EFFECTS OF LEAD LEVELS ON INDOOR AND BUILT ENVIRONMENT IN IBADAN OYO STATE NIGERIA

BY

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ABSTRACT

Environmental exposure to lead, a highly toxic heavy metal, is a significant cause of human morbidity and mortality. However, the determination of lead levels in homes and built environment have not been well investigated in Nigeria. This study was designed to evaluate the lead levels in dust, paint, paint chips, soil and water; and to ascertain the geotechnical properties of soil in the home environment in Ibadan.

Four Focus Group Discussions (FGDs) were conducted and six hundred questionnaires randomly administered to evaluate knowledge about lead exposure in Ibadan. Responses were compared using Wilcoxon rank-sum tests for continuous variables and χ^2 for categorical variables at p = 0.05. Lead levels in paint from twenty-five samples obtained from five manufacturers were measured. Three-hundred samples from urban areas were taken randomly from dust from door step of the house entrances and window sills, paint chips from walls, soil at 2000mm from fence wall and 300mm depth from front and back of the houses and portable water from taps and their lead levels measured. Atomic Absorption Spectroscopy was used to determine the lead levels in these samples. Geotechnical engineering tests were carried out to determine the Maximum Dry Density (MDD), Optimum Moisture Content (OMC), Liquid Limit (LL), Plastic Limit (PL), and California Bearing Ratio (CBR) of the sampled soil.

Most respondents (86%) from the FGDs and the questionnaires (86%) had no knowledge about lead exposure in home environment. Twenty-four (96%) from the twenty-five paint samples exceeded the recommended lead level in paint of 90 ppm. Yellow paint had the highest lead level of 50,000 ppm; indicating high risk and white paint had the lowest lead level of 84 ppm. Dust lead levels from door steps of house entrances have average of 115.1 ± 1 12.9 ppm and dust lead levels from window sills have average of 83.3 ± 13.3 ppm; due to lack of proper regular cleaning. Paint chips lead levels from walls have average of 2,894.6 ± 79.5 ppm; due to flaking old paint that emits lead. Soil lead levels in front of houses have average of 135.3 ± 4.5 ppm and soil lead levels from back of the houses have average of 69.4 ± 5.9 ppm; due to lack of landscaping to cover exposed soil surfaces. Potable water lead levels have average of 0.21 ± 0.02 ppm, against recommended value of 0.01 ppm due to usage of lead water pipes. The values of the geotechnical parameters obtained ranged from 1.8 – 2.0 g/cm^3(MDD), 8.5 - 13.8% (OMC), 17.8 – 29.6% (LL), 14.2 – 23.4% (PL), and 59 - 95% (CBR); all within normal recommended values.

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The indoor and built environments in Ibadan are highly affected by high lead levels. Lead levels in paint used in homes should be reduced to minimize human morbidity and mortality. The usage of non-lead water pipes is highly recommended. Lead levels in soil in the home environment do not affect the geotechnical characteristics of soil.

Key words: Lead, Paint, Home Environment, Geotechnical Properties
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DEDICATION

This work is dedicated to my parents Mr. Thomas and Mrs. Theresa Akhabue who gave me the foundation for my academic pursuits and my lover and friend; Professor Clement Adebayo Adebamowo; 'alias honey king'; for his all-round unflagging support, encouragement and prayers. However, all glory belongs to God, the pillar that holds my life.

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CERTIFICATION

I certify that this work was carried outby Mrs. E. O. Adebamowo in the Department of Civil Engineering, University of Ibadan, Ibadan, Nigeria.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The home (indoor environment) is where we spend the highest amount of time in intimate exposure to our environment. While there is no comparative data available for Nigeria, Americans for example, spend 90% of their lifetime indoors and the comparative periods for other countries and populations will be similar. It is therefore important that environmental Engineers,Builders and Architects: ensure that the environment is physically and psychologically safe for human habitation and flourishing.The 2005 report of the United States' National Academy of Sciences titled "Informing the Future: Critical Issues in Health", said there is a

"Connection between human health and the natural environment that surrounds people, the "built" environment that they have designed and constructed, and the social environment in which they interact with one another. In Rebuilding the Unity of Healthand the Environment: A New Vision of Environmental Health for the21st Century(2001), workshop participants suggest that the infrastructure for linking environmental health and public health is not working as well as it should.Discussions of environmental health have become too narrowly focused aroundregulations, and particularly the effects of regulations on economic growth.Instead, the focus should be on creating and maintaining an environment thatis healthy and livable for humans and other species"

This and similar reports has increased interest in all aspects of the environment and the contents of the construction materials used for the "built environment" to ensure that these materials not only serve their primary purpose from the construction point of view but also contribute to the physical and psychological health of the occupants and are not as a source of sickness and death.

1.1.1 Lead Metal

One material that has been historically linked to ill health secondary to chronic exposure from building materials used to construct homes is Lead (Pb). Many industrialized countries continue to face challenges arising from chronic exposure to this metal in the home environment and there is increasing evidence that this is a challenge in developing countries too. In Nigeria in recent times, in addition to the

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exposure to lead from building materials and household environment, environmental exposure to this metal recently led to the death of hundreds of children in Zamfara State, Northern Nigeria. The international human rights organization, described this occurrence as the worst such episode in modern human history. (Human Rights Watch 2012)

Lead is one of the most ubiquitous poisonous heavy metals. It is distributed in the environment (air, soil, sediment, surface and ground water, food, dust, paint) and biological systems (Tong *et al*, 2000). It occurs both naturally and as a result of human activities(Needleman, 2004). Its atomic number is 82 and its electron configuration is *1s2 2s2p6 3s2p6d10 4s2p6d10f14 5s2p6d10 6s2p2*. In its standard state, it remains solid until 298 K and its atomic weight is 207.2. Macroscopically, it is a bluish-white lustrous metallic substance that is very soft, highly malleable, and ductile and a relatively poor conductor of electricity. It is resistant to corrosion but tarnishes on exposure to air and it has been used since antiquity as pipes for distribution of water to households.

