data would not permit exploring the detail of these houses, it is possible that these houses were old and leaded paint was used to paint these houses in the past. It can be deduced that paints peeling from the indoor surfaces were contributing to the bulk of the dusty houses explained earlier. This stresses the need to remove lead from paints as well. This initiative has already been echoed in the past (Mathee et al., 2006a, Mathee et al., 2009).

Related to the foregoing discussion is the question of safety of the water source from lead contamination. This analysis has shown that independently of all other factors controlled for, the use of tap water situated on the property but not inside the house was associated with 0.95 lower odds of having an elevated blood lead level. (aOR 0.05, 95% CI 0.01 to 0.26, p 0.002). Similarly, if the tap for water was for communal use, the child had 0.88 lower odds of having elevated blood lead levels ≥ 10 μg/dl. The reason for these findings is not clear at this stage, but it may point to some variables that were not captured for consideration during analysis. An explanation for this findings may be advanced by a paper published in January 2011 where Brown and colleagues investigated the association between children's blood lead levels, lead service lines, and water disinfection in Washington DC for the period from 1998 to 2006 (Brown et al., 2011). The study had a total of 63,854 children and found that partial replacement of lead pipes was significantly associated with increased BLLs ≥ μg/dl (aOR 3.3, 95% CI 2.2 to 4.9) .

In their discussion they strongly stated that one of the limitations of the study was that the water consumption pattern, a factor that influences the association between water containing lead and the amount of lead recorded in the blood was not controlled for. It therefore follows that if the water supplied in these areas had lead pipes that were replaced, those with water taps inside the house were likely to be from a higher socioeconomic status and were more likely to replace their plumbing more than those of low socioeconomic status. Those families using taps located outside the house and communal taps were more likely to consume less leaded water than those with water taps inside the house due to lead concentration dilution effects for two reasons:

Firstly, the water taps outside the houses are more likely to be consumed by more people than water taps from inside the house and even larger number of families would use the communal taps hence less leaded water would be consumed by each family. Secondly, these families were more likely to collect water from other sources, such as rain water or from bore holes than those with water tap inside the house. The possibility that water could be contaminated with lead is enhanced further by Lobanga. In his research report entitled the "State of plumbing in South Africa", it was found that 50% of plumbing materials in Johannesburg (considered a role model city) were not compliant with the South African Bureau of Standards recommendations. The materials were substandard and leaks were a major concern. According to his conclusions he stated that such may encourage water contamination with metals such as lead used in the solder joints and from those used as components of brash fittings (Lobanga, 2008).

From the above discussion it may be useful to carry out tests on water samples at the point of usage in Cape Town and taking into consideration the water consumption patterns of the residence . Although sampling of water for domestic use to determine lead exposure is noted to be difficult and it is possible for sporadic or short term elevations to go unnoticed (Schock, 1999).

4.4.8 Playing with pets

Children reported to play with pets were 4.07 times more at odds of having blood lead levels ≥ 10 μg/dl. The pets may not be the problem; rather the pet may transfer some of the lead deposited to its body from a nearby play area or soil where it plays. This should only sound a warning bell that the area around the home is heavily contaminated with lead.

4.4.9 Role of care taker

Children, who lived with their relative or guardian, were 8.61 times more at odds of having blood lead level ≥ 10 μg/dl compared to children living with both parents. There are several reasons why children live with someone else in the South African setting, e.g. the socioeconomic situation at home may not be conducive. This may relate to a larger extent to the care given to these children: children may need to stay under care of someone who will closely monitor their activities.

4.4.10 Other associations

It is important to note that the prevalence of people with knowledge of lead hazards was about 51.45%. This results might show have shown that information regarding lead hazard was still inadequate.

It should be further noted that while in the past, race and language were used as proxies for socioeconomic status of the population and were significantly associated with increased blood level, in this survey they were not significant.

Living near heavily trafficked roads was not associated with blood lead levels ≥ 10 μg/dl. This may not be a reflection on the group because most of the children might be spending most of their time at school.

4.5 Limitations

While interpreting the results of the study, the following limitations of the study should be considered. Bearing in mind that the result of this analysis can still be considered as just one that could provide only few answers to the complex nature of lead exposure to the environment.

The study used relatively a small sample size; hence while interpreting the results of this study caution should be employed as the small sample may not have enable the study to obtained sufficient power to detect differences between some of the variables during the analysis. Some significant results and the wide confidence intervals observed in some of the results such as the significance of place of birth may have resulted from the small sample size as well.

The questionnaire data had substantial missing information on the independent variables. This limited the exploration of some variables' influence on others, though the outcome variable had no missing data.

This was a self-administered questionnaire; there is a possibility that some of the questions could have been misunderstood or not at all understood, creating an opportunity for response bias.

