EXPOSURE OF LEAD AMONGST PRIMARY SCHOOL CHILDREN IN FISHING COMMUNITIES IN SOUTH AFRICA

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10 June 2014

DECLARATION

I, Taskeen Khan, declare that this research report is my own work. It is being submitted for the Master of Medicine, Community Health. It has not been submitted before for any degree or examination.

On this 23rd day of January 2014

SUPERVISOR'S NOTE

As a supervisor of this short report, I would like to declare that Dr Khan has contributed substantially to this project during the conceptualisation, protocol development, data collection and analysis and report writing.

DEDICATION

To

My husband, Muhummed Daydat, my grandparents, parents and aunts.

"Do all things with love, passion and dedication!"

Patrick Driessen

PUBLICATIONS ARISING FROM THIS STUDY

Mathee A, Khan T, Naicker N, Kootbodien T, Naidoo S, Becker P. Lead exposure in young school children in South African subsistence fishing communities. Environmental Research 2013 Oct;126:179-83. doi: 10.1016/j.envres.2013.05.009. Epub 2013 Jul 6. 2013

Please note: different aspects of data was used for the dissertation versus the article e.g. the article had a sample size of 160 whilst the dissertation sample size is 196

ABSTRACT

BACKGROUND:

Lead is one of the most widely used and studied heavy metals. Lead has a number of serious detrimental effects including those related to the nervous system (seizures, ataxia) heamotological system (anaemia) and renal system. The severity and prognosis of diseases related to lead exposure is more pronounced in children, even with very low blood levels. Anecdotal reports of lead melting to make fishing sinkers in South African subsistence fishing communities prompted the conduct of an epidemiological study in four South African fishing villages to investigate the extent of lead melting and the associated risks in children.

METHODS:

A cross sectional analytical study was conducted. The study was conducted in two schools located along the western (Atlantic Ocean) coast of South Africa (HP Williams Primere in Stompneusbaai and NGK Primary School in Elands Bay) and in two schools located along the southern (Indian Ocean) coast of South Africa Bertie Barnard School in Stilbaai, Struisbaai Primere School in Struisbaai. Blood samples were collected for lead content analysis, and anthropometric measurements were taken. Questionnaires were administered to obtain information about socio-economic status and risk factors for lead exposure. A total of 196 children from grade 0, 1 and 2 were included in the study.

RESULTS:

Blood lead levels in the sample ranged from 1.9 to 22.4 µg/dl. Central tendency of the blood lead level demonstrated an arithmetic mean of 6.87 µg/dl (95% CI: 6.36 to 7.37 µg/dl) and a median of 6.1 µg/dl. More than half of the children in the study had blood lead levels between 5.0 - 9.9 µg/dl, whilst 13% that had levels higher than 10 µg/dl. Age, sex and ethnicity was not significantly associated with high blood lead levels whilst, lead melting practices and interaction of children with pets were strongly associated with high blood lead levels in children. Multivariate analysis showed that the presence of a fisherman in the household and children watching smelting were significantly associated with higher blood lead levels. Village remained a confounding variable in the model.

CONCLUSIONS:

This study is the first report on blood lead levels in fishing villages on the African continent and provides evidence that lead is still used widely as the primary substance used to make fishing sinkers. The prevalence of plumbism was high at 75%. Policy and awareness is needed to address this neglected public health concern.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

ANOVA	Analysis of Variance
BMI	Body Mass Index
BLL	Blood Lead Level
CDC	Centre for Diseases Control and Prevention
CI	Confidence Interval
DXA	Dual Energy Absorptiometry X-Ray
EDTA	Ethylene Diamene Tertraacetic Acid
EHRU	Environmental and Health Research Unit
GIT	Gastrointestinal system
MRC	Medical Research Council
NiOH	National Institute of Occupational Health
UNICEF	United Nations Children's Fund
US	United States of America
UK	United Kingdom
WHO	World Health Organisation

GLOSSARY OF TERMS

Bonferroni post hoc test: A multiple comparison test used in statistical analysis to correct data from appearing statistically significant if it is not.(1)

Chelation: The process of removing a heavy metal like lead from the bloodstream using a chelate (chemical compound). (2)

Distal causes: These causes do not impact the disease immediately. They are root causes of disease which are indirect .(3)

Fishing sinker: A weight made of heavy material to facilitate anchorage whilst fishing

Lead Smelting: Melting of lead to mould and create different objects

Level of concern: Reference value of > = 10 μg/dl previously used by CDC to determine lead poisoning.

Parenteral: Administered through a route other than the mouth or alimentary canal.(3)

Platykurtic: A type of statistical distribution where the excess kurtosis value is negative. Derived from 'platy' which means broad resembling this curves broad, wide shape.(4)

Plumbism: Lead poisoning. In this study we define plumbism at a blood lead level > = 5 μg/dl.

Proximal causes: Direct causes of disease that impact disease. (3)

Stadiometer: Piece of medical equipment used for measuring height.

Static: In this study, static is used to describe an absolute number as a cut off value for blood lead level.

CHAPTER 1

INTRODUCTION

This chapter describes the background of lead as a public health problem. The justification for the study is presented in detail and the study aim and objectives are subsequently outlined.

1.1 BACKGROUND

"Exposure to environmental lead is clearly a major public health hazard of global dimensions."(5)

Health officials from the United States (US) identified lead poisoning as a "silent epidemic" in the 1970s.(6) Despite overwhelming documented evidence on the extent of lead as an environmental and public health hazard associated with human toxicity, it is still largely neglected and under-rated.(5–12) It is estimated that approximately 890 000 children are afflicted with lead poisoning in the US at any given time.(13) Exposure to lead continues to pose such a great challenge that the U.S Centre for Diseases Control and Prevention (CDC) has revised their guidelines for children's' exposure to lead in 2012. In 1991 the CDC adopted a "level of concern" in children at 10 µg/dl of lead in blood.(12,14) Newly found evidence, resulting from numerous studies have shown that lower levels of lead are also associated with adverse health effects,(14–17) prompting the CDC to lowering the blood lead level (BLL) (at which intervention is advised) by half. As a result 5 µg/dl (static) will now be used as a reference value. In addition the term "level of concern" has been dropped as it was felt it undermined the severity of high blood lead levels.(14)

Whilst developed countries have made strides in reducing lead exposure through prevention programmes, the concern now shifts to the developing world.(5,11) African children in particular are considered to be a high risk group for lead poisoning due to socio demographic factors.(5,9,12) Thus, childhood lead poisoning remains an expansive problem in Africa.(5,18)

In a study conducted in Woodstock in 1991, South Africa mean blood levels in children were found to be 18 µg/dl(9,19) which is higher than a study conducted in Johannesburg in 2002 (mean blood lead level 11.9mg/dl). (20) These studies highlighted the need for further research on the factors associated with the widespread high blood lead levels in different regions in South Africa.

1.2 LEAD

Lead is a heavy metal occurring naturally in the Earth's crust and has been one of the most commonly used and studied metals.(7,8,11,21) It is usually found as a compound and can readily be shaped or moulded or combined with other metals to form alloys. Lead has been mined, smelted and used in various products including cosmetics, traditional medicines, paint, ceramics, pipes, storage batteries, ammunition, fishing sinkers and gasoline.(6,7,11,21–23) Exposure to these sources then causes high blood lead levels.

The following figure (1.1) shows the route of entrance of lead into the environment.

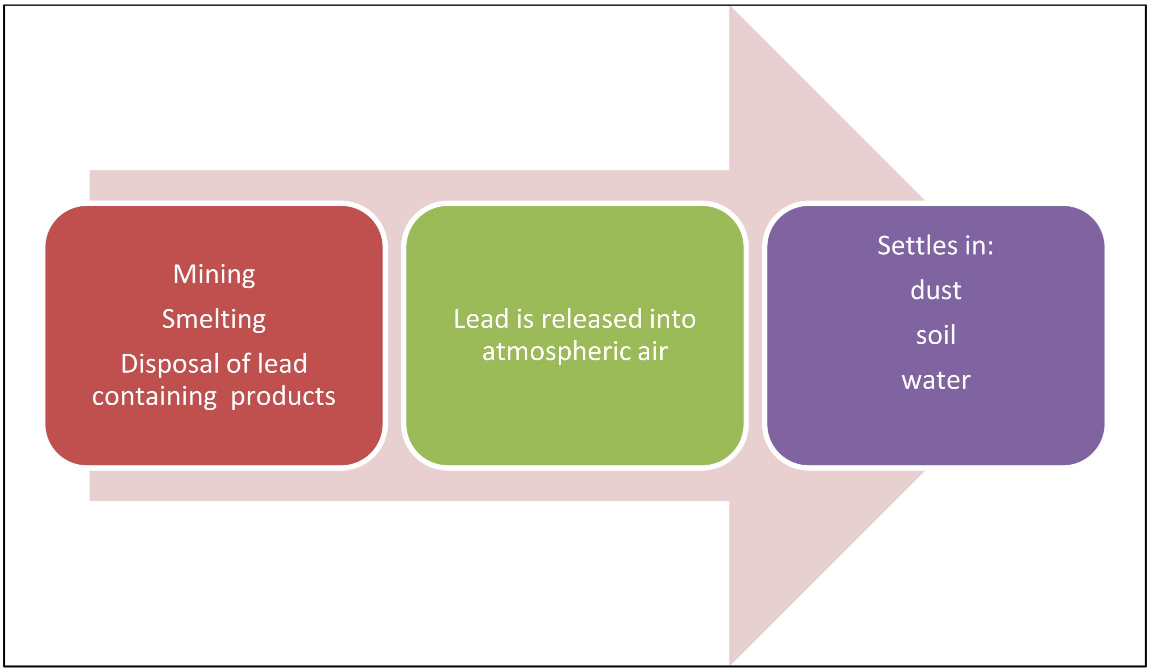


Figure 1.1: Route of entrance of lead into the environment (21)

Lead poisoning has been associated with several serious detrimental effects including neurological symptoms (ataxia, convulsions, headaches, tremor and paralysis), haematological effects (anaemia, basophilic stippling), cardiovascular effects (toxicity, hypertension), renal effects (nephrotoxicity), reproductive problems (fertility) and gastrointestinal disturbances (vomiting, nausea, anorexia, constipation and abdominal cramps). In addition, lead exposure causes developmental and cognitive deficits in children.(13,17,21,24–27)

1.3 LEAD AND SUBSISTENCE FISHING

A common source for lead exposure exists in fishing weights. Lead is smelted and then relevantly shaped to be used as a weight during fishing. (6,7,11,21–23) This type of lead exposure is described mainly as a hobby -associated exposure in literature,(22,25,25) even though fishing can be regarded as an occupation in coastal communities such as those in the four coastal provinces in South Africa.

Although there is not much literature regarding lead exposure associated with occupational fishing, studies conducted in the Chuuk Islands of Micronesia and in Cartagena, Columbia showed that elevated blood levels were associated with the production of lead sinkers.(12,28,29) It is therefore important to conduct further research on this topic amongst fishing communities in South Africa.

1.4 JUSTIFICATION FOR THE STUDY

South Africa has an extensive coastline with a large number of people residing near it. As a result fishing is both a hobby and an occupation. These coastal populations are impoverished, making subsistence fishing a vital source of income. (12)

The Environmental and Health Research Unit (EHRU) of the Medical Research Council (MRC) had been collecting data on blood lead levels in the Western Cape since the mid 1980s. An elevation in blood lead concentrations has been noted in one of the study schools located in a fishing community, relative to surrounding schools.(30)

Based on these findings of elevated blood lead levels, it was felt that a further study would be necessary to research the underlying cause or causes in greater depth. This study was planned against this background to collect blood from school going children to measure blood lead levels and to identify exposure variables that might be associated with high blood lead levels. The information generated was expected to provide a strong basis for community education programmes and policy development, as well as establish a baseline against which interventions might be measured.

1.5 RESEARCH QUESTION

Are blood lead levels high in children residing in South African fishing villages given their possible exposure to lead smelting for the production of fishing weights for subsistence fishing?

1.6 RESEARCH HYPOTHESIS

Ho: Blood lead levels are normal in children residing in South African fishing villages given their exposure to lead smelting for the production of fishing weights for subsistence fishing.

Ha: Blood lead levels are higher in children residing in South African fishing villages given their exposure to lead smelting for the production of fishing weights for subsistence fishing.

1.7 AIM

To determine the distribution of and factors associated with high blood lead levels in children attending primary schools in the fishing communities of Western Cape (Stilbaai, Struisbaai, Stompneusbaai and Elands Bay.)

1.8 OBJECTIVES

1.8.1 To determine the distribution of high blood lead levels (blood lead >5 µg/dl) of children attending primary schools in the fishing communities of Western Cape (Stilbaai, Struisbaai, Stompneusbaai and Elands Bay.)

1.8.2 To determine associated factors (with particular emphasis on the use of fishing sinkers) for elevated blood lead concentrations in children residing in fishing communities of Western Cape (Stilbaai, Struisbaai, Stompneusbaai and Elands Bay.)

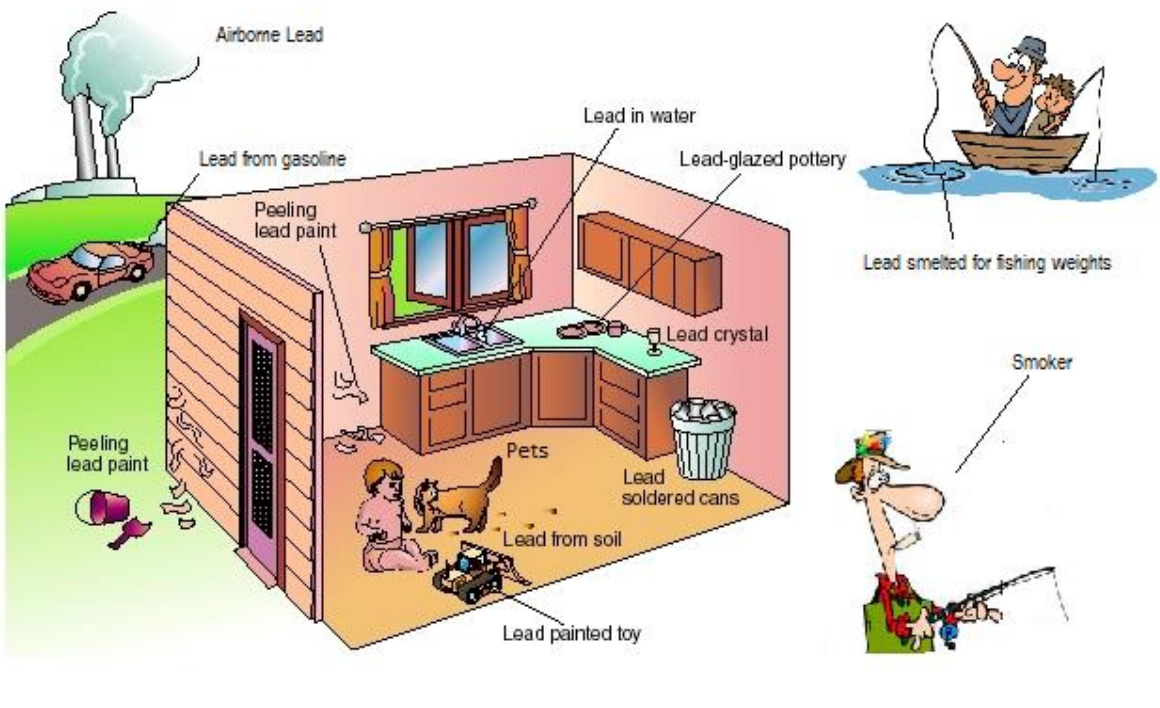
CHAPTER 2

LITERATURE REVIEW

This chapter identifies clinical and public health effects of plumbism in greater detail. Relevant literature from local and international sources with relevance to public health implications and interventions for lead poisoning is then described.