1.1.2 Sources of Human Exposure to lead

One of the commonest sources of human exposure to lead is through exhaust from use of leaded petrol. However this practice is being discontinued worldwide(Anetor, 2001). Because of this, leaded petrol is no longer a major source of lead pollution leaving building materials and household environments as the current major source of exposure. For the purpose of this research therefore, focus was on exposure to lead in the domestic environment through materials like dust, paint, soil and water.

Lead-based paints are the most common sources of exposure of children to lead in the domestic environment (Sanborn *et al*, 2002). Use of lead-based paint was common in North America through the 1940s (Sanborn *et al*, 2002). However, by 1978, the Product Safety Commission in the United States of America banned the production of paint containing lead for use on the interior and exterior aspects of home surfaces, toys and furniture(Chisolm, 2001). In Nigeria, there is no evidence of similar restriction in the use of lead in paint. Furthermore, very little information is available from Nigerian paint manufacturers about the levels of lead in their products. In addition, there is significant amount of illegal paint importation into the country. However, the America Lead-based Paint Poisoning Prevention Act recommended that paint should contain less than 0.06 per cent (600 ppm) lead in the dried film. But, since 2006, the America Environmental Protection Agency (EPA) recommended

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0.009 per cent (90 ppm) of lead in paint. Presently, the regulatory and enforcement agencies of Nigeria have no recommended value for the country.

Nigeria, like many developing countries, has been undergoing severe economic crisis. This has led to significant reduction in activity in all aspects of the economy including the construction industry. As a result many housing units are old and have not been renovated for many years. They are therefore likely to have old, flaking paint which is associated with increased risk of lead poisoning. Common paints available in Nigeria are mostly the gloss and emulsion varieties for house paints and silken and auto base for vehicle paints. Other special types exist, with most manufactured in Nigeria. Most paints containers only indicate direction for effective use and they have no information on composition and the amount of lead in the paint.

Pipe-borne water is another common source of chronic low dose lead exposure in the domestic environment. Lead concentrations in drinking and ground water vary from 1 to 60 μg/dl depending on the area, water pit and the hardness of water(World Health Organisation, 1989). In some areas with soft water, leaded water pipes and solders, the level of lead in the water rises significantly(Elwood and Fischbein 1980). Previous reports from Nigeria revealed that water lead levels has increased in the past years, from less than 5 μg/dL (0.005mg/l) in 1993 in Ibadan areas(Omokhodion, 1994), to 2.16 mg/l in 1997(Adogame, 1997). Ordinarily, the concentration of lead in nature (e.g. ground and surface water) is generally low, but unwholesome human practices have led to somewhat increased levels in water especially run off water (World Health Organisation, 1995). With leaded water-pipes and solders, the level of lead in water can rise considerably(Elwood and Fischbein 1980). In Nigeria, there is poor municipal water supply with significant proportion of the population reliant on ground water and run-offs for their source of potable water. The lead level in such sources of water is often unknown and the water is hardly treated before use. However, several studies have shown that their levels were above the permissible levels (Sridhar and Okerearu 1999; Sridhar *et al*. 2000; Sridhar 2001).

Children can also be exposed to lead through dust inhalation and ingestion (Rhoads *et al*, 1999). In a survey of households in the United Kingdom, the total estimated lead intake of young children was 36 μg/day of which 1 μg/day was by inhalation and the rest by ingestion(Thornton *et al*, 1990). The amount of lead ingested depends on the lead level of the soil, the looseness and whether the area is

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landscaped. Within buildings, window wells are the strongest independent predictors of blood lead levels in children, regardless of the condition of the building(Potula*et al*, 2001).

1.1.3 Toxic effects of Lead Exposure

The toxic effects of lead involve several organ systems within the body (Goyer, 1993). Significant exposure affects the nervous, haematologic, renal and reproductive systems leading to anaemia, nephrotoxicity, developmental delays, hypertension and behavioural disorders etc. (Goyer, 1993; Goyer, 1995). While both adults and children can suffer from chronic low dose lead exposure, the effect is more severe in children. It also reduces children's IQ.(Baghurst *et al*, 1992; Lidsky and Schneider 2003; Bellinger 2004; Needleman 2004).

1.2 Statement of the Problem

There is a general lack of adequate knowledge about lead, lead exposure and lead poisoning in the home environment in Ibadan. Moreover, there is no clue about how to prevent lead in the home environment.

The regulatory and enforcement agencies in the country should provide guidelines in the manufacturing of paint. The America Environmental Protection Agency (EPA) has the most adequate level of lead in paint of 90 ppm. Meanwhile the amount of lead in paint in Nigeria is way too high compared to the global recommendation of 90 ppm. The high lead level in paint has emerged as a significant source of health problems to the occupant in the home environment. The soils around most buildings are not properly landscaped; hence the soil around the building accumulates lead posing health effects to the inhabitants. There is also a general lack of regular cleaning in homes; hence dust accumulates causing health effects to the occupants. Hence this study addressed the following research questions:

(i) What are the sources of lead in the home environment and what is the amount of lead level in paint in households in Ibadan?

(ii) What are the sources and amount of lead in the dust, soil and water found in surfaces around the house in Ibadan households?

(iii) Are the amounts of lead associated with dust, paint, soil and water in Ibadan households high enough to pose a health risk to the occupants of the house?

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(iv) What types of remedial measures are needed to reduce household exposure to lead in Ibadan households?

(v) What is the impact of knowledge about sources of lead in the home environment in Ibadan?

(vi) Does the level of lead in soil in the home environment affect the geotechnical properties of the soil?

1.3 Aim andObjectives of the study

The aim of this study is to evaluate the determinants of lead exposure in the home environment in Ibadan. In addition, to investigate if the lead levels in the soil in the home environment affects the geotechnical properties of the soil.

To achieve the above goal, the study focused on the following specific objectives to:

(i) highlight the dangers of lead, lead exposure and lead poisoning in the home environment in Ibadan.

(ii) evaluate the knowledge, attitudes and practices of lead and lead poisoning through Focus Group Discussions in Ibadan.