The response rate for this survey in Cape Town was reported to be approximately 55%. There is a possibility that this could have introduced non-response bias to the study results. But it is also valuable to think that since the parents were not yet aware of their children's blood lead levels when the questionnaire was sent to them, this kind of selection bias may not have occurred sufficiently to distort the results. However, the non-responses have definitely affected the precision with which the proportion of children with blood lead level ≥ 10 μg/dl could be estimated.

The sampling design specifically targeted these areas; hence the results obtained can only explain what was in the three suburbs and cannot be generalised to all part of South Africa. However, they may apply to some suburbs with similar settings.

4.6 Strength

The analysis took into consideration all the study designs, and as such, results should demonstrate as closely as possible the estimates of interest but taking into account the limitations discussed above.

This study has demonstrated that simple activities may lessen the exposure level in dusty homes. In a home where a damp cloth using water alone were used , the odd of the child having BLLs ≥ 10 μg/dl would reduce by 0.88 compared to the odds a child would have when staying in homes where a dry mop was used.

The result of this study can act as future reference of blood lead distribution after a complete Phase-out of Leaded Petrol in South Africa.

CHAPTER 5

5.0 CONCLUSION

This chapter summaries the findings of the study with regards to the distribution of blood lead levels and associated factors for having elevated blood lead levels among first grade children in selected Cape Town schools in the suburbs of Woodstock Mitchell Plain and Houtsbay

The result has shown that despite phasing out leaded petrol in South Africa in 2006, first grade children in these areas still had significant concentration of lead in blood. In some schools the proportion of children with blood lead levels BLLs ≥ 10 μg/dl was up to 40%. These findings may partly be attributed to the fact that insufficient time had elapsed between complete phasing out of leaded petrol and data collection in 2007 where some of leaded petrol could still be in use especially in public transport where children could come into contact with these while they play along the streets. Large number of children in the Cape Town suburbs are still at risk of effects of elevated blood levels such us anemia, reduced concentration and poor performance at school.

Obviously the contribution of leaded petrol in the environment has reduced. Hence of importance is the high possibility of other sources of lead exposure in the environment. Of particular concern is the peeling off of leaded paints used in painting houses, furniture and children's toys which could explain why children who leaved in dusty houses, houses needing major repairs and those who attended crèche or preschool were more likely to have blood lead levels ≥ 10 μg/dl. The children would pick lead particles in the dust while they play with pets and suck their fingers.

It has been shown in this analysis that some manageable activities that can be effectively carried out at homes such as using damp mop for mopping houses and using plastic water supply pipes could go along way in reducing the chances of children living in these houses from having elevated blood lead levels.

In this study another finding of interest was the fact that only half of the parents/ guardian had knowledge that lead in the environment was associated with harmful health effects despite campaigns and the fact that lead research had previously been conducted in these same areas.

CHAPTER 6

6.0 RECOMMENDATION

In this chapter the implication and the way forward as a result of this study will be stated and elaborated. In particular findings that could have been easily done at home in order to protect the children from lead exposure will be emphasized.

As established by the analysis in this study the sources of lead exposure are wide spread and diverse, removal of leaded petrol would be insufficient on its own in reducing BLLs. Therefore, removal of non petrol sources of lead should be a priority now than ever before. Laws in South Africa regarding removal of leaded paints should be enforced and implemented as a starting point. Immediate action should be taken to repaint old houses, furniture and children toys with non leaded paint. Home owners who are still using metallic water pipes should be encouraged to replace them with those made of plastic pipes.

Poverty may lead people into doing dangerous activities including using lead related activities as a way of livelihood and as energy source. The South African government should consider increasing subsidies to enable more families to use electricity in the short term, while creating enabling conditions for socioeconomic advancement of individual families in the long term should be another approach towards reducing blood lead levels in children in these areas.

The results show that just about half of the parents/ guardian in these suburbs knew of the harmful effects of lead. Increasing the efforts to educate the population with regard to lead effects, signs/symptoms, source and preventive measures, some them backed by the result of this study should be done. Parents should be encouraged and informed that they can do a significant work towards protecting their children from lead exposure even at home. Parents should be told that they discouraging children from playing along the streets and using damp clothes to mop the house could reduce their children from lead exposure.

Recognizing that sources of lead exposure are varied and new once keep emerging , periodic surveillance of blood lead concentration in children should be carried out for purposes of monitoring progress towards reducing lead concentration in children's blood and establishing new sources of lead exposure to the community. Schools with high proportion of children with elevated blood lead levels and the homes of these children should be investigated to establish sources of lead exposure and follow up for management of individual children

6.1 Suggestions For Further Research

Several observations could not be investigated into their conclusions due to limitations within the data. Therefore the following areas should be considered for further research.