2.1 SOURCES OF LEAD EXPOSURE

There are many different sources of lead exposure which are summarised in Figure 2.1 below.



<u>Figure 2.1: Different sources of lead exposure</u>

(Figure modified, source: http://www.healthofchildren.com/L/Lead-Poisoning.html(31))

The most common and pertinent sources of lead exposure as identified by Figure 2.1 will be discussed in more detail.

2.1.1 LEAD BASED PAINT

One of the main sources of environmental lead is lead paint which is the origination of many cases of children's plumbism. Lead paint is not dangerous when intact but becomes problematic if it is peeling, chipping, chalking, cracking, deteriorating due to weather conditions or breaking down into smaller particles. These processes allow lead paint to accumulate in soil and dust and can be ingested by children. (5–7,21,23,25,32)

2.1.2 LEAD IN PLUMBING FIXTURES AND PIPES

To date, elevated levels of lead in water have not been identified as a major public health concern. However, the most common cause for contamination of drinking water comes from lead in joints connected by lead solders and pipes. (21,23,33)

2.1.3 LEAD IN GASOLINE

Most developing countries have banned the use of lead in gasoline, however it is still used in some of Africa (South Africa introduced unleaded gasoline in 1996 and banned lead in petrol in 2006) and other developing regions and contributes significantly to lead levels in the air and surrounding soil.(5,7,21,23,32)

2.1.4 SMOKER IN THE HOUSEHOLD

Smokers usually have a higher level of lead in their blood given that tobacco and tobacco smoke have been shown to contain lead. Studies also provide evidence showing that passive smokers are exposed to lead either through smoke directly, or via inhalation and or ingestion of food or dust laden with particulate smoke. (33–36)

2.1.5 PETS CARRYING LEAD

Pets have been shown to have higher blood lead absorption capacity and carry lead laden dust in increased quantities. In addition they carry soil matter which contains lead. In this way people who regularly come in contact with pets are at increased risk for lead exposure.(21,37–39)

2.1.6 OCCUPATIONS RELATED TO LEAD SMELTING

Occupations that involves lead smelting to mould lead into products like fishing weights, toys, pottery, lead-glazed glass or ammunition, place workers at high risk for lead exposure.(7,21–23) Should these smelting activities be carried out within the household, exposure to lead poisoning for all individuals living in that home is increased.

There is a paucity of information related to lead smelting for fishing sinkers and its association with plumbism as depicted by the rarity of information in the literature. Just two studies were found related to this topic. One study was conducted in the Chuuk Islands of Micronesia where blood lead levels of children and their care-givers and risk factors for lead exposure were collected and analysed. A cross sectional study on children aged 2-6 years was conducted and caregivers reported information on the possible risk factors. The blood lead levels ranged from 1 to 37 μg/dl in 256 children. Elevated blood lead levels were significantly associated with having a caregiver with an elevated blood lead levels, having a family member who made fishing weights and having a family member who melted batteries; children with elevated blood lead levels were more than three times more likely to have a family member who made fishing weights. The population attributable risk of elevated blood lead levels from the manufacture of fishing weights was 61% for children. The investigation concluded that lead smelting of batteries and making of fishing sinkers as the most important exposures leading to elevated blood lead levels in children and caregivers in Chuuk.(28)

The other study found in the literature was conducted in Cartagena, Colombia. A blood lead survey was undertaken in ten primary schools in this coastal town. A total of 189 children aged 5-9 years were included in the study. Blood lead levels ranged from 1 to 21 µg/dl in the study participants'. The authors concluded that activities such as lead smelting related processes and fishing net sinker production were the main sources of lead exposure in Cartagena.(29)

2.2 SOCIO DEMOGRAPHIC DETERMINANTS OF EXPOSURE

Incidents of lead poisoning have been shown to be higher in urban, poor, developing populations. (5,7,11)

2.2.1 PLACE OF RESIDENCE

People living in developing countries are at a higher risk for plumbism (5,7,11) due to the presence of leaded gasoline, the absence of strict law enforcement for occupational and environmental health and safety, cultural practices and the presence of 'cottage' industries in these regions.(7)

In this study, place of residence is of particular importance as fishing is carried out in these villages as an occupation. The smelting of lead to produce fishing weights can thus be likened to a 'cottage' industry. In addition, residents in fishing villages have an increased exposure to soil containing lead particles. Due to this importance, place of residence will be discussed separately in future chapters under occupational factors.

2.2.2 AGE

Lead poisoning can occur in both children and adults but the effects are far more profound in children. There are several reasons for this:

- Children have an increased intake of lead per unit body weight and their physiological uptake is fivefold greater than in adults.
- The chances of ingestion of objects laden with lead are far greater in children.
- Malnutrition (including iron deficiency and low calcium), which is greater in children than in adults, enhances lead absorption.
- Children store more lead in their soft tissues than adults.
- Lastly and most importantly, the nervous system in children is still developing rapidly which predisposes children to greater neurological toxicity than adults. Furthermore, due to this developing brain, younger children are at greater risk for neurological effects at lower blood lead levels than their older counterparts.(6,7,13,22,25,32,33,40,41)

2.2.3 SEX

The association between sex and blood lead levels is ambiguous. Whereas, some studies have reported higher mean blood levels in boys than girls,(7,15,21,42,43) a study from Africa has shown no statistical significance in blood levels of boys and girls.(44)

2.2.4 ETHNICITY

Disparities of mean blood lead levels do exist between races or ethnicity. Studies have shown that levels are lower in white children than in children of colour. (7,21) Studies from Cape Town also showed mean blood levels in coloured children to be much higher than in white children residing in the same area. (19) Thus, ethnicity may be a confounding factor and should be investigated and treated accordingly in any statistical analysis.

2.3 PATHOPHYSIOLOGY OF LEAD POISONING

Pathophysiology of lead in the human body is summarised in Figure 2.2 below. The figure was adapted from studies done on lead kinesis by Marcus et al. (45,46) and will be explained under the heading Lead Metabolism. (2.3.1)

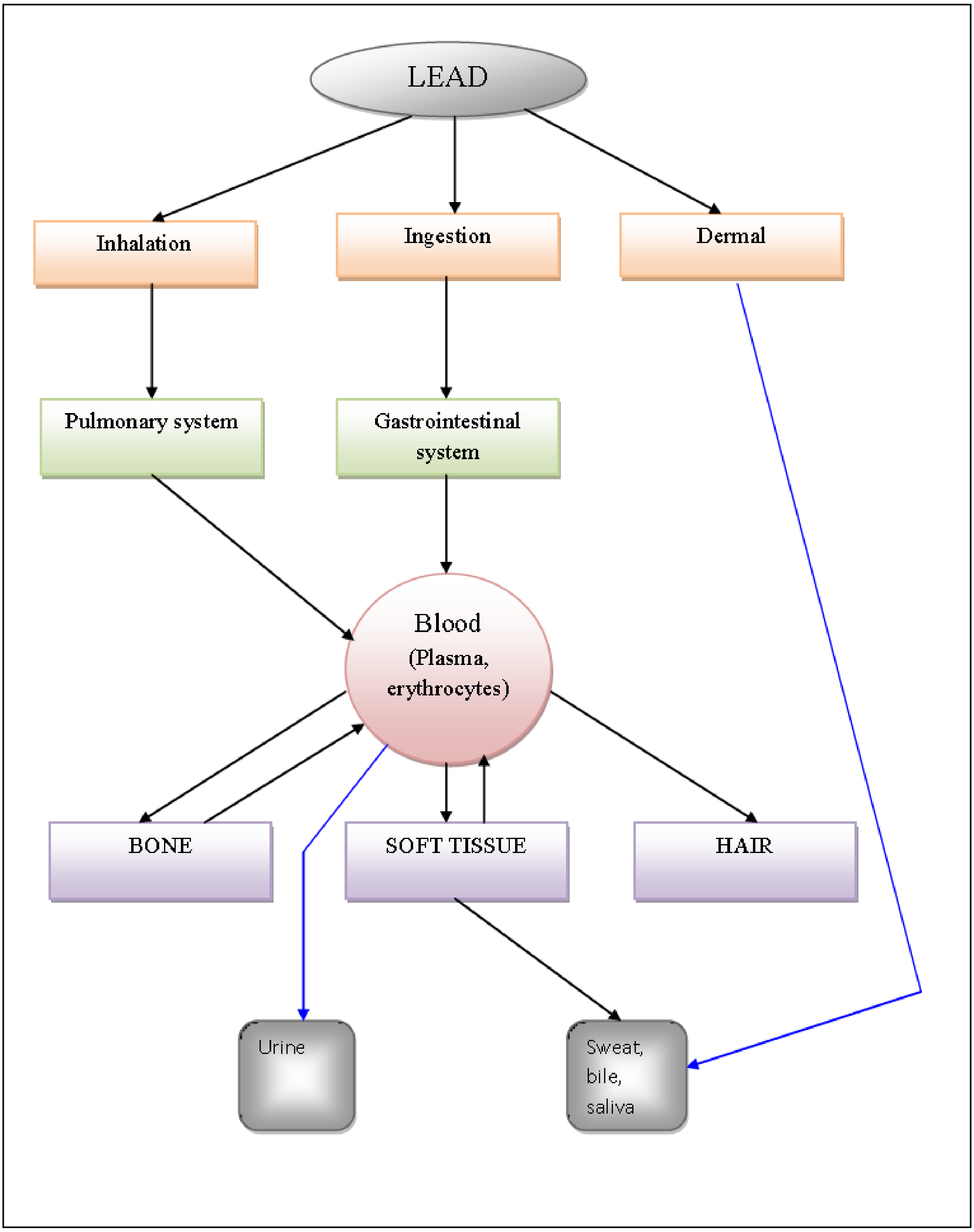


Figure 2.2: Pathogenesis of lead (45,46)

2.3.1 LEAD METABOLISM

Lead enters the body through the skin or through inhalation of lead laden dust, ingestion of food or other particulate matter that contains lead. . When lead is absorbed dermally, it appears directly in sweat and saliva but not in blood. Inhaled or ingested lead is then absorbed by blood plasma via the pulmonary or gastrointestinal (GIT) systems respectively. (6,21,23)

The majority of blood lead is accumulated in erythrocytes. From blood, lead travels to the soft tissue organs (such as the liver, kidneys, lungs, brain spleen muscles or heart) and bone. In adults 94% of total body lead is stored in bones and teeth whilst children have 73% bone storage. Thus, children have a higher storage in soft tissues. Lead can also re-enter blood from soft tissues and bone.(21,23,25,26)

Unabsorbed lead is excreted from the body mainly through faeces. Absorbed lead leaves the body through urine mainly or bile. Small amounts of lead also leave the body via sweat, saliva, hair and nails.(25)

2.3.2 BLOOD LEAD AS A BIOMARKER

Biomarkers are indicators that signal an event in biological samples. They are markers of effect, susceptibility and exposure. (21) Ideally, a measurement of total lead body burden should be used to quantify the amount of lead in the body. However, lead exposure can also be measured as total lead levels in tissues or body fluids, such as blood, bone, urine, or hair. Blood lead is the most extensively used and informative measure of lead exposure. This measurement is used to diagnose and treat lead poisoning. (21,47)

2.4 HEALTH EFFECTS

Lead poisoning has been associated with mortality in both children and adults with very high blood lead levels i.e. levels in excess of 100 μg/dl .(48–51) Exposure to high levels of lead can cause detrimental health effects in almost all systems of the body. This is particularly common in children, who store a greater percentage of lead in soft tissues compared to adults.(21) The health effects of lead poisoning is summarised in table 2.1 below according to the primary system involved.

Table 2.1: Acute and chronic health effects of lead

SYSTEM TOXICITY	ACUTE EFFECTS	CHRONIC EFFECTS
Neurological	▪ Encephalopathy	▪ Dizziness ▪ Fatigue ▪ Headaches ▪ Irritability ▪ Convulsions ▪ Slurred speech ▪ Muscle weakness ▪ Parasthesia ▪ Ataxia ▪ Tremors ▪ Paralysis ▪ Neurobehavioural effects
Renal	▪ Renal tubular disease ▪ Acute interstitial nephritis	▪ Chronic nephropathy
Cardiovascular	▪ Hypertension	▪ Conduction disturbances ▪ Ventricular arrhythmias

SYSTEM TOXICITY	ACUTE EFFECTS	CHRONIC EFFECTS
Gastrointestinal	▪ Abdominal cramps ▪ Diarrhoea ▪ Anorexia ▪ Nausea ▪ Vomitting ▪ Constipation	▪ Abdominal cramps ▪ Nausea ▪ Vomiting ▪ Constipation ▪ Metallic taste
Hepatic	▪ Inhibit enzymes	
Haematological		▪ Anaemia
Reproductive		▪ Impaired fertility in males

Neurobehavioural effects include disturbances in reaction time, hand dexterity, IQ, anxiety and mood. These effects are seen in children with blood lead levels as low as 2 µg/dl. (21,25)

The figure below (Figure 2.3) presents a summary of the causes and health outcomes of increased blood lead levels.

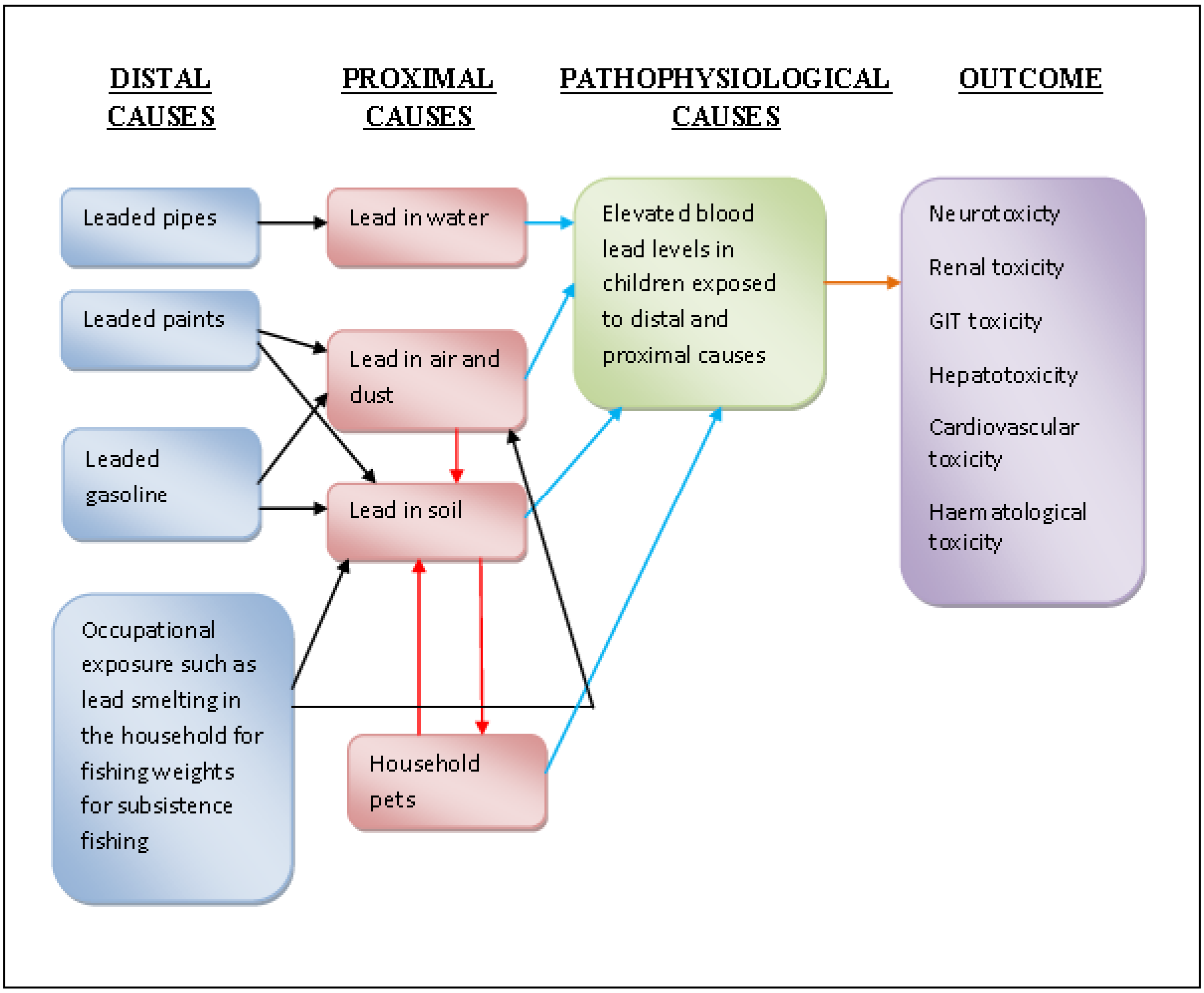


Figure 2.3: Causes and health outcomes of high blood lead level

(Adapted from a figure presented by the WHO website under chemical hazards.(52))