(iii) determine the knowledge, attitudes and practices of lead exposure and lead poisoning among Ibadan residents through self-administered questionnaires

(iv)evaluate the lead levels in samples of paints for home use sold in the Nigerian market

(v) ascertain the lead levels in household dust, paint , paint chips, soil and water.

(vi)identify correlates of high domestic lead levels in households in Ibadan.

(vii) ascertain to the Geotechnical properties of the sampled soils by carrying out engineering laboratory investigations on the soils.

(viii) highlighting the architectural and engineering significance of this study.

1.4 Hypothesis for the Study

The following hypotheses in null forms were tested for the study:

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H_{01}: There is no adequate knowledge of lead, lead exposure and lead poisoning in the home environment in Ibadan.

H_{02}: Paints sold in Ibadan are not a major source of environmental lead exposure in the home environment

H_{03}: Dust from homes in Ibadan is not a major source of environmental lead exposure.

H_{04}: Paint chips from walls from homes in Ibadan is not a major source of environmental lead exposure

H_{05}: Soil from front and back of homes in Ibadan is not a major source of environmental lead exposure

H_{06}: Water from homes in Ibadan is not a major source of environmental lead exposure

H_{07}: The presence of lead in the soil in the home environment affects the geotechnical properties of the soil.

1.5 Significance of the Research

Low level, long term exposure to lead such as that which can occur when lead-containing materials are used can lead to significant health problems. This can be a particular danger in children in whom it causes growth and developmental retardation. There exist prevention strategies at the child, family and community levels that can reduce the risk of this exposure and the danger that it poses to children and adult health.

In a study of the mechanism and pathways through which children living in cities can become exposed to lead exposure and the relative contribution of various sources, lead levels were significantly associated with children's blood lead levels, both indirectly and directly via the amount of lead in the hand of the children (Landrigan and Graef, 1987).Lead in the soil and paint contributed to the amount of lead in the dust, but paint contributed significantly more lead to home dust than soil(Potula *et al.* 2001). Finally, times spent outdoors were associated with children putting soil or dirt in their mouths, which was in turn, associated with children's blood lead levels. This data indicates that mouthing behaviours are an important route of exposure to lead among urban children and lead based paint is a more important contributor of lead to house dust than is lead contaminated soil(Potula *et aI*, 2001).

In a Saudi Arabian study, harmful effects of lead such as problems in the central nervous system, kidney, and haematopoietic system was seen in children at blood lead levels as low as 10 µg./dl. Dhaka, Bangladesh has one of the highest air lead levels in the world. In February 2001, 779 pupils, 4-12 years of age at five, primary schools were evaluated to determine blood lead levels, sources of environmental exposure and potential risk factors for lead poisoning. The mean BPb level was 14.0 mg/g/dl (Gilfillan 1965; Kaiser *et al*, 2001). Recent prevalence studies show that over 90% of children in urban and rural communities of Cape province, South Africa have blood lead levels =/>10 mg/dl. Studies in other countries likewise suggest that childhood lead poisoning is a widespread urban health problem throughout the continent of Africa(Nriagu *et al*, 1996). Other studies have shown that there are substantial benefits from reducing lead exposure and that both expensive and inexpensive measures can reduce environmental lead exposure so this problem can be controlled and remediated where it has already occurred (Schwartz *et al*, 2000).

There is therefore an urgent need to define the contribution of building materials such as paint to the amount of lead that occurs in the paint in homes in Nigeria. Other sources of lead exposure such as dust, soil and wateralso need to be measured in order to ascertain whether they are at levels that are injurious to children's health and suggest appropriate prevention strategies.

The significance of this research to building professionalsis:

Since architects, builders and civil engineers are responsible for specification of building materials, the design of homes and landscaping to reduce dust exposure, knowledge of the health implications of the materials that they choose will inform their choice of building and construction materials such as housepaint, water pipes, and house dust materials.

Knowledge of the relationship between lead content of the dust in the environment and its impact on health will guide building professionals in recommending need for remediation and renovation of building and structures

Knowledge of the relationship between lead content in the dust, paint, soil and water in the environment and its impact on health will guide building professionals in educating clients about the value of landscaping their environment in other to reduce the risk of exposure to lead in soil.

Sometimes, soils in the home environment are used for small construction works around the house. It was appropriate to investigate if the presences of lead in these

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soils in the home environment affect their geotechnical properties thereby affecting the quality of the construction works.

1.6 Scope of the Study

This research covered selected households in Ibadan and involved individuals or groups living in the homes as well. Surveys of knowledge of members of the community was done in order to know their knowledge, attitudes and practices of lead and lead poisoning with the aid of four focus group discussions and six hundred randomly distributed self-administered questionnaires. Lead levels in household dust, paint, paint chips, soil and potable water were evaluated. The geotechnical properties of the sampled soils were also evaluated.

1.7 Limitations of the Study

1.7.1 Sampling Error: Survey of a random sample of homes instead of all the housing units may lead to sampling error. This is a function of sample size and sample design. Different samples of the same size using the same design will yield different estimates of the population parameter. Lead levels may vary from room to room within the same household and not all the rooms were sampled. There may be random variation in the measurements obtained from the equipment which can lead to measurement error.

1.7.2 Non-Sampling Error: This can arise as a result of unknown differences between homes that are included in the samples and those that were not, differential response rates among homes in the different local government areas and in different time periods, classification bias arising from the technology used to measure the samples and variation in lead levels between the rooms used in the survey.

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CHAPTER TWO

LITERATURE REVIEW

2.1 Lead in the Environment

This chapter surveys previous research and reviews evolving knowledge of the distribution, toxicology, and remediation of lead toxicology.Warnings of lead's poisonous properties extend at least as far back as the second century B.C.,when Nikander, a Greek physician, described the colic and paralysis that followed lead ingestion. The early victims of lead toxicity were mainly lead workers and wine drinkers. Lead's sweet flavor made it useful in wine making to counteract the astringent flavor of tannic acid in grapes. Lead-sweetened wine, containing as much as 20 mg of lead per liter, was an important part of the diet of upper – class Romans. The synchronous decrease in fertility and increase in psychosis among the Roman aristocracy has raised speculation implicating lead poisoning in the fall of Rome(Gilfillan, 1965)

Widespread outbreaks of lead colic continued in Europe until as late as the sixteenth century, when Eberhard Gockel, a German physician, traced a colic epidemic to lead – adulterated wine. Duke Ludwig of Wurrtemberg, upon learning of an epidemic of lead colic in his duchy,banned its use in wine making, imposing the death penalty for violators. Workers in the metals trade remain an important risk group; lead exposure remains one of the leading causes of workplace illness. In the United States, more than 320,000 American workers were occupationally exposed to lead in 1998(Needleman, 2004).