- To investigate crèche school environments for sources of lead (toys, furniture, buildings, and play ground) to establish why attending a crèche school was a very big risk factor.
- Water samples in the homes and crèches at the point of usage should be evaluated for their lead content, it could shade light into the reasons why using communal taps were safer.
- Extensive evaluation in the local context, the major socioeconomic factors on how they affect blood lead levels in children.
- Monitoring of blood lead levels to demonstrate progress towards lowering BLLs after removal of leaded petrol should be implemented.

APPENDIX A Normality check for blood lead concentration (µg/dl)

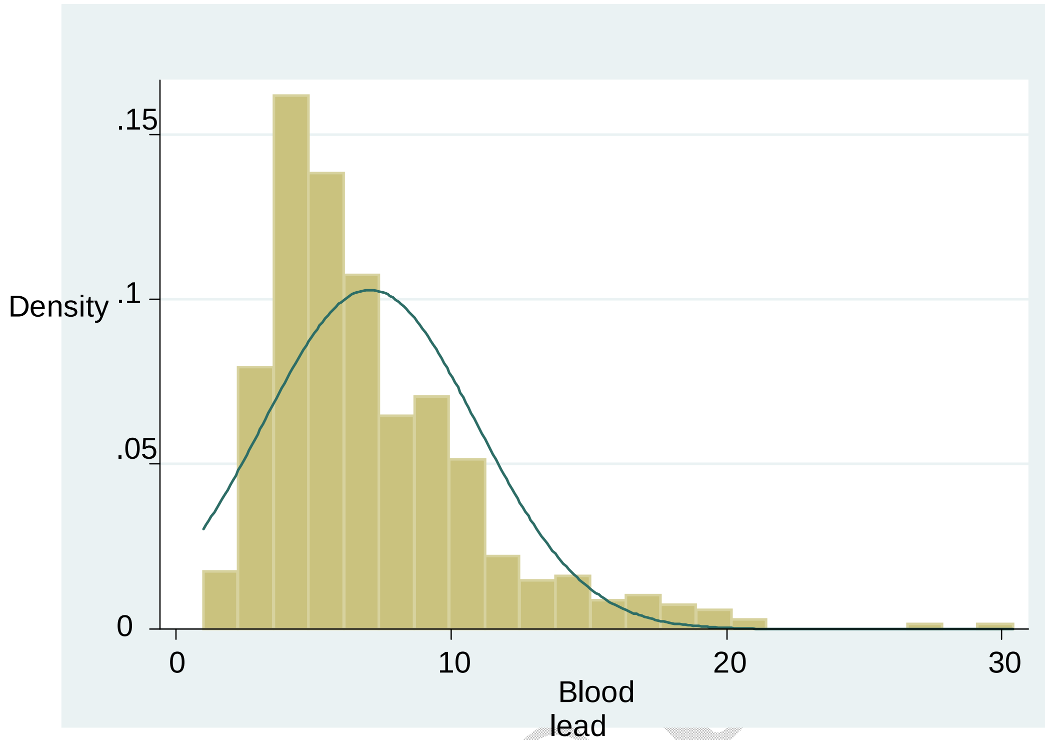

Figure A 1 Histogram of blood lead among the sample studied (µg/dl)