2.5 INTERVENTIONS

2.5.1 CLINICAL INTERVENTIONS

The most effective therapy for both adults and children suffering from lead toxicity is cessation or limitation of lead exposure.(41)

In children, parenteral chelation should be considered if they present with encephalopathy or blood lead levels above 70mg/dl. Children who are asymptomatic and have blood lead levels between 45 and 69 mg/dl can be subjected to oral chelation. In addition, children who have swallowed a foreign object (such as a fishing weight or bullet) may benefit from endoscopic removal, cathartics or whole bowel irrigation.(21,41)

In adults oral chelation is provided if they have mild symptoms or a blood lead level between 70 and 100 mg/dl. Parenteral chelation is reserved for adults with encephalopathy or a blood lead level > 100 mg/dl. (21,41)

2.5.2 PUBLIC HEALTH INTERVENTIONS

"...Given the severe and irreversible health effects of lead poisoning, particularly on children, it is important to accelerate the process of eliminating unsafe uses of lead, including the use of lead in gasoline worldwide, in light of country-specific conditions and with enhanced international support and assistance to developing countries, particularly through the timely provision of technical and financial assistance and the promotion of endogenous capacity building..."(7)

GLOBAL EFFORTS

Lead poisoning is not a new public health problem and has originations in antiquity. It was a highly prevalent problem and considered a scourge in Europe during the Middle Ages. The clinical health effects were described by both the Greeks and the Romans. However, full appreciation of childhood plumbism was underappreciated until more recently.(6) Due to global industrialisation, children have been placed at increased risk of lead exposure and therefore cases of lead poisoning have grown tremendously thus highlighting the need for urgent attention.(5,6)

As a result numerous international conferences and declarations have taken cognisance of the significance of childhood lead poisoning and the need for interventions to prevent it from continuing.(53–63) These initiatives have been summarised in Box 2.1 below.

Box 2.1: Declarations and conferences recognising the public health importance of lead poisoning, particularly in children

- 1989 Convention of the Rights of the Child
- 1992 Agenda 21, the United Nations Conference on Environment and Development
- 1996 Organisation for Economic Co-operation and Development Declaration on Lead Risk Reduction
- 1997 Declaration of the Environment Leaders of the Eight on Children's Environmental Health
- 1999 International Conference on Lead Poisoning Prevention and Treatment
- 2002 Bangkok Statement on Children's Health and the Environment
- 2005 Declaration of Mar del Plata
- 2006 Declaration of Brescia on Prevention of the Neurotoxicity of Metals
- 2009 Busan Pledge for Action on Children's Health and Environment
- 2009 International Conference on Chemicals Management

Most developed countries have instituted control programmes to reduce risks of exposure to lead. The removal of lead from gasoline has been a huge contributor to reducing children's exposure to lead in many countries.(7,8,11,28,32,53,64) In addition some countries like the US, Russia, Thailand, Australia, China and South Africa have taken measures either through legislation or restrictions on the use of lead paint for domestic dwellings.(7,11,53) Furthermore, most developed countries have educational and household interventions programmes implemented to reduce lead exposure and increase awareness levels. (11,64)

SOUTH AFRICA

A summary of South African initiatives for lead prevention and control is presented in Box 2.2.

Box 2.2: South African Initiatives

- 1996 Introduction of lead free gasoline
- 2001 Lead regulations
- 2006 Banning of lead in petrol
- 2009 Lead content restricted to 600 parts per million in household paints

South African interventions for lead poisoning have been largely at a community (national) level. In South Africa lead content was reduced from 0.84g/l in 1983 to 0.4 g/l in 1989. In 1996 unleaded gasoline was made available to motorists in SA. (65,66) In 2001, lead regulations (regulation 236) were passed as a schedule of the Occupational Health and Safety Act, 1993 (act no. 85 of 1993).(67) Lead was banned for use in gasoline in 2006.(68) In addition, South Africa restricted the use of lead in household paints to less than 600 parts per million in 2009.(53) The success of these efforts though cannot yet be confirmed and like most countries in the developing world, enforcement and monitoring of these efforts have been less than ideal. (7,53) This study hopes to bring attention to intervention strategies that can be implemented at both an individual and community level to reduce lead exposure from lead smelting for fishing weights.

CHAPTER THREE

METHODOLOGY

This chapter describes the study method used for the project and defines the study design, setting and sampling strategy. Data collection, management, measurement and analysis are also discussed in the chapter.

3.1 STUDY DESIGN

A cross sectional analytical study was conducted.

3.2 STUDY SETTING AND SCOPE

3.2.1 STUDY SETTING

Fishing villages in coastal districts of South Africa were selected for the study. The Department of Basic Education of the Western Cape was contacted to provide a list of primary schools in these villages as well as to request for permission to conduct the study. Schools were not selected based on their socio-economic quintiles. Schools in these villages were then contacted to obtain permission to conduct the study. The study was then conducted in the following four primary schools that responded positively to the request:

- HP Williams Primary School in Stompneusbaai located along the western (Atlantic Ocean) coast of South Africa
- NGK Primary School in Elands Bay located along the western (Atlantic Ocean) coast of South Africa
- Bertie Barnard School in Stilbaai-located along the southern (Indian Ocean) coast of South Africa

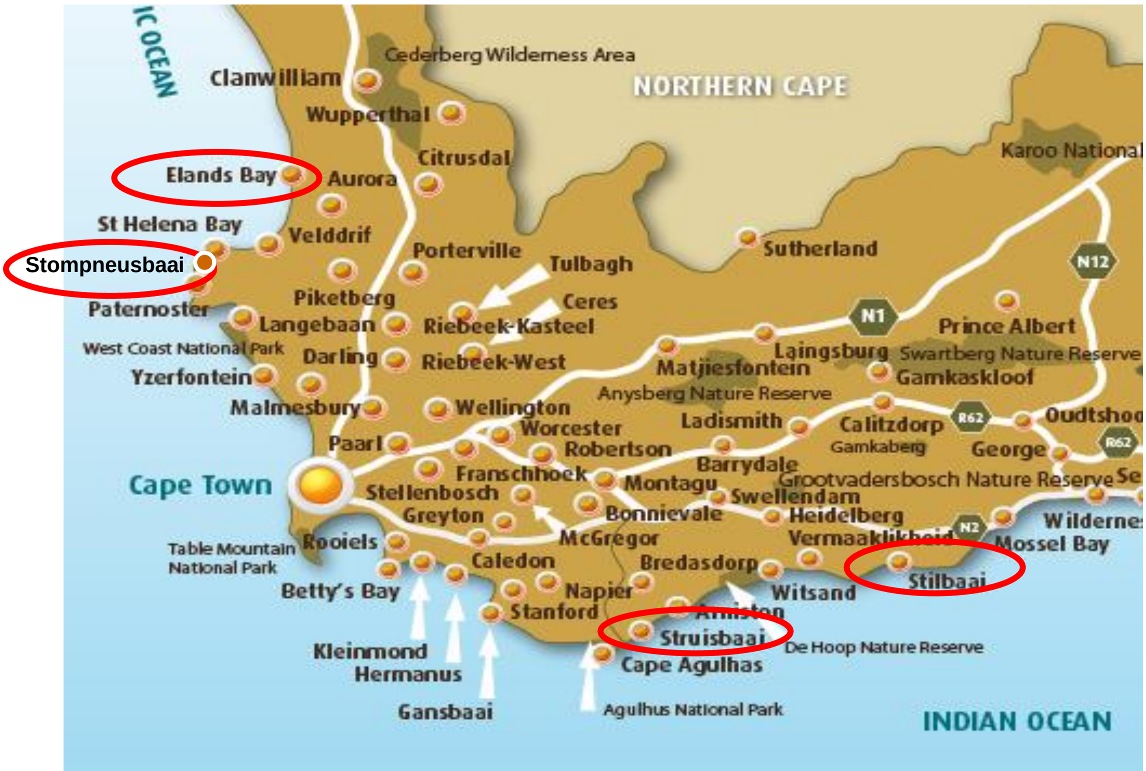
- Struisbaai Primere School in Struisbaai- located along the southern (Indian Ocean) coast of South Africa.

A geographical representation of the villages is presented in Figure 3.1 below. The villages that formed part of this study are circled in red. These villages were selected because of their (known) substantial subsistence fishing communities.

Table 3.1 describes the 4 village municipalities and the districts they represent.

<u>Table 3.1:</u> Municipalities and districts of the 4 villages used in the study

Village	Stompneusbaai	Stilbaai	Struisbaai	Elands Bay
Local municipality	Saldhana Bay	Hessequa	Cape Agulhas	Cederburg
District	West Coast	Eden	Overberg	West Coast



<u>Figure 3.1 Map of western and southern coastline of South Africa (69)</u>

3.2.2 SCOPE

This study involved primary data collection.

3.3 STUDY POPULATION AND SAMPLING

3.3.1 STUDY POPULATION

Children in grades 0, 1 and 2 from the primary schools mentioned above were included in the study, as younger children are at greater risk for neurological effects at lower blood lead levels than their older counterparts.(6,7,13,22,25,32,33,40,41) Also, since it would be difficult to test children below the age of 5 years due to the invasive nature of the venipuncture, children from grades 0, 1 and 2 were selected for this study. The total study population was 386 (see table 3.2)

3.3.2 SAMPLE SIZE

A census method of sampling was used. All children in grade 0, 1 and 2 in these four primary schools were part of the sample. The expected sample size was calculated as follows:

Based on a total study population of 386 and prevalence of plumbism of 17% (CI: 5%) (based on a study done in South Africa (blood lead level > =30 µg/dl)) (19), an $\alpha = 0.05$ and $\beta = 0.08$, the expected sample size was 139 for a simple random sample. However, a decision was reached to distribute information sheets and questionnaires to all study participants as the total study population was small. A response of 196 was obtained. A point of concern was the poor response from Stompneusbaai and Stilbaai. The sample size is described in table 3.2.

<u>Table 3.2:</u> Sample size

	Total	Stompneusbaai	Stilbaai	Struisbaai	Elands Bay
Population	386	65	75	133	113
Sample	196	23	13	81	79

The power of the study was recalculated at to 0.9.

3.4 STUDY PERIOD

The study was conducted in the period 13 March to16 March 2012. All questionnaires and blood samples from children were collected during this period to avoid any bias due to seasonality. Fishing depends on seasonality and the peak fishing season in South Africa is between September and May.(70) Thus, this study period was chosen to coincide with the peak fishing season.

3.5 DATA COLLECTION

3.5.1 TOOLS

Various tools were used to facilitate data collection and these included a structured questionnaire (Tool 1, Appendix 1), anthropometry recording (Tool 2, Appendix 2) and blood lead level testing Tool 3, Appendix 3).

3.5.1.1 STRUCTURED QUESTIONNAIRE (TOOL 1)

The structured questionnaire used for the study (Tool 1) was translated into Afrikaans, (as this was the language predominantly spoken in these communities) by professional translators and back-translated to ensure accuracy. Information sheets, consent forms and questionnaires were distributed to the children to take home through the school in advance and were self-administered by the parent or guardian. The questionnaires were then brought back to the school the next day and were collected by the study team from the school on the day blood samples were collected.

3.5.1.2 ANTHROPOMETRIC TESTING (TOOL 2)

On the day blood samples were collected, height and weight measurements of each child were taken and the Body Mass Index (BMI) was then calculated for each using these measurements.

3.5.1.3 BLOOD SAMPLES (TOOL 3)

Samples of venous blood were collected from participating children in sterile test tubes (BD Vacutainer system) containing the anticoagulant ethylene diamene tetraacetic acid (EDTA). All blood samples were collected by medical practitioners currently registered with the Health Professions Council of South Africa (HPCSA). Disposable, sterile blood sampling equipment and aseptic sampling techniques were used throughout. Once collected, blood samples were stored under refrigeration and despatched to the analytical laboratory in Johannesburg as soon as possible, using a specialised biological tissue transportation service.(12)

3.6 RELIABILITY AND VALIDITY OF MEASUREMENT TOOLS

3.6.1 QUESTIONNAIRE

The study questionnaire was designed by the researcher with the assistance of the supervisors who are experts in this field. In addition, it was piloted amongst the staff members in the department to identify ambiguous questions and the necessary amendments were made.

3.6.2 BLOOD LEAD ANALYSIS

Blood lead analyses were conducted in the laboratories of the National Institute for Occupational Health (NiOH) in Johannesburg, which participates in national and international quality control programs. Lead concentrations were measured using a flameless atomic absorption method of addition (Model Perkin-Elmer Analyst 300 with HGA 850) adapted from Baily.(71) With each batch of samples a reagent blank and set of working standards were run simultaneously. The coefficient of variation in blood lead samples was 5.8%, which is consistent with studies done elsewhere. (72) The limit of detection for lead in blood was 0.1 μg/dl.(12)

3.7 STUDY VARIABLES

Data from the questionnaire was segregated into five categories as described below:

1. Occupational factors – examined factors such as place of residence, paternal occupation: fisherman
2. Socio-demographic factors – examined factors such as age, sex and ethnicity
3. Environmental (housing) related factors – examined factors such as smoking in the home, plumbing, status of paint and interaction with pets
4. Fishing and smelting related lead factors – examined specifically fishing practices and associated lead exposures
5. Biological factors - assessed anthropometric measurements, BMI and biochemical measurements (blood lead levels).

3.7.1 DESCRIPTION OF VARIABLES

The variables presented in the categories above are expanded on below. A list of variables used for bivariate analysis is then presented.

3.7.1.1 OCCUPATIONAL FACTORS

a) Place of residence

Residents in fishing villages have an increased exposure to lead due to smelting activities for the production of fishing weights and exposure to soil where lead can settle. Data was collected for four fishing villages. However, it was found that Stilbaai and Stompneusbaai were similar in response rate and it was seen during data collection that these villages were similar in socio-economic status.

The income level of the households in Stilbaai and Stompneusbaai reported no income levels below 1000 ZAR, whereas Struisbaai and Elands Bay were dominated by households with total incomes less than 1000 ZAR.