It was only a century ago that childhood lead poisoning was recognized. The rapid growth of scientific understanding can be divided into four stages. The first reports of lead- poisoned children in Brisbane, Australia, in 1892 were greeted with widespread disbelief that lead toxicity could afflict children (Gibson, 1892). Although the disease had reached epidemic proportions, there was considerable doubt that lead was the cause. Many of the homes in Brisbane were raised on piles, with large wooden- enclosed verandahs that served as play areas for children. The rails were painted with white- lead which chalked and powdered in the hot Brisbane sun. The cause of the epidemic, lead-containing paint, was established in 1904, and house paint was banned for household use in Brisbane in 1920(Needleman, 2004).Childhood lead poisoning was first described in the United States in 1914(Blackfan, 1917).

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The prevailing belief in the second stage of knowledge was that acute poisoning had only two outcomes: death or complete recovery without any residual effects. This misconception was discarded in 1943 with the first follow-up study of children who had recovered from acute toxicity. Nineteen of 20 survivors had significant deficits such as behavioral disorders, learning difficulties, and school failure(Byers and Lord, 1943).

World-wide, lead is present in small quantities in rocks, soil and plants(World Health Organisation, 1995). It occurs mostly as lead ores and Galena (Lead sulphide, PBS) is the major compound of lead that is associated with sulphide of silver, copper, arsenic, bismuth, antimony and tin(World Health Organisation, 1995). Commercial production of lead is usually through mining, smelting, refining and secondary recovery, all of which add to environmental pollution and degradation (World Health Organisation, 1989). Lead is abundant in the earth's crust compared to most trace metals, and has an average natural concentration of between 10 and 20mg/kg of earth's crust. Volcanic activities and emissions, weathering and emissions from sea spray contribute as natural sources;these and other minor sources amount to about 1900 tonnes per year world-wide (Nriagu, 1979).

Human activities have contributed enormously to natural inputs of lead in the environment.Industrial activities such as iron and steel production, copper smelting, coal combustion and addition of organic lead to fuel contribute to nearly 330,000 tons of lead being discharged into the atmosphere yearly (World Health Organisation, 1989). The amount of lead in plants as a result of root absorption is directly proportional to the concentration of lead in the soil (World Health Organisation, 1989). In Nigeria, there are small quantities of lead in Ogoja (Cross River State), Abakaliki (Ebonyi State), along Benue River in Taraba State (Wukari region) and in association with gold in Bagega, Zamfara State (Ndiokwere, 1984).

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2.1.1 Physical and Chemical Properties of Lead and its Compounds

Lead exhibits a characteristic bluish or silver-grey colour, and is a soft metal which can be cut easily with a pen-knife unlike gold and silver. The melting point is 327.5^0C and the boiling point is 1740^0C. Lead isotopes have atomic weights of 208, 206, 207 and 204 in order of abundance in the earth's crust. This property of appearing in four isotopic forms has been utilized in non-radioactive tracer studies to observe environmental and metabolic pathways of Lead (World Health Organisation, 1989). Lead has three oxidation states of +0, +2 and +4 and hence stands on the periodic system Group IVB metal order. The +2 oxidation is the commonest occurring form in inorganic salts of Lead; however, the +4 oxidation state is the most important in organo-lead compounds (World Health Organisation, 1995). The solubility of lead in water is affected by the pH of the aqueous medium. Lead chlorate and chloride salts are reasonably soluble in cold water and lead forms salts with organic acids like lactic acid, acetic acid and is quite stable as tetramethyl compounds of lead, though these last two compounds are insoluble (World Health Organisation, 1995).

Lead has high density and atomic weight and these properties have been utilized in radiological sectors to prevent irradiation of unwanted areas, and also lead coated with gold (by electroplating) has been a deceptive thing and can fool a novice due to its similar but different weight per size when compared to gold bars (Zielhuis, 1983).Table 2.1 shows the physical and chemical properties of lead.

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TABLE 2.1: Physical and chemical characteristics of Lead

STATE	SOLID PROPERTIES
Appearance	Bluish-grey
Chemical Class	Metal
Place in Periodic Table	System GRP IVB
Ato~~p~~mic Symbol	Pb
Atomic Number	82
Atomic Weight	207.20
Atomic Arrangement	Face-central cubic
~~Interatomic~~Inter atomic distance	0.349nm (3.49A)
Electronic configuration	2, 8, 18, 32, 14
Melting Point	328^{0}C
Boiling Point	1740^{0}C
Density at 20^{0C}	11.34g/cm^{3}
Normal chemical Valencies	2 and 4
Heat of fusion	26.2 KJ/Kg (6.260 Cal/g)
Tensile Strength	Fairly strong
Malleability	Low (Not easily malleable)
Specific Heat (0$^{0/c}$ to 100%)	127J (~~KjK~~KJ) (0.031 Cal/g/c)
Coefficient of Linear Expansion	0.000029^{O}C
Natural Isotopes	204 (11.4%), 206 (25.2%)
Artificial States	207 (21.7%), 208 (51.7%)
Radioactive Isotopes	195-203, 205, 209-214
As (alloys) formation	Forms alloys easily
Chemical Resistance	Resists attack by conc. H_2S0_4

Source: (Savory 1989)

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2.1.2 Uses of Lead and its Compound

Lead, (with its compounds and alloys) is one of the earliest metals known to man. It was used as early as 6,000 years ago in Asia Minor(Grandjean, 1979). Most of the lead produced is utilized in Europe (Britain primarily) and United States of America. Based on this, the following are the common uses of lead:

- Antiknock in petrol (Lead tetra alkyls)
- Grid structure and compounds in batteries
- Ammunition (shots, bullets and explosives)
- Pigments for paints and inks
- Foils on wine bottles
- Lead pipes and solders
- Electroplating on other metals e.g. Steel
- Covering for power and telephone cables
- Lead eye pencils and eye lids paints
- In accelerators in the rubber; artificial leather and linoleum industries
- Lead arsenate in insecticides
- As type-metal
- Caulking

Some modern uses of lead especially in urban industrialized or industrializing cities include use as sheets for roofing, pipes, blocks for screening off radioactive emissions and house paints(Lenihan and Fletcher, 1991)(WHO,1989). In food and consumables, lead is still being used to make cigarette wraps and in their butts, also in bottle closures for alcoholic beverages, in wines, locally employed in traditional remedies, quite useful in ceramic wares and in seams of cans used to store canned foods (WHO, 1995).