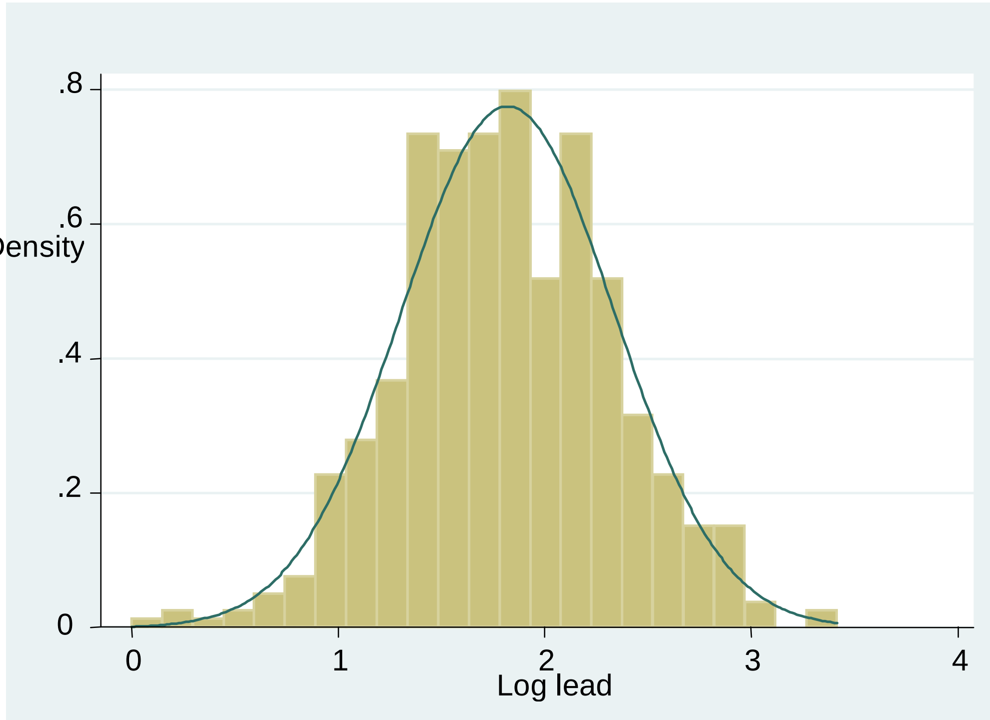

Figure A 2 Histogram of natural logarithm transformed blood lead among children (μg/dl)

APPENDIX B Collinearity diagnostics

```
pwcorr pborn gender q10howdoes q13doeschi q15 rq17childat rq20childof rq22doeshes rq23doyuuse q241befo
> re rq28childgi rq29childev q33howwoul rq35ishomeo q37fuelisu rq40homeiso q42doyouge rq43tipeplu rq44
> isthere rq46ishomei rq49doeschi q52dusting q53houseis nq561mother rq64doyoube crowding
```

	pborn	gender	q10how~s	q13doe~i	q15	rq17ch~t	rq20ch~f
pborn	1.0000						
gender	-0.0319	1.0000					
q10howdoes	-0.0016	0.0894	1.0000				
q13doeschi	-0.0716	-0.0907	-0.0545	1.0000			
q15	-0.0818	0.0620	-0.0151	0.1489	1.0000		
rq17childat	-0.0486	-0.0124	0.1613	-0.0441	-0.0969	1.0000	
rq20childof	-0.0437	0.0818	-0.0930	-0.0191	0.0643	-0.1038	1.0000
rq22doeshes	0.0780	-0.0056	-0.0710	0.1203	0.0733	0.0307	0.0770
rq23doyuuse	0.0653	-0.0924	0.0432	-0.0525	-0.0786	0.0932	-0.0442
q241before	-0.1375	0.0638	0.0499	0.1231	-0.0125	0.1296	-0.0146
rq28childgi	0.0279	-0.0178	-0.0629	0.0675	0.0321	-0.0429	0.0593
rq29childev	-0.0237	0.2753	0.0535	-0.0449	-0.0162	-0.0038	0.0464
q33howwoul	-0.0478	0.0402	-0.1942	0.2175	0.2831	-0.0624	0.1230
rq35ishomeo	-0.0226	-0.0090	-0.0412	-0.0571	-0.1195	0.0575	0.0124
q37fuelisu	-0.0576	0.0793	0.0685	0.0080	0.0022	-0.0001	-0.0190
rq40homeiso	-0.1177	0.0544	-0.1455	0.0230	0.0603	-0.0961	0.1271
q42doyouge	-0.0092	0.0197	-0.0397	0.1510	0.2772	0.0097	0.0919
rq43tipeplu	0.0194	-0.0531	0.0556	-0.0371	-0.1845	0.0674	-0.0533
rq44isthere	0.0119	-0.0309	-0.0983	-0.0551	0.0163	-0.0993	0.0791
rq46ishomei	0.0132	-0.0201	-0.1896	0.1117	0.1670	-0.1171	0.1059
rq49doeschi	-0.0109	-0.1130	-0.1310	-0.0282	-0.0358	-0.0744	0.0505
q52dusting	0.0867	-0.0544	-0.0242	0.0109	0.0307	-0.0040	-0.0066
q53houseis	0.1073	-0.0278	0.0291	-0.0451	0.0440	-0.0151	-0.0585
nq561mother	-0.1238	0.0613	0.0537	0.0853	0.0597	0.0008	-0.0317
rq64doyoube	0.0015	-0.0091	0.0454	0.1120	-0.0451	0.0128	0.0197
crowding	-0.0201	0.0379	-0.1893	0.1456	0.0435	-0.2242	0.0472