There was significant differences amongst the 4 villages (chi square test was significant p =0.00). Households in Stilbaai and Stompneusbaai have similar incomes and they were significantly higher than the households in Struisbaai and Elands Bay. However, households in Struisbaai (44.78%) had significantly higher income than households in Elands Bay (32.35%). The information related to income has been summarised in table 3.3 below:

<u>Table 3.3:</u> Income levels by village

Village	Total income,1000 ZAR (row %)	Total income >1000 ZAR (row%)
Stilbaai	0 (0%)	19 (100%)
Stompneusbaai	0 (0%)	10 (100%)
Struisbaai	37 (55.22%)	30 (44.78%)
Elands Bay	46 (67.65%)	22 (32.35%)

Therefore it was decided to combine households in Stilbaai and Stompneusbaai and data was analysed in these 3 residential categories.

Furthermore, a post-hoc analysis was done on the four villages and blood lead levels. A Bonferroni test was done to determine similarities between villages. The results showed a p value of 1.000 between the villages of Stilbaai and Stompneusbaai. A statistical difference between villages 3 and 4 was found with a p value of 0.00. A summary of the Bonferroni analysis is shown in Table 3.4 below:

<u>Table 3.4:</u> Post hoc test of village and lead category

	Stilbaai & Stompneusbaai	Struisbaai
Struisbaai	0.03 p value	
Elands Bay	0.00 p value	0.00 p value

This shows that both exposure and effect for place of residence was different and thus it was treated as a confounder.

b) Paternal occupation of fisherman

Being a fisherman in a subsistence fishing village is an occupational factor associated with increased exposure to lead. In addition due to economic hardship present in the villages of this study, these fishermen are more likely to smelt lead in their homes to make fishing weights. This places their children at increased risk of lead exposure and plumbism.

3.7.1.2 SOCIO DEMOGRAPHIC FACTORS

In table 3.3 below, socio-demographic variables are summarised by type and a description of their responses presented.

<u>Table 3.5:</u> Description of socio-demographic

VARIABLE	TYPE	RESPONSES
Age	Numerical	
Sex	Categorical	Male or female
Ethnicity	Categorical	Black African, Coloured, Asian, White, Other

3.7.1.3 ENVIRONMENTAL (HOUSING) RELATED FACTORS

Environmental factors, in particular housing related factors, are important sources of lead exposure for children living in that household. Table 3.4 summarises these variables.

<u>Table 3.6:</u> Description of environmental (housing) related factors

VARIABLE	TYPE	RESPONSES
Regular smoker in the household	Categorical	yes, no
Plumbing	Categorical	metal, plastic, other
Paint peeling inside the house	Categorical	yes, no , don't know
Paint peeling outside the house	Categorical	yes, no , don't know
Interaction with pets	Categorical	yes, no , don't know

The housing related factors are confounders indicating other possible sources for lead exposure resulting in high blood lead levels in children. Therefore the variables listed in table 3.6 were selected for analyses to determine if they influenced the blood lead levels. Initially bivariate analyses were conducted, followed by a regression analysis to determine associations. These variables are associated with documented sources of lead exposure.

3.7.1.4 FISHING AND SMELTING RELATED LEAD FACTORS

The purpose of this study was to determine if fishing and lead smelting activities increased blood lead levels in children exposed to these practices. As such information was collected on the practices associated with fishing and smelting of lead to make fishing sinkers. Table 3.5 explains details of these variables.

<u>Table 3.7:</u> Description of fishing and lead smelting factors

VARIABLE	TYPE	RESPONSES
Use of lead sinkers for fishing	Categorical	every time, now and then, seldom, never
Melt lead to make sinkers	Categorical	yes, no , don't know
Frequency of lead smelting	Categorical	weekly, monthly, annually, very seldom, never
Children ever watch lead melting	Categorical	yes, no , don't know
Children melt lead themselves	Categorical	yes, no , don't know
Lead melted in cooking pot	Categorical	yes, no , don't know
Are lead weights for fishing ever made using a hole in the sand?	Categorical	yes, no , don't know
Have you ever been told that lead is harmful to health?	Categorical	yes, no , don't know
Children play with lead sinkers	Categorical	yes, no , don't know
Do children ever play with lead sinkers?	Categorical	yes, no
Are children involved in the collection of lost fishing	Categorical	yes, no , don't know

sinkers along the beach?		
Does the child undertake fishing him/herself?	Categorical	yes, no , don't know
Has anyone in this household ever swallowed a lead sinker?	Categorical	yes, no , don't know

The variables described above relate to fishing activities particularly with the use and creation of lead sinkers. They also examine children's involvement in activities related to using and smelting lead in order to make fishing sinkers required for fishing.

Due to the similarities of these variables, they were tested for collinearity and significance to determine the exposures most relevant and associated with fishing activities and lead smelting.

Table 3.8 shows the results of the collinearity testing. Pearson's chi-squared test ($\chi 2$) was used for the analysis as all the variables were categorical. Collinearity was seen between variables and the variables that were insignificant (p value > 0.05) were dropped from further analysis. A final list of variables related to fishing and smelting related factors was then drawn up to be used for further statistical analysis in the form of bivariate and multivariate analyses.

<u>Table 3.8:</u> Chi square tests (p value) to determine collinearity among fishing and smelting practices

	How often do you use lead sinkers when you go fishing?	Does anyone melt lead to make fishing sinkers	Do children ever watch smelting?	How often is lead melted at home?	Do children in this home ever melt lead themselves?	Is lead melted in cooking pot	Have you ever been told that lead is harmful to health?	Do children ever play with lead sinkers?	Are children involved in the collection of lost fishing sinkers along the beach?	Does the child undertake fishing him/herself?	Has anyone in this household ever swallowed a lead sinker?
Does anyone melt lead to make fishing sinkers	0.00										
Do children ever watch smelting?	0.00	0.00									
How often is lead melted at home?	0.00	0.00	0.00								
Do any of the children in this home ever melt lead themselves?	0.32	0.45	0.00	0.61							
Is lead melted in cooking pot	0.04	0.03	0.59	0.08	0.03						

	How often do you use lead sinkers when you go fishing?	Does anyone melt lead to make fishing sinkers	Do children ever watch smelting?	How often is lead melted at home?	Do children in this home ever melt lead themselves?	Is lead melted in cooking pot	Have you ever been told that lead is harmful to health?	Do children ever play with lead sinkers?	Are children involved in the collection of lost fishing sinkers along the beach?	Does the child undertake fishing him/herself?	Has anyone in this household ever swallowed a lead sinker?
Have you ever been told that lead is harmful to health?	0.78	0.54	0.76	0.39	0.68	0.42					
Do children ever play with lead sinkers?	0.27	0.53	0.00	0.62	0.00	0.05	0.88				
Are children involved in the collection of lost fishing sinkers along the beach?	0.11	0.95	0.02	0.02	0.00	0.60	0.67	0.00			
Does the child undertake fishing him/herself?	0.57	0.61	0.04	0.36	0.07	0.10	0.93	0.00	0.00		
Has anyone in this household ever swallowed a lead sinker?	0.76	0.97	0.00	0.17	1.00	0.07	0.96	0.01	0.09	0.00	

	How often do you use lead sinkers when you go fishing?	Does anyone melt lead to make fishing sinkers	Do children ever watch smelting?	How often is lead melted at home?	Do children in this home ever melt lead themselves?	Is lead melted in cooking pot	Have you ever been told that lead is harmful to health?	Do children ever play with lead sinkers?	Are children involved in the collection of lost fishing sinkers along the beach?	Does the child undertake fishing him/herself?	Has anyone in this household ever swallowed a lead sinker?
Fisherman in the household	0.00	0.00	0.00	0.00	0.07	0.11	0.13	0.40	0.67	0.17	0.31

3.7.1.5 BIOLOGICAL VARIABLES

Biological variables are described in table 3.9 below.

Table 3.9: Description of biological factors

VARIABLE	TYPE	DESCRIPTION
Height (cm)	Continuous	Taken using vertical stand
Weight (kg)	Continuous	Taken using manual scale calibrated daily
Body Mass Index (BMI) (kg/cm^2)	Continuous	Calculated using the Quetelet Index [BMI = weight (kg) / height(m)^2] (73)
Blood lead levels (µg/dl)	Continuous	Biochemical measurement. Range 1.9 to 22.4 µg/dl

a) Height

Height was measured with a stadiometer placed against a wall whilst children were standing. The measurement was then recorded on the anthropometry tool.

b) Weight

Weight was measured in kilograms using the same scale in all schools. This was then recorded on the anthropometry tool.

c) Body Mass Index (BMI)

The dual energy x-ray absorptiometry (DXA) has been shown to be most effective as a marker of fat mass in children.(74–77). However, it is an extremely expensive and difficult exercise due to the unavailability of DXA machines in primary care settings. It was therefore decided to use BMI as a proxy indicator for body fat. A study conducted in South Africa also used BMI for prediction of body fat in adolescents.(78) BMI was calculated using the height and weight measurements taken and applying the following formula (10):

$$BMI = \text{Weight in kg} / (\text{Height in m})^2$$

BMI was used as a continuous variable instead of calculating percentiles due to absence of demographic information.

d) Blood lead levels

Blood lead levels were stratified into the following categories based on guidelines from the Centre for Disease Control (CDC). In 2012, the CDC reduced the value from >=10 µg/dl for the blood lead 'level of concern' poisoning to >=5 µg/dl. However, the WHO and many other studies still use >=10 µg/dl as a 'level of concern. Thus lead was categorised as in table 3.7 below:

Table 3.10: Categorisation of blood lead level

Category	Blood Lead level
1	< 5.0 µg/dl
2	5.0 – 9.9 µg/dl
3	>=10.0 µg/dl

3.8 LIST OF VARIABLES TESTED IN THE STUDY

Based on the results presented above, a list of variables was created for further bivariate analysis and is presented below:

3.8.1 OCCUPATIONAL FACTORS

- Place of residence
- Paternal occupation: fisherman

3.8.2 SOCIO-DEMOGRAPHIC

- Age
- Sex
- Ethnicity

3.8.3 ENVIRONMENTAL (HOUSING) RELATED FACTORS

- Home within one block of a busy road
- Regular smoker in the household
- Plumbing
- Paint peeling inside and outside the house
- Interaction with pets

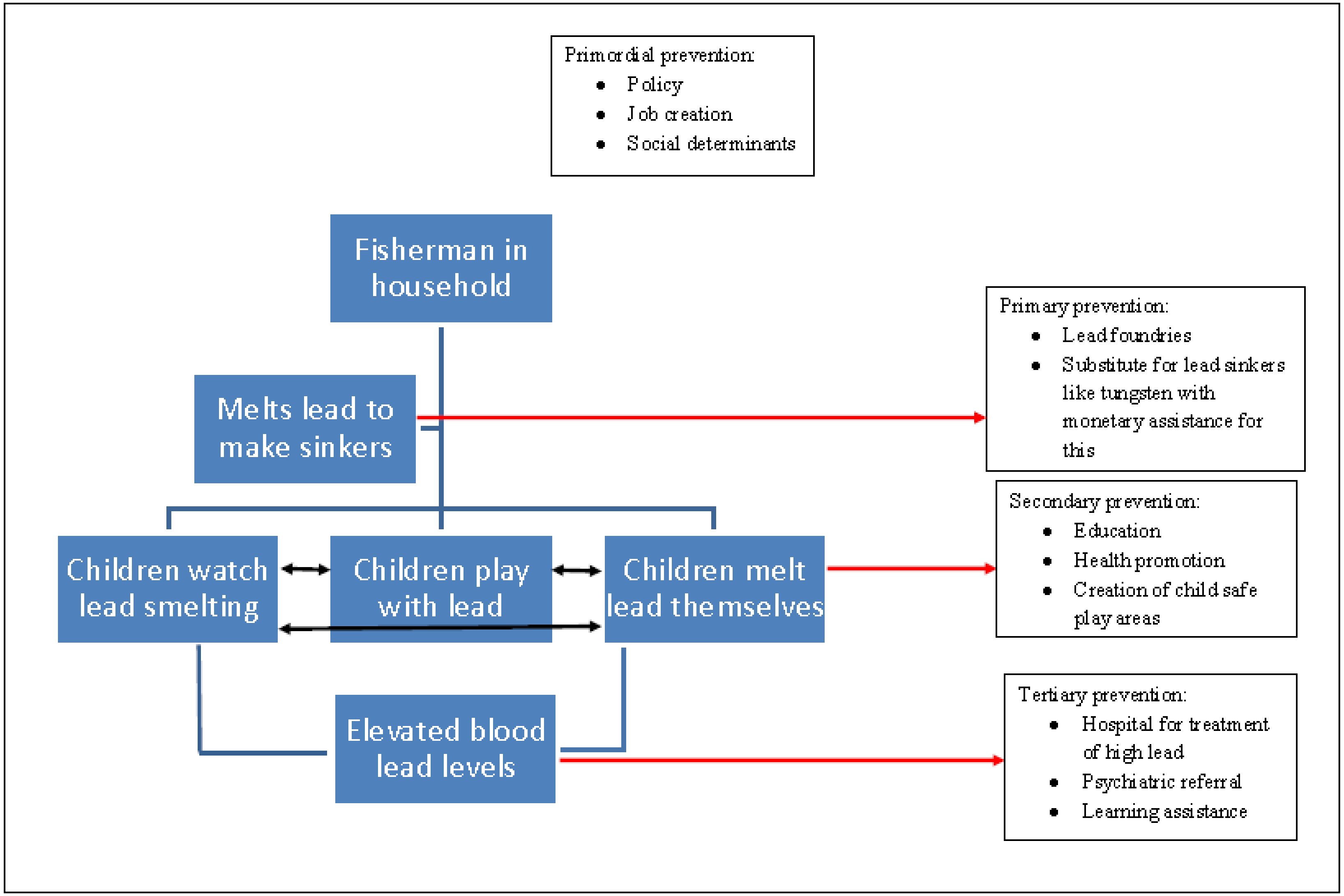
3.8.4 FISHING AND SMELTING RELATED LEAD FACTORS

- Use of lead sinkers for fishing
- Melting lead to make sinkers
- Smelting lead at home
- Children ever watch lead melting
- Children melt lead themselves
- Children play with lead sinkers

3.8.5 BIOLOGICAL

- Body mass Index (BMI) (kg/m^2)
- Blood lead levels (µg/dl)

Based on this list and results of the collinearity testing a schematic summary was created and is presented as figure 3.2. The solid arrows indicate association between factors and levels of care are also summarised.



<u>**Figure 3.2 Schematic representation of study hypothesis**</u>

3.9 DATA ANALYSIS

Data was entered into a Microsoft Excel 2007 spreadsheet by two independent data capturers. The data was then compared to ensure errors were identified and corrected. The corrected spread sheet was then imported into Stata 12 (79) for statistical analysis. Descriptive statistics and ordinal regression were used to answer the study aim and objectives. A critical point value of $p< 0.05$ was used to determine statistical significance.

3.9.1 DESCRIPTIVE ANALYSES

Distribution of continuous variables namely blood lead and BMI were assessed. Data was then assessed by this distribution. For normally distributed data the arithmetic mean and standard deviation was used. For non-normally distributed data, the median and interquartile ranges were used to summarise the variable. Proportions and frequencies were used to summarise categorical variables like village, sex and race.

3.9.2 TESTS OF ASSOCIATION

The Shapiro Wilk test was used to determine if blood lead concentrations were normally distributed. The k-density was used to affirm this test graphically. Blood lead levels were then log transformed to cater for the fact that levels were not normally distributed. Categorised blood lead levels were used as the outcome variable for the bivariate and multivariate analyses.

Pearson's chi-squared test ($\chi 2$) was used for the bivariate analyses for all the variable categories presented above with the exception of age for which a one way ANOVA was done. Further analysis in the form of multinomial regression was done to determine the direction of the association of variables found to be statistically significant in the bivariate analysis.