2.2 Human and Environmental Exposure

Natural environmental source of exposure to lead is low compared to man-made sources of exposure, which is primarily through emissions into the atmosphere in the form of combustion sources.The consensus of opinion is that children's primary route of lead exposure is through oral ingestion of lead-based paint and lead-contaminated soil(Needleman and Gatsonis, 1990). In contrast, the primary route of

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exposure in adults is inhalation of lead-containing dusts and fumes in occupational settings, particularly during mining, smelting, and refining operations or during battery manufacturing and reclamation operations. Some children of workers in occupations associated with high level of exposure to environmental lead also had elevated blood lead levels, which are believed to be a result from exposure to lead-contaminated clothing. Exposure to lead may also occur through eating or smoking in a lead contaminated environment (Sittig, 1991).

Lead based paint remains the most common source of lead exposure for young children. White lead paint containing up to 50% lead was in widespread use in the United States through the 1940s. Subsequent to this time period and up to the 1970s, binder paints containing 5% lead were more common. In 1978, the Consumer Product Safety Commission banned the use of paint containing more than 0.06% lead by weight in residential surfaces, toys and furniture (Environmental Protection Agency, 1990). It has been estimated, however, that 83% of privately owned housing units and 86% of public housing units in the United States built before 1980 still contain some lead-based paint(Environmental Protection Agency, 1990).

There is no information available on the amount of lead in paint in Nigeria because there is no requirement that paint manufacturers should indicate the level of lead in their paint. However, the Lead-based Paint Poisoning Prevention Act recommended that safe paint should contain less than 0.009% (90ppm) lead in the dried film. The level and distribution of lead paint in households is a complex function of history (age of wall paints and buildings), geography, and socio-economic factors. Common paints available in Nigeria are mostly gloss and emulsion for house paints and products like the silken and auto-base for vehicle paints. Other special types exist, with most manufactured in Nigeria. There are several paint industries in Lagos City alone.

Lead levels of up to 100 µg/l have been detected in run-off waters. Lead concentration in drinking-water and ground water varies from 1 to 60µg/dl depending on the area, water pH, and hardness of water (WHO, 1989). In some areas having soft water, with leaded water-pipes and solders, the level of lead in the water can be raised reasonably (Elwood and Fischbein, 1980). Previous reports by researchers in Nigeria revealed that water lead levels has progressively increased in the past years, with records of less than 5µg/dl (0.005 mg/dl) in 1993 in Ibadan areas (Omokhodion, 1994)to an estimated increased range of 0.01-2.16 mg/dl in 1997(Adogame,

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1997).Some amount of lead is added to water by painting of water storage container because most paints used contain lead chromate (Adebayo, 1997). Previous records of some quality parameter for water from wells in Idimangoro area of Lagos, showed 0.07 µg/l (lead) as of 1977 Federal Environmental Protection Agency ((FEPA 1991) signifying an increasing level to date.

Lead level in air is closely related to dust lead level, since it is through the former that the latter gets its exposure from. Most lead in ambient air is in the form of sub-micron-sized particles(WHO, 1995). Major sources of lead contamination of air include motor vehicles exhaust, pesticides, distillation and burning of coal, incineration of refuse and mining activities (Adebayo, 1997). One of the major sources of lead in Nigeria air is through gasoline combustion since Nigerian refineries produce only leaded fuels and about 70-80% of this is emitted as fine lead particles (Agbo, 1997). It has long been established that reasonable levels of lead can accumulate in both unprepared and prepared foods(Adeyemi, 1998).

The third U. S. National Health and Nutrition Examination Survey (NHANES III, 1988 to 1991) specifically addressed blood-lead levels in the United States and their correlation with socio-demographic factors. Notably, blood-lead levels were consistently higher for younger children than for older children, for older adults than for younger adults, for males than for females, for blacks than for whites, and for central-city residents than for non-central-city residents. Other correlates of higher blood-lead levels included low income, low educational achievement, and residence in the northeast region of the United States (Brody *et al*, 1994).

Most recently, phase II of NHANES III, as reported by the(Center for Diseases Control, 1997)continues to indicate declining blood-lead levels in the U.S. population. This recent update also confirmed that blood-lead levels among children aged 1-5 years were more likely to be elevated among those who were poor, non-Hispanic black individuals, living in large metropolitan areas, or living in older housing. During the 1991-1994 survey period, the mean blood-lead level of the U.S. population aged >1 year was 2.3 µg/dL, down from 2.8 µg/dL reported for the time period 1988-1991. The average blood-lead level of the most susceptible individuals (children) continues to decline with the most recent data reporting that among those aged 1-5 years, approximately 4.4% (890,000) had blood-lead levels >10 µg/dL, down from 8.9% (1.7 million) during the 1988-1991 survey period. More importantly, for children with blood lead >20 µg/dL (levels at which children may be at greater

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risk) prevalence has declined from 24.7% in 1976-1980 to 1.1% in 1988-1991, to 0.4% in 1998 (Center for Diseases Control, 1997). Despite these encouraging findings, the most recent data indicate that blood-lead levels vary considerably by age, sex, race/ethnicity, urban status, income, and other socio-demographic factors. Collectively, the result demonstrates a significant decline in blood-lead levels for the U.S. population and also for selected subgroups of the population. The NHANES data provide evidence that blood-lead levels for the vast majority of those assessed were below the CDC level considered to be the benchmark forintervention (10 ug/dl). The major causesof the observed decline were likely attributable to the removal of >99% of lead from gasoline and the removal of lead from paint, soldered cans, and plumbing systems (Table 2.2).