	rq22do~s	rq23do~e	q241be~e	rq28ch~i	rq29ch~v	q33how~l	rq35is~o
rq22doeshes	1.0000						
rq23doyuuse	-0.0689	1.0000					
q241before	-0.0497	-0.0268	1.0000				
rq28childgi	0.0731	-0.0710	-0.0071	1.0000			
rq29childev	0.0936	0.0533	0.0642	-0.0065	1.0000		
q33howwoul	0.1494	-0.1267	-0.0087	0.0935	-0.0156	1.0000	
rq35ishomeo	-0.0481	0.0744	-0.0791	0.0896	0.0517	-0.0476	1.0000
q37fuelisu	0.0374	0.0545	0.0445	0.0082	0.1124	-0.0074	0.0249
rq40homeiso	0.0329	0.0351	0.0396	0.0930	0.0113	0.2324	0.0595
q42doyouge	0.1319	-0.1257	0.0338	0.0587	-0.0511	0.6083	-0.0709
rq43tipeplu	-0.0263	0.0966	-0.0083	-0.0085	0.0337	-0.1949	-0.0065
rq44isthere	0.0192	-0.0709	-0.0476	0.1100	0.0230	0.0103	0.0307
rq46ishomei	0.1000	-0.0654	-0.0418	0.1064	0.0297	0.3270	0.0253
rq49doeschi	0.0186	0.0110	-0.0447	0.0234	-0.0129	-0.0398	0.0120
q52dusting	-0.0657	0.1012	0.0303	0.0348	0.0075	0.0553	-0.0387
q53houseis	-0.0342	0.0174	-0.0689	0.0008	0.0796	0.0331	-0.0548
nq561mother	-0.0617	-0.0243	-0.0329	-0.0070	-0.0149	-0.0863	-0.0078
rq64doyoube	0.0357	0.0400	0.0842	0.0225	-0.0066	0.0133	-0.0206
crowding	0.0416	-0.1399	0.0099	0.0349	0.0201	0.2636	0.0308

	q37fue~u	rq40ho~o	q42doy~e	rq43ti~u	rq44is~e	rq46is~i	rq49do~i
q37fuelisu	1.0000						
rq40homeiso	0.0389	1.0000					
q42doyouge	0.0653	0.1435	1.0000				
rq43tipeplu	0.0519	-0.0210	-0.0887	1.0000			
rq44isthere	-0.0195	0.0607	0.0395	-0.0586	1.0000		
rq46ishomei	-0.0399	0.2792	0.2733	-0.1172	0.3594	1.0000	
rq49doeschi	-0.0116	0.0128	-0.1015	0.0202	0.0367	0.0164	1.0000
q52dusting	0.0526	-0.0171	0.0788	0.0568	0.0084	0.0252	0.0132
q53houseis	-0.0083	-0.1021	-0.0847	-0.0245	-0.0181	0.0097	-0.0155
nq561mother	-0.0026	-0.0698	-0.0352	0.0201	-0.0475	-0.0708	-0.0605
rq64doyoube	0.0659	0.0823	-0.0050	0.0334	-0.0858	0.0307	-0.0327
crowding	-0.0086	0.1433	0.1531	0.0048	0.0797	0.1594	0.0216

	q52dus~g	q53hou~s	nq561m~r	rq64do~e	crowding
q52dusting	1.0000				
q53houseis	0.2460	1.0000			
nq561mother	0.0183	0.0281	1.0000		
rq64doyoube	-0.0438	-0.0619	0.0568	1.0000	
crowding	0.0055	-0.0335	0.0460	0.0220	1.0000

Figure B 1 Collinearity check

APPENDIX C Logistic regression diagnostics

```
. linktest
(running logit on estimation sample)

Survey: Logistic regression

Number of strata   =         3                Number of obs      =        256
Number of PSUs     =        12                Population size    =        880
                                              Design df          =          9
                                              F(   2,      8)    =    3049.54
                                              Prob > F           =     0.0000

------------------------------------------------------------------------------
             |             Linearized
      hilead |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        _hat |   1.258124    .311812     4.03   0.003     .5527558    1.963491
      _hatsq |   .0798046   .0352264     2.27   0.050     .0001171    .1594922
       _cons |  -.0791763   .1379995    -0.57   0.580    -.3913527    .2330002
------------------------------------------------------------------------------
```

Figure C 1 Misspecification error check

```
. svylogitgof
   Number of observations =                             256
F-adjusted test statistic = F(9,1) =             -2.801e+16
                 Prob > F =                           1.000
```

Figure C2: Overall goodness of fit for survey multivariable model, was not significant

```
. test _Iq15_2 _Irq43tipep_3 _Iq53housei_3 _Inq561moth_2 _Inq561moth_2  _Icrowding_2

Adjusted Wald test

 ( 1)  [hilead]_Iq15_2 = 0
 ( 2)  [hilead]_Irq43tipep_3 = 0
 ( 3)  [hilead]_Iq53housei_3 = 0
 ( 4)  [hilead]_Inq561moth_2 = 0
 ( 5)  [hilead]_Inq561moth_2 = 0
 ( 6)  [hilead]_Icrowding_2 = 0
       Constraint 5 dropped

       F(  5,     5) =    1.02
            Prob > F =    0.4929
```