Based on the analysis of bivariate analysis, the variables that are significantly associated with blood lead level could be identified and included in a multivariate analysis (ordinal logistic regression). The significant variables would be reported and a probabilistic model would be built based on the analysis. Residual analysis was done. This model would be further tested in a stochastic model. An uncertainty analysis was done to test generalizability of the model.

3.10 ETHICS

The study proposal was approved by the Human Research Ethics Committee (Medical) at the University of the Witwatersrand (Ethics clearance: M111132 – Appendix 4). Permission to conduct the study was granted from the provincial education department of the Western Cape (Appendix 5). Permission was granted by the four school principals.

Study information sheets (Appendix 6) was sent to the parents/guardians of all prospective study participants to inform them about the study, as well as their right of refusal to participate in, or withdraw from, the study at any time, without negative consequences or a requirement to furnish reasons for doing so. Children were not admitted to the study unless parents or guardians had signed an informed consent form (Appendix 7). Child assent was also required (Appendix 8 and 9 respectively).

Confidentiality was maintained by allocation of exclusive identification numbers to each study participant. In addition, information was only made available to researchers from the study.

CHAPTER FOUR

RESULTS

This chapter presents the results of the study. It begins with a univariate analysis of biological variables, followed by the bivariate analysis. Multinomial regression, ordinal regression, stochastic regression and finally residual factor analysis is then presented.

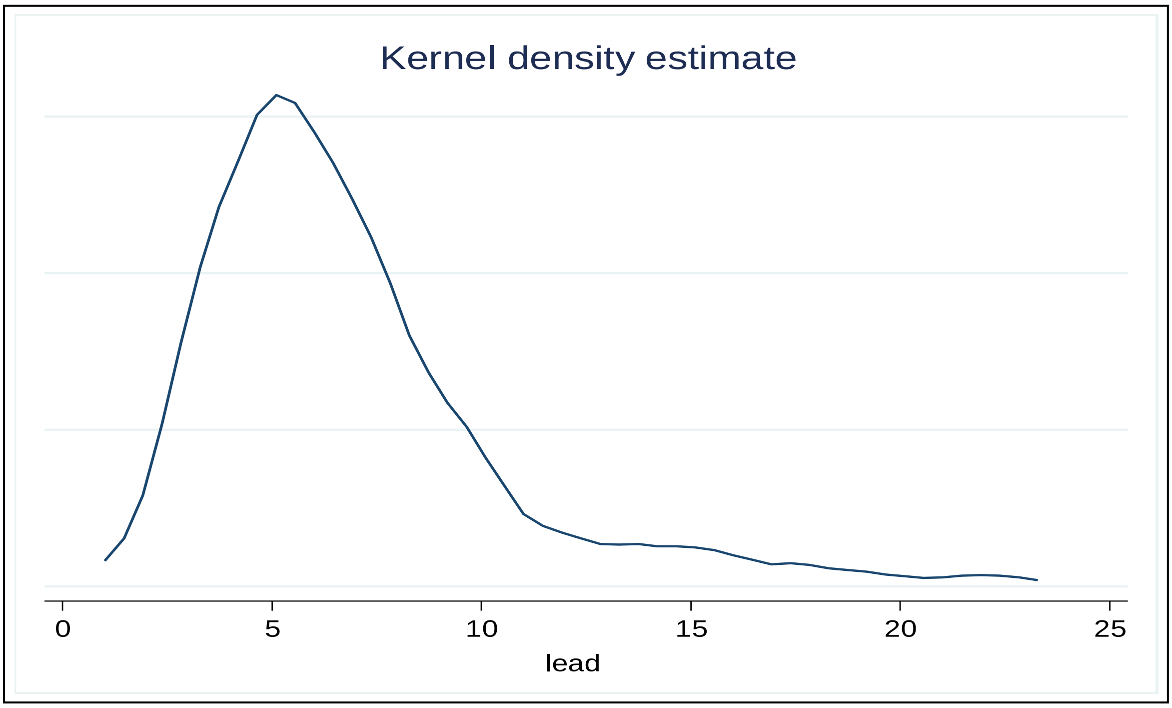
4.1 BLOOD LEAD

Blood lead levels in the sample ranged from 1.9 µg/dl to 22.4 µg/dl.

The distribution of blood lead concentrations were tested both graphically and numerically. The Shapiro Wilk test was used to determine if blood lead levels were normally distributed but revealed that blood lead levels were significantly skewed to the right as a platykurtic curve ($p<0.0001$) (Table 4.1). This is graphically demonstrated with a k-density graph presented in figure 4.1.

Table 4.1: Variance values of blood lead

Variable	Variance	Skewness	Kurtosis
Lead	12.98	1.74	6.63



<u>Figure 4.1: K density estimate for blood lead level</u>

Central tendency measurements of the blood lead levels demonstrated an arithmetic mean of 6.87 µg/dl (95% CI: 6.36 to 7.37 µg/dl) and a median of 6.1 µg/dl. The geometric mean was 6.13 µg/dl (95% CI: 5.74 to 6.55 µg/dl).

The variance of the data showed a range of 1.9 µg/dl to 22.4 µg/dl; an inter quartile range of 3.85 µg/dl (4.4 µg/dl to 8.25 µg/dl) and a standard deviation of 3.6. Based on the skewness and kurtosis, the most appropriate central tendency would be the median and the measure of spread of the inter quartile range.

The blood lead concentration was log transformed to establish if this would cater for the non-normal distribution and enable further statistical testing. The values for skewness (0.28) and kurtosis (3.12) improved with the log transformation. However this did not create a normality that could be used for further statistical analysis. As a result lead was stratified into three categories (Table 3.7 in the methodology section) as described below. Table 4.2 also presents values for the frequency and percentage of children stratified by the three lead categories.

<u>Table 4.2:</u> Frequency and percentages of lead by category

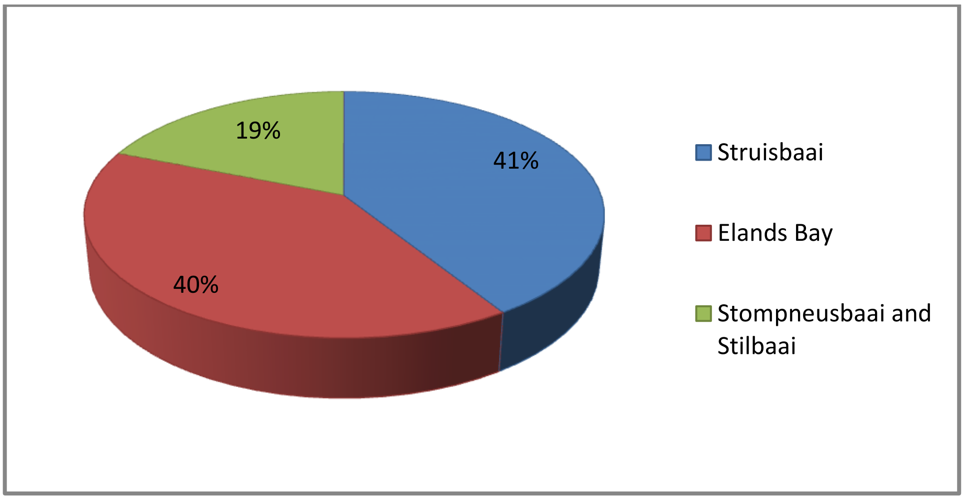
Lead category	Frequency	Percent
1 (< 5.0 µg/dl)	68	34.69
2 (5.0 – 9.9 µg/dl)	103	52.55
3 (>=10.0 µg/dl)	25	12.76
Total	196	100

More than half of the children in the study had blood lead levels between 5.0 - 9.9 µg/dl. Another cause for concern is the 13% of children that had levels higher than 10 µg/dl. This confirms that a large proportion of children in our study had high blood lead levels.

4.2 OCCUPATIONAL FACTORS

4.2.1 PLACE OF RESIDENCE

Most of our study respondents resided in Struisbaai and Elands Bay. Figure 4.2 illustrates these statistics.



<u>Figure 4.2: Percentages of respondents by village</u>

4.2.2 PATERNAL OCCUPATION: FISHERMAN

Fishing as an occupation for the father in the household was reported in 48% of respondents to the question.

4.3 SOCIO-DEMOGRAPHIC FACTORS

4.3.1 AGE

The mean age of children in the study was 7.5 years and ranged from 5 years to 14 years. The age distribution is presented in figure 4.3 below.

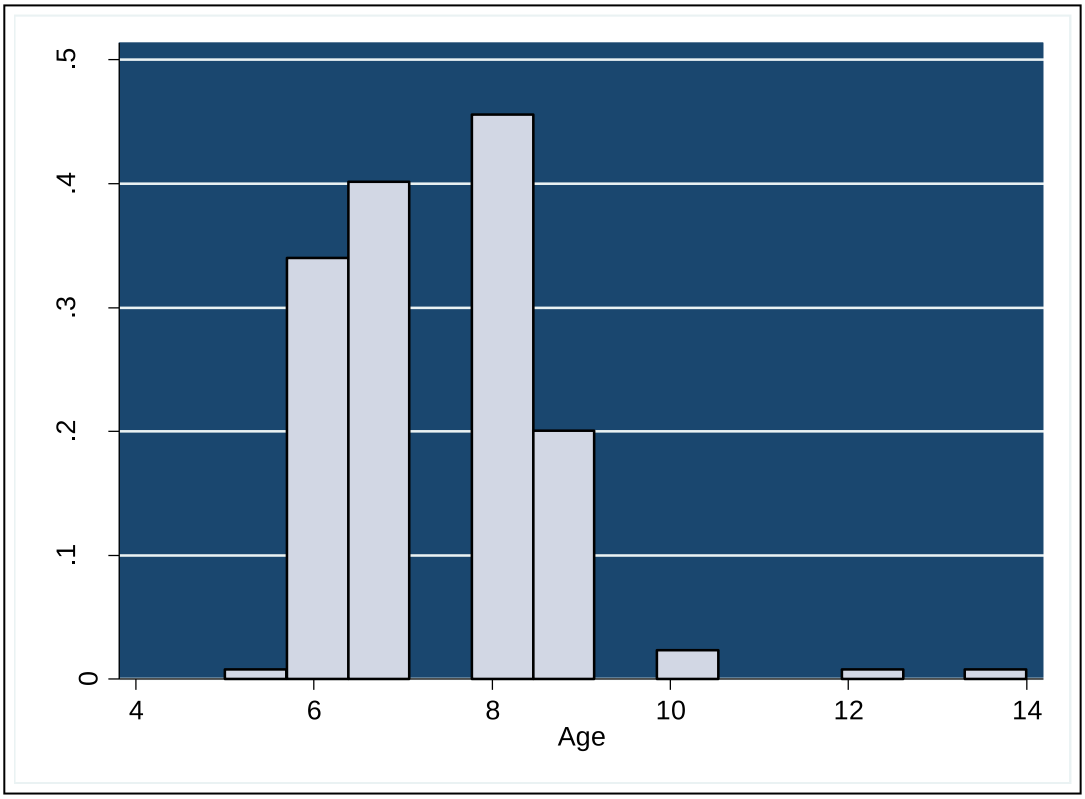


Figure 4.3: Distribution of age

4.3.2 SEX

The percentage of males was slightly higher than the percentage of females in the study (56 versus 44% respectively).

4.3.3 ETHNICITY

Coloured children represented the predominant race group in the study accounting for 80% of the sample. There were also a few African Black and White children (16% and 4% respectively). These statistics are represented graphically in figure 4.4 below.

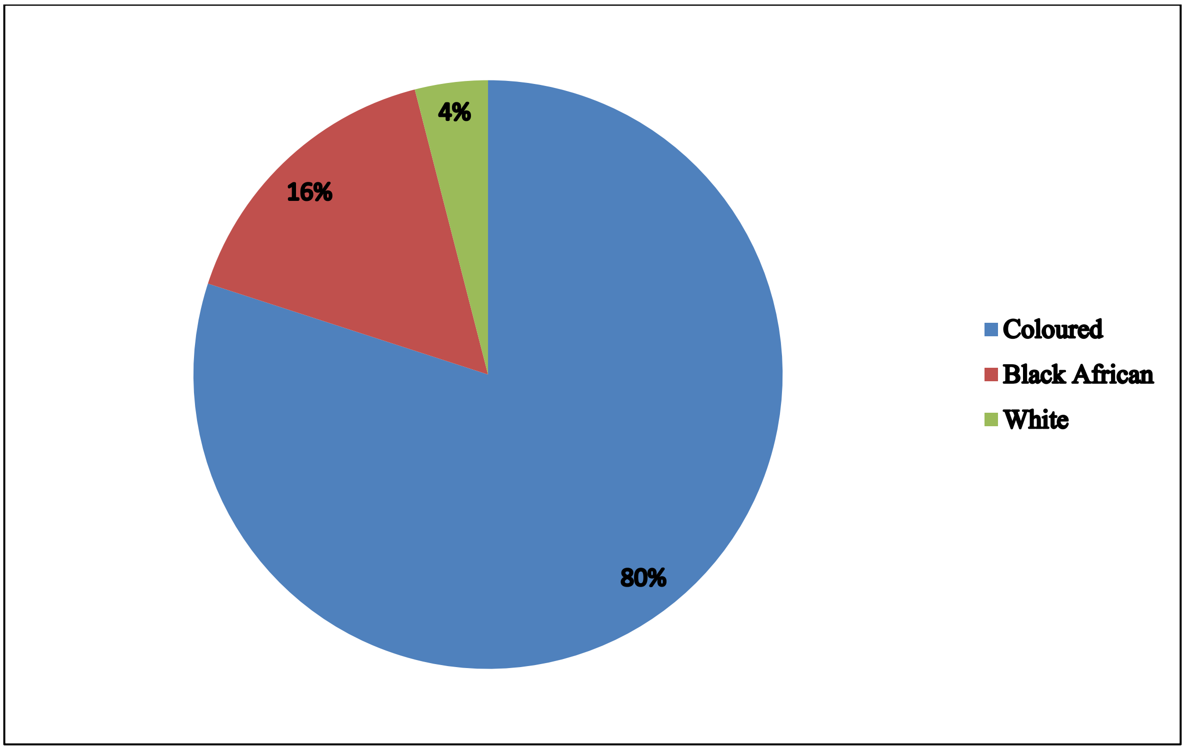


Figure 4.4: Ethnicity of respondents

4.4 ENVIRONMENTAL (HOUSING) RELATED FACTORS

4.4.1 REGULAR SMOKER IN THE HOUSEHOLD

The figure (4.5) below shows the percentage of households that reported the presence of a regular smoker within that household.