Due to the overall decline in blood-lead levels among the U.S. population, the 1997 CDC lead screening guidelines called for targeted screening of at-risk children which differs from the previous 1991 recommendation for virtually universal screening of children 12-72 months of age and recently noted that, "Many children, especially those living in older housing or who are poor, need screening and, if necessary, appropriate interventions to lower their blood-lead levels(Center for Diseases Control, 1997). At the same time, children living where risk for lead exposure has been demonstrated to be extremely low do not all need to be screened.

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Table 2.2: Blood lead levels –United States, 1991-1994

Black, non-Hispanic	21.9	(9.4 -51.1)	13.7	(9.1-20.6)	3.4	(1.4-7.9)	11.2	(6.7 -18.7)	4.3	(3.7-5.0)
Mexican American	13.0	(5.7– 29.8)	2.3	(1.1-5.1)	1.6	(5.5-5.2)	4.0	(2.2-7.2)	3.1	(2.7-3.5)
White, non-Hispanic	5.6	(2.2– 14.4)	1.4	(0.3-6.0)	1.5	(0.3-7.0)	2.3	(1.0 -5.0)	2.3	(2.1-2.5)
Income [e]										
Low	16.4	(9.9-27.2)	7.3	(4.6-11.4)	4.3	(2.1-9.1)	8.0	(5.4-11.7)	3.8	(3.3-4.2)
Middle	4.1	(1.3-12.8)	2.0	(1.0-4.1)	0.4	(01.-1.3)	1.9	(1.1-3.2)	2.3	(2.1-2.5)
High	0.9	(0.1-6.5)	2.7	(0.6-11.3)	0[f]		1.0	(0.3-3.4)	1.9	(1.7-2.1)
Urban status [g]										
Population ≥1 million	11.5	(6.4-20.2)	5.8	(3.2-10.4)	0.8	(0.3-2.1)	5.4	(3.0-9.8)	2.8	(2.4-3.2)
Population ≤1 million	5.8	(2.0-16.8)	3.1	(0.9-10.1)	2.5	(0.7-9.6)	3.3	(1.5-7.0)	2.7	(2.3-3.0)
Total	8.6	(0.1-6.5)	4.6	(2.9-7.5)	1.6	(0.6-4.4)	4.4	(2.9-6.6)	2.7	(2.5-3.0)

Note. Source: CDC DC (1997). Update: Blood lead levels- United States, 1991-1994. MMWR 46, 141-145.

[a] Sample size = 2392 and includes racial/ethnic groups in addition to those listed separately

[b] Age of housing was unknown by the household respondent for 11.7% of children aged 1-5 years, approximately 5.6% of these children had BLLs ≥10µg/dL.

[c] Confidence interval.

[d] Data for other racial/ethnic groups were too small for reliable estimates.

[e] Income categories were defined using the poverty-income ratio (PIR; the ratio of total family income to the poverty threshold for the year of the interview): low income was defined PIR≤1.300; middle as PIR 1.301-3.501. Persons with data missing for income were included in the analysis of income.

[f] No children in the sample had these characteristics; however, the true estimates divided into two categories; metropolitan areas with a population 1 million and metropolitan.

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2.2.1 Routes of Exposure

The consensus of opinion is that primary route of lead exposure is through oral ingestion of lead-based paint and lead contaminated soil (Needleman and Gatsonis, 1990). In contrast, the primary route of exposure in adults is inhalation lead containing dusts and fumes in occupational settings, particularly during mining, smelting, and refining operations or during battery manufacturing and reclamation operations. Some children of workers in occupations associated with high level of exposure to environmental lead also had elevated Blood lead, which is believed to be a result from exposure to lead-contaminated clothing. Exposure to lead may also occur through eating or smoking in a lead contaminated environment (Sittig, 1991) Lead base paint remains the most source of lead exposure for young children, while lead paint containing up to 50% lead in widespread use in the United States through the 1940s. Subsequent to this time period and up to the 1970s, binder paints containing 5% lead were more common. In 1980, the Consumer Product Safety Commission banned the use of pain containing more than (90ppm) lead by weight in residential surfaces, toys and furniture (Environmental Protection Agency (EPA) 1990. It has been estimated, however, that 83% of privately owned housing units and 86% of public housing units in the United States built before 1980 still contain some lead based paint (Environmental Protection Agency (EPA) 1990).

There is no information available on the amount of lead in paint in Nigeria because there is no requirement that paint Manufacturers should indicate the level of lead in their paint. However the lead-based paint poisoning prevention at recommended that safe paint should contain less than 0.009% (90ppm) in the dried film. The level and distribution of lead of paint in dwelling units is a complex function of history (age of wall paints and buildings) geography, and socio-economic factors.

Common paints available in Nigeria are most of the gloss and emulsion for house paints and products like the silken and auto base for vehicle paints. Other special types exist with most manufactured in Nigeria. There are several paint industries in Lagos City alone.