Figure C 3 Adjusted Wald's test for all marginally significant factors

Appendix D Wald's Test Results

```
. test _Iq15_2

Adjusted Wald test

 ( 1)  [hilead]_Iq15_2 = 0

       F(  1,     9) =    4.94
            Prob > F =    0.0533

. test _Irq43tipep_3

Adjusted Wald test

 ( 1)  [hilead]_Irq43tipep_3 = 0

       F(  1,     9) =    3.53
            Prob > F =    0.0931

. test _Iq53housei_3

Adjusted Wald test

 ( 1)  [hilead]_Iq53housei_3 = 0

       F(  1,     9) =    3.41
            Prob > F =    0.0978

. test _Inq561moth_2

Adjusted Wald test

 ( 1)  [hilead]_Inq561moth_2 = 0

       F(  1,     9) =    3.70
            Prob > F =    0.0865

. test _Inq561moth_2

Adjusted Wald test

 ( 1)  [hilead]_Inq561moth_2 = 0

       F(  1,     9) =    3.70
            Prob > F =    0.0865

. test _Icrowding_2

Adjusted Wald test

 ( 1)  [hilead]_Icrowding_2 = 0

       F(  1,     9) =    5.09
            Prob > F =    0.0505
```

Figure D 1 Wald's test for individual test for marginally significant factors

APPENDIX E Permission to use data set

CONFIDENTIAL DISCLOSURE AGREEMENT

1. I ......ALIRAKI LISBON...... seeks to obtain access to specific data owned by and possessed by the Environment and Health Research Unit of the Medical Research Council ("MRC") which data is proprietary to such Unit (hereinafter referred to as the "Confidential Information").

2. The MRC is willing to grant ......ALIRAKI LISBON...... hereinafter referred to as the "Recipient") access to the HEAD data set subject to the following conditions being complied with:
That the Recipient:

   2.1 keep the data, data analysis and/or conclusions reached, and/or inferences drawn from such data, and identities of study subjects should these be disclosed, and any other confidential information as disclosed by the MRC, confidential and shall only disclose such information to those employees or persons on a 'need to know' basis who will be working with such data and /or other Confidential Information and then only on the basis of a clear understanding by those persons of their obligation (a) to maintain the confidential or trade secret status of such information and (b) to restrict the use of such information solely to that Party's purpose;

   2.2. shall use the Confidential Information disclosed by the MRC for research purposes only, not to use the Confidential Information disclosed by the MRC in any way whatsoever for commercial gain, and shall at all times acknowledge the source of such Information;

   2.3. shall not publish their research or research findings, or present at conferences or any public gathering using the Confidential Information of the MRC without the prior written approval of the MRC. A copy of such publication/s shall be furnished to the Director of the Environment and Health Unit for scrutiny at least 30 (thirty) days prior to publication or presentation, and who shall be entitled to raise any objection/s thereto within 15 (fifteen) days of receipt thereof. The Recipient shall in so far as reasonably possible accommodate the objections made by the MRC and amend the publication in accordance therewith, should the parties not be able to agree, the recipient shall not be allowed to publish the material.

3. The Parties understand that disclosure of the Confidential Information could destroy the value of the information, and Recipient agrees to protect the Confidential Information disclosed to it with the same degree of care that would

apply to its own confidential or proprietary information.

4. Confidential Information shall not include:

   a. information which is, or later becomes, generally available to the public through no fault of the Recipient;

   b. information which the Recipient can show by written records was provided by an independent third party having no obligation of secrecy with respect to the information; and

   c. information which the Recipient can establish by written records was previously known to it or was independently developed by the Recipient without reference to the Confidential Information.

5. No license or other right under any patent, copyright, or know-how is granted or implied by this Agreement.

6. This Agreement shall remain effective for a period of five (5) years. The MRC reserves the right to terminate this Agreement without notice and require the Recipient to return, within thirty (30) days of receiving notice of termination, all Confidential Information and all copies of the Confidential Information (in any form whatsoever) to the Director of the Environment and Health Research Unit in the case of breach of this Agreement. The five (5) year confidentiality requirement shall survive the termination of this Agreement.

7. Upon the expiration of this Agreement, each Party shall discontinue use of all Confidential Information. Within thirty (30) days after this Agreement expires, each Party shall return all Confidential Information to the other of them, including any copies of the Confidential Information. This Paragraph shall not apply if the Parties have executed a separate agreement that permits the Parties to continue using the Confidential Information provided under this Agreement.

8. This Agreement shall be interpreted and the rights of the Parties shall be governed by the law of the Republic of South Africa. Any disputes under this Agreement shall be resolved in a court of competent jurisdiction within South Africa.