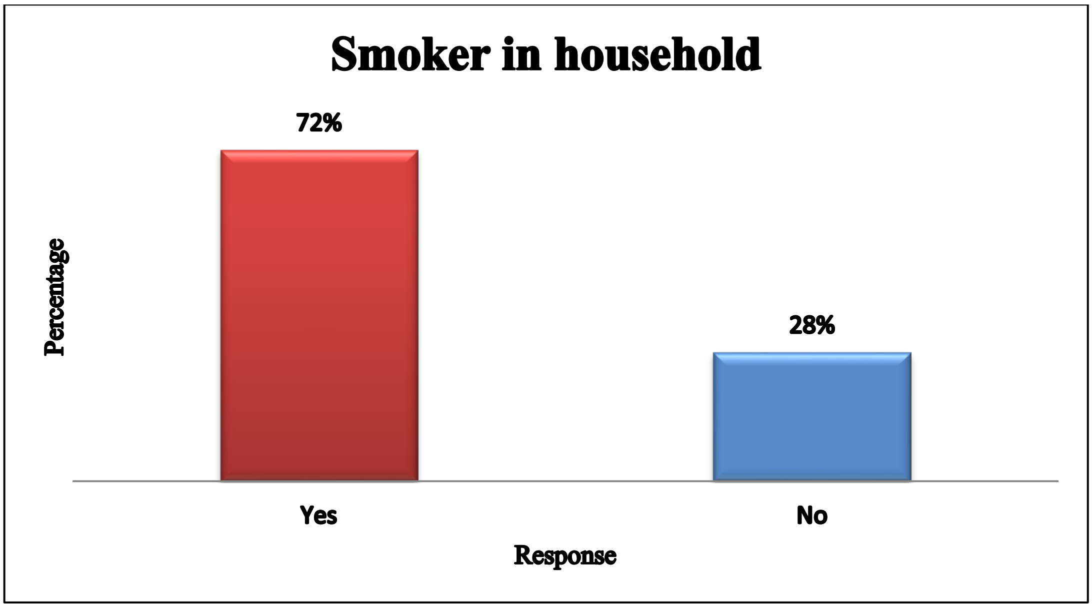


Figure 4.5: Percentage of smokers versus non-smokers

4.4.2 PLUMBING

Most households (52%) had been fitted with plastic plumbing. Metal plumbing was reported in 42% of households whilst a small proportion of respondents (6%) reported having other types of plumbing not further described.

4.4.3 PAINT PEELING INSIDE OR OUTSIDE THE HOUSE

Peeling paint indoors and outdoors were reported by 33% and 36% respectively. Bivariate analysis will be done to determine if this variable is a confounder.

4.4.4 INTERACTION WITH PETS

Sixty one percent of respondents reported that their children played regularly with pets. The pets are seen as carriers of lead laden dust and if significant following bivariate analysis thus considered a confounder.

4.5 FISHING AND SMELTING RELATED FACTORS

In table 4.3, fishing and smelting related factors are shown with a number of people that responded to the questions relating to these. In addition a number of positive responses are displayed.

Table 4.3: Responses to lead and smelting related factors

Variable	N	Number of positive responses	% of positive responses
Use of lead sinkers for fishing	148	85	57
Melt lead to make sinkers	151	30	20
Frequency of lead smelting	127	51	40
Children ever watch lead melting	106	17	16
Children melt lead themselves	150	8	5
Children play with lead sinkers	166	7	4

More than half of all positive respondents admitted to using lead sinkers for fishing (57%). Only 20% of respondents reported that they smelt lead to make sinkers, however 40% of all respondents admitted to smelting lead at home. Activities related to children watching, melting or playing with lead were reported to be low (16%, 5% and 4%) respectively.

4.6 BIOLOGICAL FACTORS

4.6.1 BODY MASS INDEX

The mean BMI value was 15.64 and values ranged between 9.76 and 24.38. A distribution curve is shown for BMI in figure 4.6.

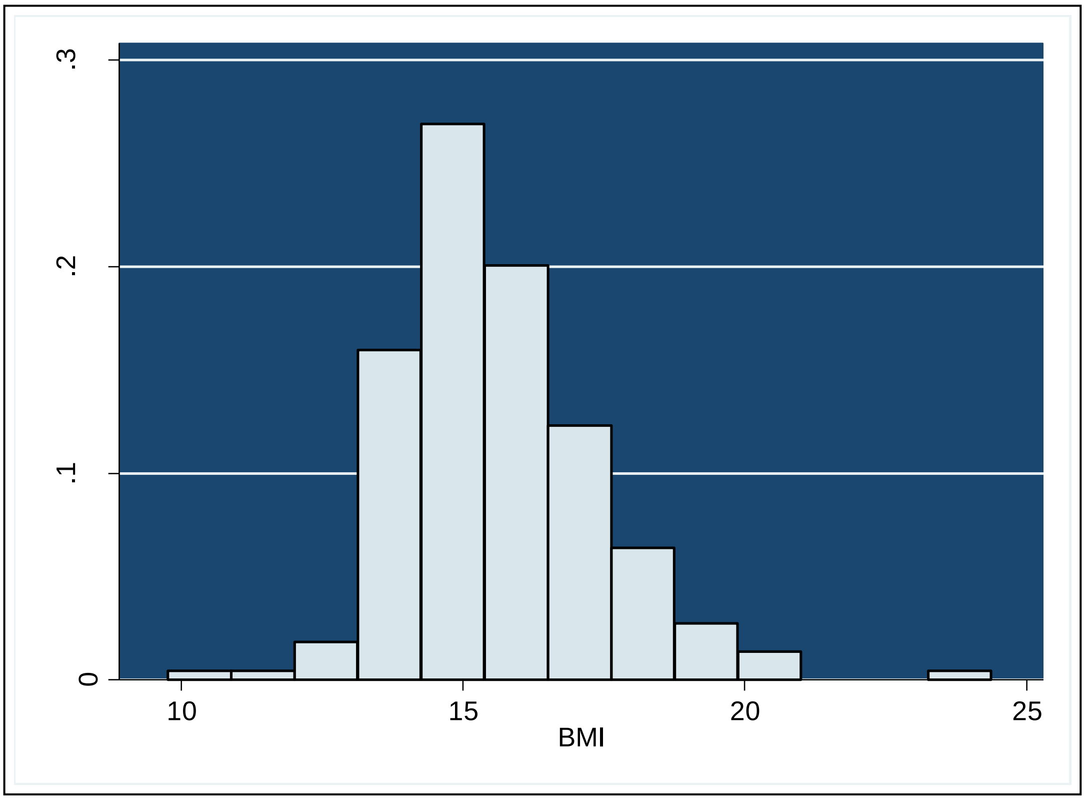


Figure 4.6: Distribution of BMI

4.7 BLOOD LEAD LEVEL AND ASSOCIATED FACTORS

In the following section blood lead level and possible associated factors (as a categorical variable as summarised in table 3.7) will be analysed.

4.7.1 LEAD AND OCCUPATIONAL FACTORS

4.7.1.1 LEAD AND VILLAGE

Table 4.5 summarises the analysis of blood lead levels by village.

<u>Table 4.5:</u> blood lead level by village

Lead category	Village 1 (Stillbaai + Stompneusbaai)	Village 2 (Struisbaai)	Village 3 (Elands Bay)
1	25 (13%)	24 (12%)	19 (10%)
2	11 (5%)	49 (25%)	43 (22%)
3	0	8 (4%)	17 (9%)

As can be seen children in Village 1 had a predominance of blood lead levels in category 1 (69%) with no children having blood lead levels in category 3. However Villages 2 and 3 show significantly dominant levels in category 2 (60 % and 54% respectively). There was also a presence of blood lead levels in category 3 in these villages (10% and 22% respectively). A statistical significance of 0.000 was found when a Pearson chi square test was done between village and lead indicating that there was a significant difference between village and blood lead levels.

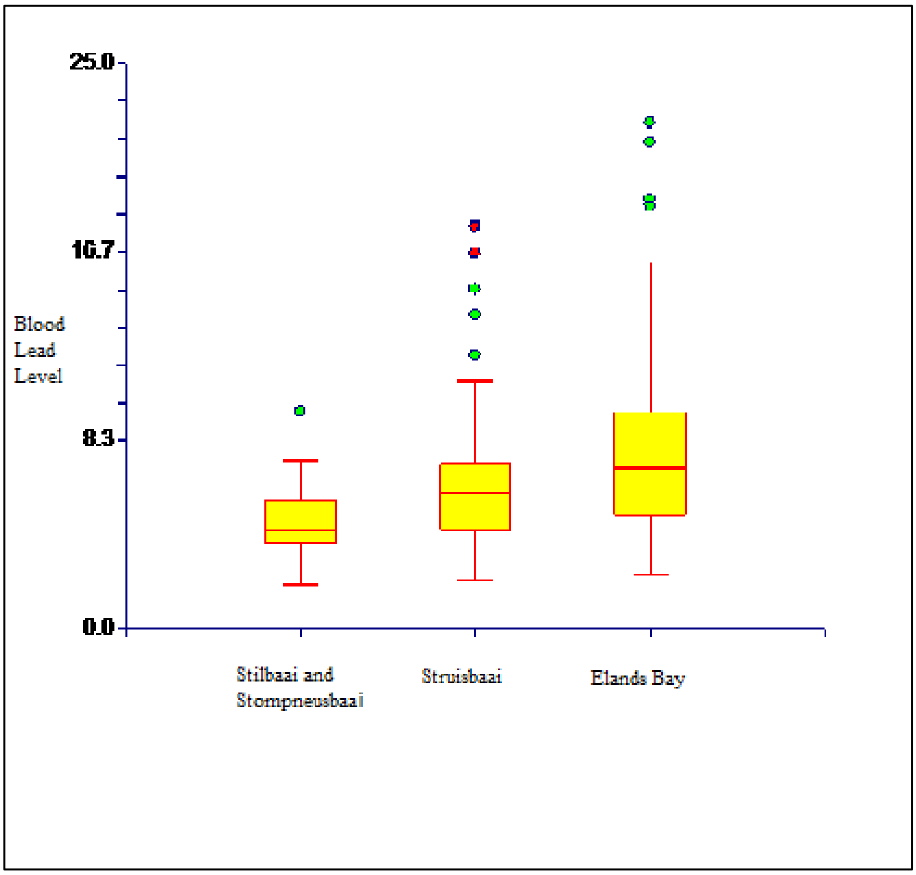


Figure 4.5: Box plot of village and blood lead levels

4.7.1.2 LEAD AND PATERNAL OCCUPATION: FISHERMAN

A statistical significance was found between blood lead level and a paternal occupation as a fisherman. The p value was < 0.0001 after a chi square test.

4.7.2 LEAD AND SOCIO-DEMOGRAPHIC FACTORS

Results of the bivariate analysis of lead categories and socio-demographic variables are summarised in table 4.6. Age, sex and ethnicity were not statistically significant.

<u>Table 4.6:</u> Bivariate analysis of blood lead level and socio-demographic variables

Variable	Statistical Test	P value
Age	ANOVA	0.63
Sex	Chi square	0.75
Ethnicity	Chi square	0.87

4.7.3 LEAD AND ENVIRONMENTAL (HOUSING) RELATED FACTORS

The relationship of blood lead levels and housing related factors was explored in order to determine if there was any statistically significant association between them. A Pearson chi square test was used.

<u>Table 4.7:</u> Association of blood lead level and housing related factors

VARIABLE	p VALUE
Home within one block of a busy road	0.85
Regular smoker in the household	**<0.01***
Plumbing	0.93
Paint peeling inside the house	0.71
Paint peeling outside the house	0.29
Interaction with pets	**<0.05***

*Significance at a p value of 0.05

A regular smoker in the household and the presence of pets were significantly associated with higher blood lead levels (p<0.01).

4.7.4 FISHING AND SMELTING RELATED FACTORS

The association of fishing and related lead smelting factors was tested for statistical significance using the Pearson chi square test. Results are presented in table 4.7 below:

<u>Table 4.8:</u> Association of blood lead level and fishing related activities

VARIABLE	p VALUE
Fishing related practices	
Use of lead sinkers for fishing	< 0.05*
Smelting related practices	
Melt lead to make sinkers	<0.0001*
Frequency of lead smelting	<0.01*
Children ever watch lead melting	<0.05*
Children melt lead themselves	<0.05*
Children play with lead sinkers	0.55

**statistically significant*

Aside from the children playing with lead sinkers (p = 0.55), fishing and smelting associated practices were found to be significantly associated with high blood lead levels.

Ordinal logistic regression was then done to determine the direction of the significant associations. Blood lead levels >=5.0 µg/dl were seen with:

- the regular use of fishing sinkers p =0.00 CI: 1.24 – 2.93
- in households that reported the melting of lead for the production of sinkers p= 0.00 CI: 0.16-0.78

- more frequent smelting of lead in the home p=0.00 CI: 0.16-0.78
- in households where children watched lead being smelted p=0.01 CI: 0.28 – 2.07
- in households where children smelted lead themselves 0.04 CI:0.13 – 2.28

4.7.5 LEAD AND BIOLOGICAL FACTORS

Blood lead levels and BMI were found to be independent of each other (Spearman's correlation, p = 0.35).The following scatter plot (figure 4.7) shows actual blood lead levels (not categorised) by actual BMI values.

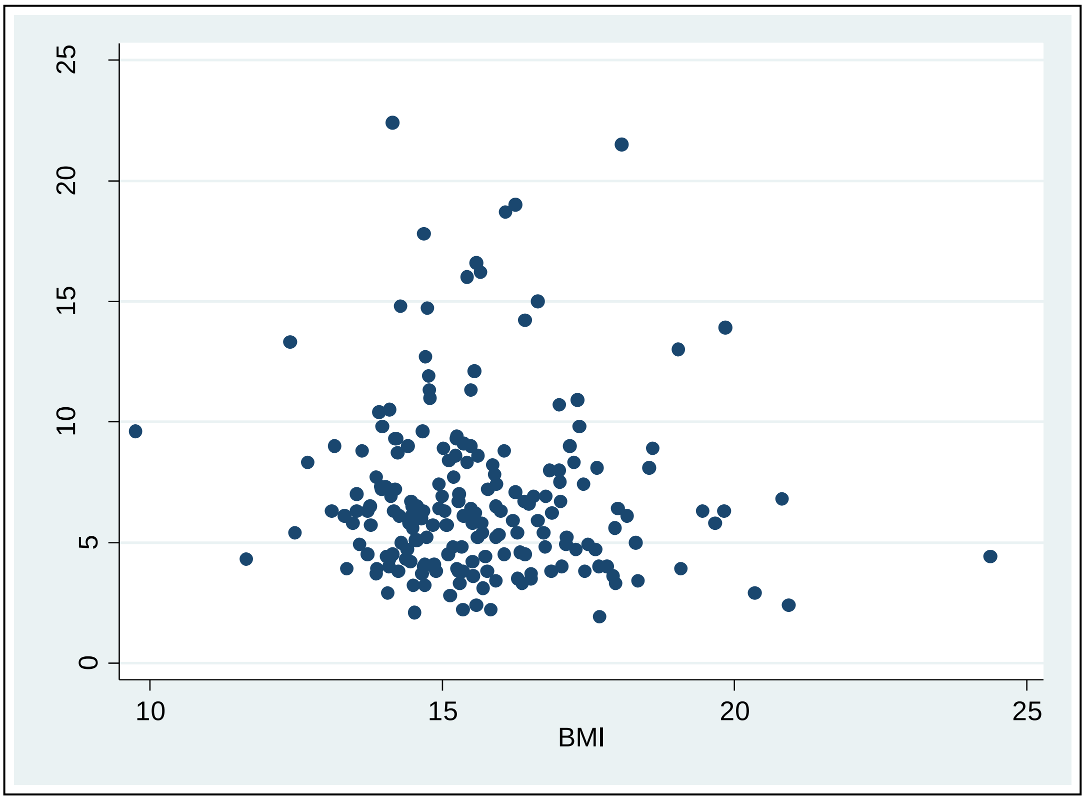


Figure 4.7: Scatterplot blood lead level and BMI

4.8 BLOOD LEAD LEVEL AND VARIOUS FACTORS

Ordinal logistic regression was done with lead categories as a dependent variable and the variables listed below as independent variables.

4.8.1 OCCUPATIONAL FACTORS

- Place of residence
- Paternal occupation: fisherman

4.8.2 ENVIRONMENTAL (HOUSING) RELATED FACTORS

- Regular smoker in the household
- Interaction with pets

4.8.3 FISHING AND SMELTING RELATED LEAD FACTORS

- Use of lead sinkers for fishing
- Melt lead to make sinkers
- Smelting lead at home
- Children ever watch lead melting
- Children melt lead themselves
- Children play with lead sinkers

Confounders were identified as:

- Place of residence
- Regular smoker in the household
- Interaction with pets

In the model, place of residence remained significant (p= 0.04 CI: 0.01 – 1.99) as a confounder. Children watching lead being smelted remained a significant (p= 0.03 CI: 0.32 – 5.3) lead exposure and determinant of plumbism. The presence of a fisherman in the household was almost significant (p=0.09 CI: 0.37 – 4.67).