Lead levels of up to 100µg/dl depending on the area, water pH, and hardness of water (World Health Organisation, 1989). In some areas having water; with leaded water-pipes and solders, the level of lead in the water can be raised reasonably

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(Elwood and Fischbein, 1980). Previous reports by researchers in Nigeria revealed that water lead levels has progressively increased in the past years,with record of less than 5µg/d1 (0.005 mg/d1) in 1983 in Ibadan area (Omokhodion, 1994) to an estimated increased ranged of 0.01-2.16 mg/d1 in 1997(Adogame, 1997). Some amount of lead is added to water by painting of water storage container because most paint used contains lead chromate (Adebayo, 1997). Previous records of the quality of water from wells in Idimangoro area of Lagos, showed 0.07µg/1 (lead) as of 1997 signifying an increasing level to date. Lead level in air is closely related to dust level, since it is through the former that the latter gets its exposure from. Most Lead in ambient air is in the form of sub-micron-sized particles (WHO, 1995) Major sources of lead contamination of air include motor vehicles exhaust, pesticides, distillation and burning of coal, incineration of refuse and mining activities (Adebayo, 1997). The major source of lead in Nigeria air is through gasoline combustion since the Nigeria refineries produce only leaded fuels and about 70-80% of this is emitted as fine lead particles (Agbo, 1997). It has long been established that reasonable levels of lead can be observed accumulated in food products, both unprepared and prepared food (Adeyemi, 1998). The third U.S. National Health and Nutrition Examination Survey (NHANES III, 1988 to 1991) specifically addressed blood-leadLevels in the United State and their correlation with sociodemographic factors. Notably, blood-lead levels were consistently higherfor younger children than for older children, for older adults than younger adults, for males than or females, for blacks than for whites, and for central-city resident than for non-central-city residents. Other correlates of higher blood-lead levels included low income, Most recently, phase II of NHANES III, as reported by the (Center for Disease Control, 1997) continues to indicate declining-lead levels in the U.S. population. This recent update also confirmed that blood-lead level among children aged 1-5 years were more likely to be elevated among those who were poor, non-Hispanic black individuals, living in large metropolitan areas, or living in olderhousing. During the 1991-1994 survey periods, the mean blood-led level of the U.S. populated aged > 1 year was 2.31µg/dl, down from 2.81µg/dl reported for the time period 1988-1991. The average blood-lead level of the most susceptible individuals (children) continues to decline with the most recent data reporting that among those aged 1-5 years, approximately 4.4% (890,000) had blood-lead levels > 10 µg/l, down from 8.9% (1.7 million) during the 1988-1999 survey period. More importantly, for children with blood lead >20µg/dl (level at

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which children may be at greater risk) prevalence has declined from 24.7% in 1976-1980 to 1.1% in 1988-1991, to 0.04% in 1988 (Center for Diseases Control, 1997) Despite these encouraging findings, the most recent data indicate the blood-lead level vary considerably by age, sex, race/ethnicity, urban status, income and other socio-demographical factors. Collectively, the result demonstrates a significant decline in blood-lead levels for the U.S. population and also for selected subgroups of the population. The NHANES data provide evidence that blood-lead level for the vast majority of those assessed are below the CDC level considered to be the benchmark for intervention (10 µg/dl). The major causes of the observed decline are likely attributable to the removal of > 99% of lead from gasoline and to removal of lead from paint, soldered cans, and plumbing systems (Table 2). Due to the overall decline in blood-lead levels among the U.S. population, the 1997 CDC lead screening guidelines calls for targeted screening of at-risk children which differs from the previous 1991 recommendation for virtually universal screening of children 12 – 72 months of age. The Centre for Deceases Control recently noted that "Many children, especially those living in older housing or who are poor, need screening and, if necessary, appropriate intervention to lower their blood lead – levels. At the same time, children living where risk for lead exposure has been demonstrated to be extremely low do not all need to be screened'

2.3 The Toxicology of Lead

The main target for lead toxicity is the nervous system in both adults and children. Lead reduces children's Intelligent Quotient (IQ). It causes hyperactivity and colic in children. In adults, lead causes fertility and reproductive problems, hypertension, cancer of the lungs and liver. (Nriagu, 2004).

2.3.1 Absorption, Distribution, Excretion, and Elimination of Lead

Humans may begin to accumulate lead in their bodies either during prenatal development (from placental transfer due to maternal exposure) or following birth as a result of trace level exposure from a variety of sources. Adults absorb 5 to 15% of ingested lead and generally retain less than 5% of what is absorbed (Goyer *et al*, 1996). Young children absorb significantly more ingested lead (approximately 30-49%) than adults due to physiological and metabolic differences (Goyer *et al*, 1996). Once in the blood, lead is distributed primarily among three compartments – blood,

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soft tissue (kidney, bone marrow, liver, and brain), and mineral tissues (bone and teeth). The fractional distribution of lead in bone (contrasted with other body stores) increases with age from about 70% of body lead in childhood to as much as 95% with advancing age. Lead that is not absorbed by the body is excreted primarily through the faeces.

While information is available concerning the absorption of lead following direct inhalation, oral, and dermal exposure (largely from laboratory animal studies under controlled conditions), there is less information regarding the absorption of lead by humans exposed to environmental lead. This is particularly true of lead that may be ingested by children from lead-contaminated soil. In assessing potential exposures of young children to lead in soil, the Environmental Protection Agency (EPA) has generally relied on a computer model (UBK) to predict blood-lead levels, assuming that 30% of ingested lead will be absorbed. While this may be an approximate estimate for certain soils, studies of soil ingestion in young children in several mining communities have revealed much lower blood-lead levels than predicted by the EPA model using default assumptions (Schoof, Steele et al. 1993) This suggests that lead absorption under experimental conditions may not be reflective of absorption under real-life

conditions of exposure.

Finally, the overall nutritional status and eating behaviour of individuals influences the absorption and toxicity potential of lead in several ways. Lead intake from water and other beverages tends to be absorbed to a greater degree than lead in food, while lead ingested during fasting conditions is absorbed to a greater extent than lead ingested during food consumption (Mahaffey, 1990). Lead interacts and competes physiologically with several essential elements, principally calcium, iron, and zinc, and dietary deficiencies of calcium and iron clearly enhance the absorption of lead (Goyer, 1996). (Benton and Buts, 1990) have recommended the insurance of an adequate daily supply of iron and calcium in the diet for this reason.

2.3.2 Health Effects of Lead

The toxic effects of lead may involve several organ systems within the body and vary from subtle biochemical effects, which are not adverse but rather indicators (biomarkers) of exposure, to clinical or overt effects such as lead poisoning

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(plumbism)(Goyer, 1993). Frank anemia may occur at 80 μg/dl, while reduced hemoglobin production may occur at lower blood-lead levels (above 50 μg/dl lead in blood in adults and 40 μg/dL in children (Goyer, 1996).