This Agreement shall be effective on the earlier of the date signed by the Parties or the disclosure of the Confidential Information to each other.

THUS DONE SIGNED AND AGREED

Signed at_Johannesburg___on the_17.06.2010

For the Medical Research Council
Name: Dr Angela Mathee
Capacity: Director

Signed at_Johannesburg____on the 17.06.2010

For .../...
Name: ALIRAKI LISBON
Capacity: WITSWATERSRAND UNIVERSITY

APPENDIX F Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Lisbon Aliraki

CLEARANCE CERTIFICATE	**M10939**
PROJECT	Factors Associated with Elevated Blood Lead Level in First Grade School Children in Cape Town, South Africa
INVESTIGATORS	Lisbon Aliraki.
DEPARTMENT	School of Public Health
DATE CONSIDERED	01/10/2010
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 01/10/2010 **CHAIRPERSON** ....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor : Prof Angela Mathee

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...

APPENDIX G Questionnaire used to extract information from the original data set

1 Study Code_________________

This questionnaire is adopted from Medical Research Council children's environmental health survey and modified to be used for extracting information for secondary data analysis

School Name: ....

Class: …………………......................

SECTION A: BACKGROUND DETAILS

In this section we would like to obtain a few background details about your child.

1. In which year when the child was born?...…….…………………………..

2. Is the child a (please circle correct answer)

    1. Boy

    2. Girl

3. What language does the child speak at home MOST OF THE TIME? (circle one only)

    1. English

    2. Afrikaans

    3. Xhosa

    4. Sotho

    5. Zulu

    6. Other (please specify) …………………………….

4. Where was your child born?

    1. South Africa

    2. another country in Africa

    3. a country elsewhere in the world

5. What is the “race”/population group of the child? (This question is being asked because population group is still closely linked to economic status in South Africa, which in turn is closely linked to certain environmental factors.)

1. African Black
2. Coloured
3. Asian
4. White
5. Other (please specify) …………………………….

6. How does your child usually get to school (please circle one answer only)

1. Walk
2. Bus/Taxi
3. Train
4. Private car
5. Bicycle
6. Other (please specify) …

7. After school, or during weekends, where does the child play most of the time? (circle one answer only)

1. Inside the house
2. Outside the house
3. Street
4. At some other place (please specify)
5. Don’t know

8. What kind of surface does the place where your child plays most of the time, have?

1. grass
2. tar or tiles or brick paving
3. sand
4. don't know

9. How long has the child lived in this house? ……………………………..…years.

10. Did the child attend a crèche or play-school before he/she went to school?

1. No
2. Yes
3. Don't know

11. Have you noticed your child often sucking his/her fingers or chewing his/her nails?

1. No
2. Yes
3. Don't know

12. Have you ever noticed the child putting non-food objects into his/her mouth? (circle one answer only for each item)

Paint chips / bits of dried paint	No	Yes	Don't know
Cement/plaster	No	Yes	Don't know
Sand/Soil	No	Yes	Don't know
Sticks	No	Yes	Don't know
Match sticks	No	Yes	Don't know
Cigarette ends	No	Yes	Don't know

Other:	No Yes Don't know

13. Does he/she still eat such non-food items?

    1. No

    2. Yes

    3. Don't know

14. Do you use any pottery, china or ceramic dishes for cooking, serving or storing food?

    1. No

    2. Yes

    3. Don't know

15.24. How frequently does the child wash his/her hands on the following occasions:

Before eating	Always	Sometimes	Never
After playing in dusty areas	Always	Sometimes	Never
Before going to sleep	Always	Sometimes	Never

SECTION B: HEALTH AND DIET

In this section some information about the child's health and diet is needed.

16. Has your child ever been given any home-made medicines or remedies for illness or to improve health?

1. No
2. Yes
3. Don't know

If yes, please specify_______________________________

17. Does your child ever use any make-up, such as eyeliner or kohl pencils?

4. No
5. Yes
6 don't know

18. How often does the child eat tinned/canned food?

1. Often
2. Seldom

SECTION C: HOUSING

In this section we would like to have some information about the household in which the child is presently living

19. Is this home:

1. Owned
2. Rented

20. How would you describe the child's home?

1. House
2. Flat
3. Backyard dwelling
4. Informal house (shack)
5. Other (please specify)

21. Approximately, how old is the child's home? …………………………………… years

22. Is the child's home on or within one block of a very busy road? 1. No 2. Yes

23. How many rooms, not counting the kitchen, bathroom or toilet, does this home have? ………

24. What fuel is used most of the time for cooking?

1. Electricity
2. Paraffin
3. Gas
4. Wood
5. Coal
6. Car batteries
7. Other (please specify) ....……..

25. Does anyone regularly smoke at home?

1. No
2. Yes

26. How many people regularly smoke cigarettes in the home? (At least one cigarette per day at home)

....