Model R^2 was 0.90. The actual and predicted r^2 for three lead categories are described in Table 4.9. Overall 86.9% of the subjects could be classified correctly. All the subjects with lead category 3 could be classified correctly.

<u>Table 4.9:</u> Classification of lead categories

Blood lead levels	Actual vs Predicted	% Correctly
Categories	**R-Squared**	**Classified**
1 (< 5.0 µg/dl)	0.83632	80
2 (5.0 – 9.9 µg/dl)	0.78726	85
3 (>=10.0 µg/dl)	0.91039	100
Total		86.957

When the 3 significant factors were tested for ordinal regression, r^2 decreased to 0.57. This indicates that even though other variables were found to be insignificant they probably influence the model due to the high collinearity of variables. Therefore, no further statistical testing was done for the model.

CHAPTER FIVE

DISCUSSION

This chapter discusses the relevant results presented in Chapter Four. Local and international literature serves as references to determine possible associations with findings from this study.

5.1 INTRODUCTION

This study aims to determine the distribution and factors associated with lead poisoning in subsistence fishing communities. Particular attention was paid to collecting and analysing data associated with fishing and lead smelting related activities. In this way, this study will hopefully contribute to both individual and community targeted public health interventions to reduce children's exposure to lead from fishing related practices.

An individual level analysis was done as blood lead levels were collected on individual study participants. Although questionnaires were collected at a household level it was felt that activities related to lead exposure would be different depending on a child's age and behaviour.

5.2 BLOOD LEAD LEVELS

In our study of 196 children residing in fishing villages, the mean blood lead level was 6.87 µg/dl and blood levels ranged from 1.9 to 22.4 µg/dl. The median was 6.1 µg/dl. Both the mean and median were above the revised CDC guidelines. Three quarter (75%) of the children had a blood lead level >= 5 µg/dl and 13% had blood lead levels >= 10 µg/dl. Thus the prevalence of plumbism in our population was very high at 75%. The mean blood level and proportion of children with blood lead levels >= 10 µg/dl are significantly higher than those found in children from fishing villages elsewhere in the world. In Cartagena, Colombia, a mean blood lead level of 4.74 µg/dl was found with 7.4% of children having a blood lead level of >= 10 µg/dl.(29) Similarly, mean blood lead levels in the Chuuk Islands were 3.9 µg/dl compared to our mean of 6.87 µg/dl.

Additionally, if we compare mean blood lead levels from this study with studies carried out in the US and Europe (Sweden), we see that our blood lead levels are several times higher, than those found in the developed world. In the US, mean blood lead levels were reported as 1.9 µg/dl and in Sweden mean blood lead levels were 1.3 µg/dl.(80,81) The explanations for this relate to stricter lead regulations and earlier policy and legislative action targeting lead prevention and control in the developing world.

Blood lead levels found in this study in fishing villages are more comparable to studies conducted in Africa. Mean blood lead levels in Kampala, Uganda were found to be 7.1 µg/dl which is similar to the mean blood lead level found in this study.(82) A study done in Kinshasa, in the Democratic Republic of Congo showed a blood lead level range of 1.5 to 22.0 µg/dl which is very comparable to the range found here of 1.9 to 22.4 µg/dl.(44) However, these studies were carried out in cities where sources of lead exposure are quite different and mainly attributable to fumes from leaded gasoline. (44,82)

In South Africa, most studies were carried out when the blood lead level of concern was far higher than 5µg/dl or even 10 µg/dl. Thus comparing mean blood lead levels were difficult locally. However, mean blood lead levels from this study were similar to those levels found in Woodstock, Cape Town prior to the introduction of unleaded gasoline.(68)

5.3 SOURCES AND DETERMINANTS OF LEAD EXPOSURE

There are various sources of, and factors associated with, plumbism. In this study, we were particularly interested in occupational fishing and lead smelting activities. Confounders in the form of occupational, socio-demographic factors and environmental (housing) related factors were also tested for and dealt with accordingly.

After modelling, only place of residence, paternal occupation of fishing and children watching lead smelting remained significant. These results correspond with studies done in the Chuuk Islands and Cartagena which showed the production of fishing weights as a significant exposure for elevated blood lead levels in children of those villages. These studies also showed no relationship between the sex of children and the blood lead level.(28,29) Thus the schematic diagram presented in figure 3.2 can be adapted to figure 5.1.

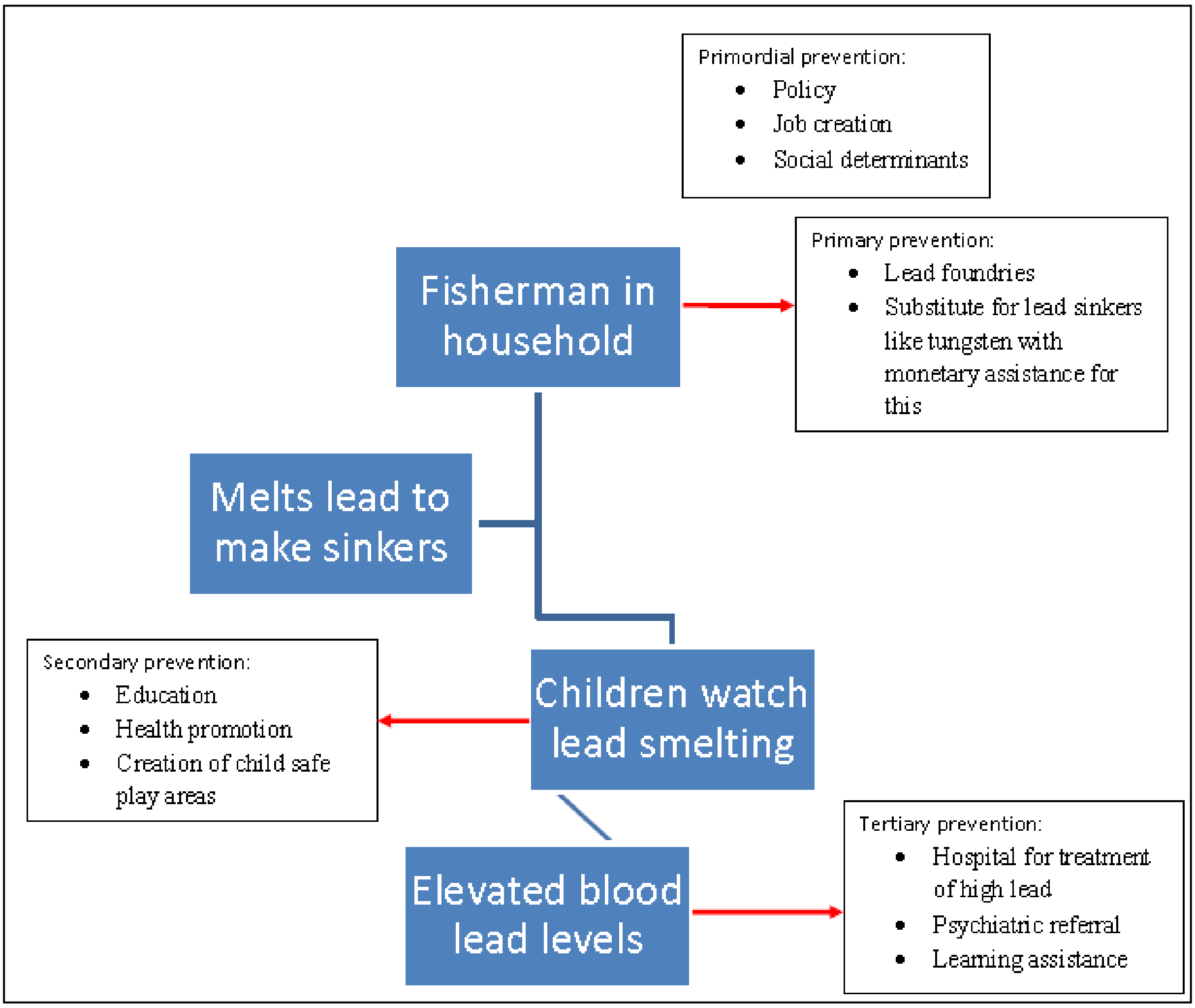


Figure 5.2: Schematic diagram of causes of elevated blood levels

5.4 PUBLIC HEALTH INTERVENTIONS

This study proves that lead poisoning in children residing in fishing villages is of public health concern. Despite the progress South Africa has made with regulations for the use of lead, the introduction of lead free gasoline and the limitation of lead in household paint, there is much more that needs to be done in order to reduce the prevalence of lead poisoning.

Public health interventions should be targeted at individual and community levels in fishing villages. Regarding community level interventions, lead regulations need to be more strictly enforced. In addition the National Department of Health in conjunction with other sectors of government such as trade and industry should look towards developing strategic policies and guidelines for lead poisoning prevention. At a provincial level, surveillance of lead poisoning needs to be set up and local municipalities should use environmental health practitioners to monitor lead pollution. At the individual level, primary interventions should be directed towards educating the population on the hazardous effects of lead. In addition, promotion of hand washing and education on the smelting and use of lead for fishing sinkers should be provided at schools to target children of fishing communities. Although education and promotional campaigns have not proven to be very successful for children with very high blood lead levels (28,29,32) they are necessary and can provide some short term solutions. Secondary prevention should focus on screening in high risk areas, which will require laboratory support as the test for blood lead is currently quite expensive and not available in most laboratories. In order for clinicians to manage plumbism efficiently as a tertiary level intervention, they will need guidelines and clinical support. In order for these interventions to work, a holistic approach to both individual and community level interventions are necessary simultaneously.

In the UK, some states of the US and Canada, the use of lead based fishing weights have been banned and outlawed in national parks which has prompted the substitution of other substances like tungsten for this purpose.(7,53) However, the replacement of lead with another seems to be a more long term goal in the South African context given the economic hardship and poverty in the country. Similarly, if we look towards banning lead completely we leave these impoverished communities with even less hope of gaining an income. Ultimately, job creation and poverty elimination will assist in the reduction of lead poisoning in children residing in subsistence fishing villages in South Africa. This however is beyond the scope of public health alone and of this study.

5.5 LIMITATIONS

The questionnaire could not be tested for internal or external validity. Isotopic analysis was not done to determine the source of lead exposure scientifically. Schools were not chosen according to socio-economic quintiles and this could have accounted for the disparities associated between Villages and blood lead levels. This could lead to issues with generalizability. However, the focus of this study was to determine the prevalence of plumbism and establish association with lead fishing and smelting practices rather than focus on social determinants of health. The sample size was relatively small and response rates were not uniform. The use of a structured questionnaire in the absence of an interview may have resulted in the misinterpretation of some questions. As with all cross sectional studies, components necessary to infer causality could not be studied for e.g. quanitification and cessation related to exposure. However, the aim of this study was not to prove causality but rather to establish association which can be done adequately through a cross sectional design.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

This chapter summarises key results of the study. Recommendations and further research are then discussed.

6.1 CONCLUSION

This study is the first report on blood lead levels in fishing villages on the African continent and provides evidence that lead is still used widely as the primary substance used to make fishing sinkers. Lead is smelted in the household exposing residents of that household to vapour containing lead and lead laden dust or soil.

6.1.1 OBJECTIVE 1

To determine the distribution of high blood lead levels (blood lead >5 µg/dl) of children

The study showed the prevalence of plumbism in the population was extremely high at 75%. No significant differences were seen with age, sex or ethnicity.

6.1.2 OBJECTIVE 2

To determine associated factors (with particular emphasis on the use of fishing sinkers) for elevated blood lead concentrations in children

This study confirms an association of the smelting of lead for occupational fishing activities and elevated blood lead levels in children exposed to this smelting. In addition children watch this smelting, may smelt lead themselves or play with lead thereby increasing their chances of plumbism.

6.2 RECOMMENDATIONS

6.2.1 NATIONAL POLICY ON LEAD PREVENTION AND CONTROL

A national policy on lead prevention and control is essential to curb high prevalence rates of plumbism in South African children. This policy will also serve to support efforts by the WHO and the United Nations Children's' Fund (UNICEF) towards creating a safer environment for children. The policy should provide a framework for primary, secondary and tertiary levels of intervention. Given, South Africa's extensive coastline there should also be consideration of occupational fishing and the smelting of lead in households for the production of sinkers.

6.2.2 LEAD HAZARD AWARENESS AND PREVENTION CAMPAIGNS

Educational campaigns should be carried out in communities and schools to increase knowledge on the hazardous effects of lead. High risk communities, such as residents in fishing villages, should be targeted for these efforts.

6.2.3 BLOOD LEAD SCREENING AND SURVEILLANCE

Screening for blood lead should be carried out in high risk communities. Due to children's vulnerability to lead poisoning, initial screening efforts can be limited to children. An efficient surveillance system to monitor these blood lead levels should be implemented at least in high risk provinces initially.

6.2.4 ESTABLISHMENT OF PROPERLY EQUIPPED FOUNDRIES

In the short term, in order to prevent children's exposure to lead from smelting, foundries should be created where lead can be smelted safely. Although the smelting of lead for fishing sinkers should be strongly discouraged, it cannot be completely and immediately stopped due to economic challenges. Thus, in the interim properly equipped foundries is a solution for reducing lead exposure in subsistence fishing villages.

6.3 FURTHER RESEARCH

This study serves to initiate further research in establishing causality of high blood lead levels in fishing villages on the African continents. To this end, further research will be summarised using the Bradford Hill criteria for causation of disease. (83)

6.3.1 ASSOCIATION BETWEEN LEAD SMELTING BY SUBSISTENCE FISHERMEN AND HIGH BLOOD LEAD LEVELS OF THEIR CHILDREN

This study confirms that there is an association between high blood lead levels and lead smelting activities related to occupational fishing. However, given issues with generalisability and sample size, research should be extended nationally to support these findings. In addition, strength between the exposure and high blood lead levels can be further investigated.

6.3.2 QUANTIFICATION OF THE RELATIONSHIP OF ASSOCIATION

The aim of this study was not to quantify the relationship between the association of lead smelting activities and blood lead levels. However, further research can be done to calculate a dose-response relationship to increase plausibility of the association.

6.3.3 CESSATION OF EXPOSURE

It is also important to determine if cessation of lead smelting in the presence of children will prevent or decrease high blood lead levels. This would assist with definitive legislative and policy actions.

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APPENDIX 1: RELEVANT SECTIONS OF QUESTIONNAIRE (TOOL1)

Study Code	

SCHOOLS ENVIRONMENT & HEALTH STUDY

This questionnaire is part of the Medical Research Council Children's Environmental Health survey. We ask that you take the time (about 45 minutes) to answer the questions. We thank you in advance for your assistance in this important study.

If you have questions or need further information, please do not hesitate to call Professor Angela Mathee (082 464 7038) or Dr Nisha Naicker (072 117 3408) or Dr Taskeen Khan (0786936695).