27. Is the home often:

1. Very dusty
2. Slightly dusty
3. Not dusty

28. Where is your toilet?

1. inside the house
2. outside the house
3. Don't know

29. Where do you get your water from most of the time?

1. tap inside the house
2. tap on the property, but outside of the house
3. a communal tap
4. Rainwater tank
5. Borehole
6. River/stream
7. Other

30. What type of plumbing (water pipes) does the home have?

1. Metal
2. Plastic

3. Other (please specify) ....

31. Is there paint peeling from the inside walls, doors or windowsills of the home?

1. No

2. Yes

3. Don’t know

32. Is there paint peeling from the outside walls, doors or windowsills of the home?

1. No

2. Yes

3. Don’t know

33. Is this home in need of major repairs?

1. No

2. Yes

3. Don’t know

34. Has there been any painting, decorating or renovation in the home during the past year?

1. No

2. Yes

3. Don’t know

35. How many cars are owned by people who permanently live in the child’s house?

…………………………….

36. Does the child often play with pets (such as a cat or dog)?

1. No

2. Yes

3. Don’t Know

37. Does anyone living in the same house as the child do the following jobs?(lead related)

	No	Yes	Don’t know
Making jewellery			
Car repairs or maintenance			
Spray-painting of cars			
Construction, building or renovation work			
Plumbing			
Painting			
Welding or soldering			
A job involving guns or bullets (for example the police service)			
Leaded or stained glass			
Battery factory			
Scrapyard			
Lead mine			
Fishing			
Repairing electrical appliances			
Pottery			
Petrol station			

Other job that involves the use of lead. Please specify ……………………

38. Does anyone living in the same house as the child participate in any of the following hobbies or jobs at or from home? (lead related)

	No	Yes	Don't know
Car repairs			
Spray-painting of cars			
Construction or renovation work			
Plumbing			
Painting			
Guns and ammunition			
Leaded or stained glass			
Fixing of TVs, radios, hi-fis or music centres			
Fishing			
Make metal jewellery			
Fixing electrical appliances			

39. When dusting the house, what do you use MOST OF THE TIME?

1. dry cloth

2. damp cloth (soaked in water only)

3. damp cloth soaked in water + a cleaning solution. (such as washing powder, Handy Andy or Sunlight liquid)

40. When the house is swept, what do you use MOST OF THE TIME?

1. a dry broom

2. a wet mop (soaked in water only)

3. a wet mop (soaked in water & a cleaning solution such as washing powder or Handy Andy).

SECTION D: SOCIAL ASPECTS

In this section we will ask some questions about other people living in this home.

41. How many people live in this house? ………………………………………….

42. How many siblings (sisters and brothers) does the child have? ………….

43. With whom does the child live (you may circle more than one answer)

1. Mother and father

2. One parent only

3. A relative (grandparent, aunt etc.)

4. Guardian

5. Other (please specify) …………………

44. How many of the adults living in this house have a job at this time?

……………………………………………

45. Does anyone living in the house work from home?

1. No
2. Yes
3. Don't know

46. What is the total monthly income for this household?

1. R0 to R1000
2. R1001 to R3000
3. R3001 to R5000
4. R5001 to R8000
5. R8001 to 10 000
6. more than R10 000

47. Record of the child's blood lead levels

Section ONLY to be answered by residents working in a LEAD-RELATED INDUSTRY (such as a battery factory, paint work, car repairs, spray-painting, jewellery making, soldering or welding and a job that involves guns and bullets)

48. Does the child's father take a shower BEFORE leaving work at the end of the day?

1. No
2. yes
3. don't know

49. What happens to the child's father's work clothes at the end of the work day?

1. leaves work clothes at work
2. brings work clothes home
3. don't know

50. Where are the child's father's work clothes washed?

1. at work
2. at home

51. What happens to the child's father's work boots at the end of the work day?

1. does not wear boots at work
2. leaves boots at work
3. brings boots home
4. don't know

52. What does the child's father do as soon as he comes home from work each day?

1. play with children
2. have dinner
3. relax
4. take a bath/shower
5. other (please specify)

53. Does anyone living in the house work from home?

1. No
2. Yes
3. Don't Know

54. Do you believe that lead in the environment can cause health Problems?

1. No
2. Yes
3. Don't know

55. Height of the child in centimetres……………..

56. Weight of the child in kilograms………………

COMMENT: Please list any comments about the questionnaire or study.

....

....

....

END OF QUESTIONNAIRE

THANK YOU for answering the questions. Your assistance is highly appreciated.

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