Study town or site	
School name	
Grade of study child	
Date of interview	

SECTION A: BACKGROUND DETAILS

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

1.	**What is your child's first name?**	
2.	**What is your child's surname?**	
3.	**What is your home address?**	
4.	**What is your telephone number?**	
5.	**In which year was your child born?**	
6.	**Is the child a (please tick alongside the correct answer)**	
	1. Boy	
	2. Girl	
7.	**What language does the child speak at home MOST OF THE TIME? (please tick <u>one only</u>)**	
	1. English	
	2. Afrikaans	
	3. isiXhosa	
	4. seSotho	
	5. isiZulu	
	6. Other (please specify)	
8.	Where was your child born	
	1. South Africa	
	2. Another country in Africa	
	3. Another country elsewhere in the world	

9.	**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)	
10.	**How does your child usually get to school (please circle one answer only)**	
	1. walk	
	2. bus or taxi	
	3. train	
	4. private car	
	5. bicycle	
	6. other (please specify)	

SECTION C: HOUSING

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

33.	**Does anyone regularly smoke at home?**	
	1. Yes	

	2. No	
34.	**If yes, how many household members smoke regularly at home?**	
35.	**Which of the following do household members smoke** (please tick all forms mentioned)?	
	1. Cigarettes	
	2. Hookah pipes	
	3. Traditional pipes	
	4. Snuff	
	5. Other (please specify)	
36.	**Do household members ever smoke inside the house?**	
	1. Yes	
	2. No	
	3. Don't know	
39.	**What type of plumbing does the house have?**	
	1. Metal	
	2. Plastic	
	3. Other (please specify)	
40.	**Is there paint peeling from the inside walls, doors or windowsills of the home?**	
	1. Yes	
	2. No	
	3. Don't know	

41.	**Is there paint peeling from the outside walls, doors or windowsills of the home?**	
	1. Yes	
	2. No	
	3. Don't know	
42.	**Is this home in need of major repairs?**	
	1. Yes	
	2. No	
	3. Don't know	
43.	**Has there been any painting, decorating or renovation in the home during the past year?**	
	1. Yes	
	2. No	
	3. Don't know	
45.	**Does the child often play with pets (such as a cat or dog)?**	
	1. Yes	
	2. No	
	3. Don't know	
46.	**When dusting the house, what do you use MOST OF THE TIME?**	
	1. dry cloth	
	2. damp cloth (soaked in water only)	
47.	**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 or Sunlight liquid.			
48.	**Does anyone living in the same house as the child do the following jobs?**			
		Yes	No	Don't know
	1. Making jewellery			
	2. Car repairs or maintenance			
	3. Spray-painting of cars			
	4. Construction, building or renovation work			
	5. Plumbing			
	6. Painting			
	7. Welding or soldering			
	8. A job involving guns or bullets (for example the police service)			
	9. Leaded or stained glass			
	10. Battery factory			
	11. Scrap yard			
	12. Lead mine			
	13. Fishing			
	14. Repairing electrical appliances			
	15. Pottery			
	16. Petrol station			
	17. Other job that involves the use of lead. Please specify ……………………			

SECTION D: SOCIAL ASPECTS

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

58.	**What is the <u>total</u> 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			
59.	**How often do you use lead sinkers when you go fishing?**			
	1. Every time			
	2. Now and then			
	3. Seldom			
	4. Never			
60.	**Does anyone melt lead to make fishing sinkers?**	No	Yes	Don't know
	If yes, where is the melting undertaken:			
	1. Inside the house?			
	2. In another indoor space?			
	3. Outdoors?			

61.	**When the lead melting is taking place, do children ever watch?**	No	Yes	Don’t know
62.	**Do any of the children in this home ever melt lead themselves?**	No	Yes	Don’t know
63.	**What is the lead melted in?**			
	1. A cooking pot			
	2. Another utensil – please specify			
64.	**What other equipment is used to make home-made lead sinkers?**			
	1. Gas stove			
	2. Flame thrower			
	3. Home-made mould			
	4. Shop mould			
	5. Gloves			
	6. Mask			
	7. Protective glasses			
	8. Vise grip			
	9. Ladle or spoon			
	10. Pliers			
	11. Other (please specify)			

65.	**Where do you get the lead to make sinkers from?**			
	1. Collecting lost sinkers on the beach			
	2. Diving for lost sinkers			
	3. Battery shops or battery recycling places			
	4. Old batteries			
	5. Scrap yards			
	6. Tyre repair and wheel balancing centres			
	7. Cables			
66.	**Have you ever used a sinker that was not made from lead?**			
	1. Yes			
	2. No			
67.	**If yes, what was it made from?**			
	1. Steel			
	2. Bismuth			
	3. Aluminium alloy			
	4. Stone			
	5. Glass			
	6. Tungsten			
	7. Spark plugs			
	8. Chains			
	9. Bones			
	10. Live bait			

	11. Nuts and bolts	
68.	**How did it compare with lead sinkers?**	
69.	**If you were told that the use of lead sinkers may be hazardous to people would you use alternatives?**	
	1. Yes	
	2. No	
	3. Don't know	
70.	**If you were told that the use of lead sinkers may be hazardous to the environment, would you use alternatives?**	
	a) Yes	
	b) No	
	c) Don't know	
71.	**Have you ever been told that lead is harmful to health?**	
	a) Yes	
	b) No	
	c) Don't know	
72.	**Do children ever play with lead sinkers?**	
	1. Yes	
	2. No	
73.	**Do children ever melt lead to play with (for example to make jewellery)?**	

	1. Yes	
	2. No	
74.	**Are children involved in the collection of lost fishing sinkers along the beach?**	
	1. Yes	
	2. No	
	3. Don’t know	
75.	**Does the child undertake fishing him/herself?**	
	1. Yes	
	2. No	
	3. Don’t know	
76.	**Has anyone in this home ever been burned by molten lead?**	
	1. Yes	
	2. No	
	3. Don’t know	
77.	**Has anyone in this household ever swallowed a lead sinker?**	
	1. Yes	
	2. No	
	3. Don’t know	

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

....

....

....

END OF QUESTIONNAIRE

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

APPENDIX 2: ANTHROPOMETRIC TOOL (TOOL 2)

BLOOD LEAD STUDY

ANTHROPOLOGICAL SHEET

School:

Area:

Contact details:

Grade:

Date:

Number	Study ID	Consent	Sex	Weight	Height
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

APPENDIX 3: BLOOD COLLECTION TOOL (TOOL 3)

BLOOD LEAD STUDY

BLOOD SHEET

School:

Area:

Contact details:

Grade:

Date:

Number	Study ID	Consent	Sex	Blood taken	
				Yes	No
1					
2					
3					
4					
5					
6					
7					
8					
9					

APPENDIX 4: ETHICS CLEARANCE

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

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Dr Taskeen Khan

CLEARANCE CERTIFICATE	M111132
PROJECT	Exposure of Lead in Primary School Children in Six Fishing Communities in South Africa
INVESTIGATORS	Dr Taskeen Khan.
DEPARTMENT	School of Public Health
DATE CONSIDERED	25/11/2011
M1111320DECISION OF THE COMMITTEE*	Approved unconditionally

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

DATE 16/01/2012 **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 5: PERMISSION FROM WESTERN CAPE DEPARTMENT OF EDUCATION

WESTERN CAPE
Education Department
Provincial Government of the Western Cape

RESEARCH

Audrey.wyngaard2@pgwc.gov.za
tel: +27 021 476 9272
Fax: 0865902282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20120104-0017
ENQUIRIES: Dr A T Wyngaard

Dr Taskeen Khan
Environmental Health and Research Unit
Medical Research Council

Dear Dr Taskeen Khan

RESEARCH PROPOSAL: EXPOSURE OF LEAD IN PRIMARY SCHOOL CHILDREN IN SIX FISHING COMMUNITIES IN SOUTH AFRICA

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from 01 February 2012 till 30 March 2012
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number.
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

    The Director: Research Services
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.
Signed: Audrey T Wyngaard
for: HEAD: EDUCATION
DATE: 05 January 2012

MELD ASSEBLIEF VERWYSINGSNOMMERS IN ALLE KORRESPONDENSIE / PLEASE QUOTE REFERENCE NUMBERS IN ALL CORRESPONDENCE / NCEDA UBHALE IINOMBOLO ZESALATHISO KUYO YONKE IMBALELWANO

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GRAND CENTRAL TOWERS, LOWER PARLIAMENT STREET, PRIVATE BAG X9114, CAPE TOWN 8000

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APPENDIX 6: STUDY INFORMATION SHEET

PARENT/GUARDIAN INFORMATION SHEET

STUDY TITLE: Exposure of lead in primary school children in fishing communities in South Africa

Dear Parent/Guardian

I am Dr. Taskeen Khan and I will be doing the study above in collaboration with the University of the Witwatersrand and Medical Research Council. I will really appreciate participation of you and your child in my study.

Introduction:

The Medical Research Council (MRC) is conducting a children's health study at schools in some parts of the country. In this study, we would like to measure the levels of lead in the blood of grade 0, 1 and 2 children between the ages of five and eight years old who reside and school in fishing areas or towns. Previous studies conducted by the MRC showed high levels of lead in certain groups of children.

Invitation to participate:

We are asking you to take part in the research study and for your permission to include your child in the research study. There will be no costs incurred by either you or your child by participating in this study.

What is the study about:

This study is conducted to assess levels of exposure to lead of grade 0, 1 and 2 learners that reside in fishing villages. Lead is a heavy metal and is toxic and can cause serious health problems to individuals when exposed to them for extended periods of time.

What is involved in the study:

If you agree to take part in the study, we will ask that you complete a questionnaire which should take about 40 minutes. The questionnaire will focus on information about your child's health, housing conditions, school performance, household activities, lead smelting activities, fishing activities and socio-economic status.

We also ask that you allow us to take about a teaspoon of blood from your child (approximately 7 millilitres). A professional nursing sister or a medical doctor will take the blood sample at school. Sterile, disposable equipment will be used and discarded immediately. The technique is safe and there is only slight discomfort as the needle passes through the skin. Over the years we have sampled blood from thousands of children without any problems.

Risks:

There is minimal risk involved; your child may feel a small pain as the needle passes through the skin in the child's arm. In addition there may be some bruising and/or light headedness. If discomfort is experienced in answering some of the questions or during any of the procedures described above, assistance will be provided on site. You are also free to withdraw your participation at any point during the process (without having to give reasons) and do not have to answer questions you are not comfortable with.

Blood Results:

Your child's blood sample will be sent to the laboratory in order to test if they have high levels of lead in your blood. You as a parent or guardian may call us at any time to obtain your results. If your child has very high levels of lead we will let you know so that you can get the help that you need. You will then need to contact a doctor or local clinic for further assistance for your child.

Benefits:

The study will produce data that will help us understand what children are exposed to in their daily lives living in close proximity to fishing villages. This data may be very helpful in our efforts to protect South African children. Similar MRC studies on blood lead levels have contributed to major public health achievements such as the removal of lead from petrol and from paint.

Participation is voluntary:

To be able to include your child in the study you have to sign a form saying that you give us permission to do so. If you do not want to participate, nothing will happen. You may also discontinue participation in the study at any time without giving reasons and without penalty or loss of any benefits, and your child's schooling will not be influenced.

Confidentiality:

We will make every effort to keep personal information confidential. Personal information will only be disclosed if required by law. When the interviews are completed, the forms containing your personal information will be kept separately in a locked cupboard at the Medical Research Council.

The results of this study may be published, but the names of participants will not be given to anyone. The study findings will be reported to the school principals and representatives from the department of education. If you would like to, we would be pleased to let you have the results of your child's blood tests after the study is completed.

This study has been approved by the Witwatersrand University's Human Research Ethics Committee – Medical (HREC). You may contact the HREC ethics committee at telephone number 011 1234.

If you would like to discuss the study further, or have any questions, please do not hesitate to contact Dr Taskeen Khan, telephone: 0786936695

APPENDIX 7: INFORMED CONSENT

PARENT/GUARDIAN INFORMED CONSENT

Name and surname of parent/guardian	Name of school
Name and surname of child	Name of class
Street address	Name of teacher
Age of child	Study code

I,……………………………………………………………………………………………

(Full name(s) and surname of parent/guardian)

hereby agree to have my child participate in the Medical Research Council's school health study. I have been informed about the study goals and I understand that my child will be expected to donate a small amount of blood (about 7 millilitres). The blood sample will be taken by qualified medical personnel under aseptic conditions. My child's height and weight will also be measured.

I understand that I will be expected to complete a questionnaire.

I understand that ethical approval for this study has been obtained.

I participate in this study on condition that all results will be treated with strict confidentiality.

I acknowledge that the results of this research project will be published in medical and scientific journals. However, my child's name will not be mentioned.

I understand my participation is voluntary, and that I am free to withdraw from the project at any time without giving a reason or prejudice.

Parent/Guardian's
Signature…………………………………………..date…………………………

APPENDIX 8: CHILD ASSENT SHEET

<u>STUDY TITLE</u>: Exposure of lead in primary school children in 3 fishing villages in South Africa

<u>Good Day</u>

I am Dr. Taskeen Khan and I will be doing the study as a project. I will really appreciate if you participate in my study.

You are being asked to participate in this study because you are a pupil attending grade R or 0, or first grade or second grade at Bertie Barnard School in Stilbaai, Struisbaai Primere School in Struisbaai, Wagenhuis Primary School in Arniston, St Augustine's Primary School in Paternoster, HP Williams Primere in Stompneusbaai and NGK Primary School in Elands Bay in the Western Cape. Before you decide to take part in this study, we want to tell you about the study so that you may ask any questions that you may have.

<u>Why is the study being done?</u>

This study is done to test if some young children in South Africa may be exposed to some lead and if there is any connection to the use of lead fishing sinkers. The

Medical Research Council did a study before which showed that some children have high levels of lead in their blood. When a person has very high levels of lead in the blood they may get sick. In this study we will collect blood and personal information from grade R or 0, first grade and second grade schoolchildren in selected South African schools. A small amount of blood will be taken from you if you choose to take part in this study and will be used to check if you have high levels of any of these lead in your blood.

<u>What will I be asked to do?</u>

If you and your parent/guardian agree that you participate in the study a professional nursing sister or a trained medical doctor will draw about a teaspoon of blood from a vein in your arm. Your blood sample will be sent to the laboratory in order to test if you have high levels of lead in your blood. Your mother or father may call us at any time to obtain your results. If you have very high levels of lead we will let you and your parent/legal guardian know so that you can get the help that you need.

<u>Can bad things happen to me by being in the study?</u>

You may feel a small pain as the needle passes through the skin in your arm. In addition you may have some bruising, light headedness and there is minimal risk of infection. Over the years we have taken blood samples from thousands of children without any problems.

Your blood sample will have a barcode and your study number only, to ensure confidentiality. Only the researchers will have access to your information and it will not be made available to anyone except if required by law.

<u>What help might I get from being in the study?</u>

If the laboratory results show that you have alarmingly high levels of lead in your blood which could be harmful to your health - you and your parent/legal guardian will be told. This will help you in order to get the help that you need from the doctors.

In addition, by taking part in the study you will help us find out if there is a link between using lead fishing sinkers and children being sick from lead poisoning. This information will help other children living in your area and in South Africa.

Can I refuse to be in the study?

Yes you can refuse to be in the study and even if you say yes you want to be in the study – you can stop us at any time. If you decide not to take part in the study or if you change your mind we will not be upset with you and your teacher will not be upset with you either. If there is anything that you are not comfortable with regarding the study you can speak to your parents, your teacher, or anyone of us about it.

APPENDIX 9: CHILD'S STATEMENT OF ASSENT

SUBJECT'S STATEMENT OF ASSENT

The consent form has been read and explained to me and my parent/legal guardian has given me permission to participate in this study. My parent/legal guardian has been given a signed and dated copy of this consent form.

I have heard the information read to me. Yes/No

I have had my questions answered. Yes/No

I know that I can ask questions later if I have them. Yes/No

Child's Name ______________________ Date _________________________

Signature of Child ______________________ Date __________________________

Signature of Researcher/ Person Explaining Consent Form____________________

Date __________________________

Witness name ______________________

Date ___________________________

Witness signature ______________________