Neurotoxicity and chronic kidney toxicity are the chief concerns for adults with excess occupational exposure to lead. Nerve conduction velocity is reversibly slowed in peripheral nerves at blood-lead levels of 30 μg/dL, whereas overt effects on the nervous system, such as wrist drop, require blood-lead levels of 60 μg/dL or greater (Goyer, 1996). The adverse effects of lead on the kidney have been well documented (Goyer, 1971). Acute lead poisoning, in both humans and experimental animals, produces similar functional and morphological changes in the proximal renal tubular lining cells. These changes may progress to diffuse nephropathy with tubular atrophy and dilatation. It has been suggested that chronic and excessive lead exposure may result in end-stage renal disease(Wedeen, 1982). The unrecognized lead toxicity may also be responsible for gout and hypertension associated with renal disease. As is noted inEnvironmental Protection Agency's report, chronic nephropathy such as described above requires relatively heavy exposure to lead(Environmental Protection Agency, 1986). The blood-lead levels in the range of 40-80 μg/dL are associated with the formation of nuclear inclusion bodies in the renal tubular epithelium as the first manifestation of lead accumulation in the kidney.(Goyer, 1993). Nuclear inclusion bodies as well as cytomegalic, swollen mitochondria, and increased number of iron-containing lysosomes in proximal tubule cells are reversible lesion. General population studies have observed correlations between blood-lead levels and renal parameters such as decreased creatinine clearance rates, increases in serum creatinine, and changes in kidney function. The results of occupational studies indicate that maintaining blood-lead levels below 60 μg/dl will prevent renal changes in the majority of lead-exposed workers. Subtle alterations in renal biomarkers have been observed below this level, although there is no evidence of clinical renal dysfunction at these low blood-lead levels. The biological significance of these changes needs further clarification as does the role of confounding exposure to other substances such as cadmium, an important variable in occupationally induced renal disease.

Bone is a major organ for lead deposition and skeletal lead has been used as a measure of cumulative lead exposure (Hu *et al*, 1996). Lead has also been suggested to affect bone function by altering growth and stature and perturbing vitamin D

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metabolism. It is currently unclear whether these represent direct or secondary effects of lead exposure. Some scientific evidence suggests that the presence of lead in bone may produce subtle alterations in the cells that are responsible for bone metabolism. However, because of the problem associated with extrapolation of effects observed in cell culture lines to humans it is difficult to determine the potential relevance to bone metabolism in humans.But while cellular and molecular actions of lead in bone have been well documented in several *in vitro* and *in vivo* studies using diverse biological systems, it is difficult to separate the direct from the less direct actions and experimentally characterizing those actions as key and obligating events in chronic lead toxicity.(Pounds *et al*, 1991).

Questions have been raised about the possible effects of lead upon vitamin D metabolism, an effect which could be mediated through the kidney. It has been reported that associations between blood lead and decreasing levels of vitamin D metabolite over blood lead ranging in concentration from 2 to 12 µg/dL (Rosen and Markowitz, 1980). No threshold for this effect could be demonstrated and it was speculated that lead at low exposure levels may result in an interference with vitamin D metabolism with possible adverse effects on bone growth in children. However, Koo and Succop measured indices of vitamin D metabolism in 105 children with average lifetime blood-lead concentrations of 4.8-23.6 µg/dL and concluded that there was no effect on vitamin D metabolism, calcium and phosphorous homeostasis, or bone mineral content in children whose nutritional status is adequate and who experience low to moderate lead exposure (Koo *et al*, 1991)

The reproductive toxicity potential of lead has been recognized for some time. Severe lead intoxication is associated with sterility, abortion, stillbirths, and neonatal morbidity and mortality from exposure in uterus (Bellinger *et al*, 1987). The evidence for low-level exposure, however, is less suggestive. Current research has focused on the prenatal effects of lead at low exposure levels. A review of the literature indicates that prenatal lead exposure can alter the developing brain of some experimental animals, but it has proven difficult to demonstrate similar prenatal effects of lead on neurodevelopment in infants and children (Ernhart, 1992). There has been limited evidence that higher prenatal exposures (resulting in maternal blood-lead levels >15 µg/dL) are associated with reduced birth weight or increased risk of preterm delivery

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(Fahim *et al*, 1976). Most data on these outcomes are either contradictory or demonstrate no effect.

Spontaneous abortions are not apparent at maternal blood-lead levels less than 30 µg/dL and the weight of evidence suggests that lead does not cause congenital anomalies (Fahim *et al*, 1976).

Despite the large number of studies conducted on male reproductive function in workers occupationally exposed to lead, definitive statements on the effects are difficult to make. The existing scientific uncertainty is reflective of the difficulty inherent in conducting studies of this complex endpoint. Small cohort size, mixed exposures in the workplace, and lifestyle confounders conspire to hamper the interpretation of the database. The available data indicate that extremely high lead exposure can have a marked adverse impact upon semen quality. Aberrant sperm morphology, decreased sperm count, and decreased sperm density have all been demonstrated in heavily exposed individuals (Hu *et al*, 1992). However, it is not possible to precisely define the levels of exposure at which these effects will be exerted. General population and occupational exposure levels less than approximately 50 µg/dL appear to have little, if any, impact on sperm parameters. With the exception of the early studies of some authors, currently available evidence suggests that the effects on semen quality are most likely to occur when the blood-lead levels of individuals are consistently elevated to levels of 50-60 µg/dL or higher. ;(Lancranjan *et al*, 1975; Tuohimaa and Wickmann, 1985).~~(Tuohimaa and Wickmann 1985)~~ The evidence suggests that lead may affect semen quality impairing spermatogenesis, which is likely mediated by perturbations in endocrine function (Sokol *et al*, 1994) Several studies have documented similar hormonal mechanisms in primates Even though the precise mechanisms by which lead impairs spermatogenesis is not known, the primary risk associated with this endpoint is likely to be impaired fertility. In total, most studies assessing male exposure to lead have observed no impact on male fertility (Coste *et al*, 1991).

Lead has been classified as an animal carcinogen, but data on human carcinogenesis are considered inadequate. Some recent studies of cancer rates in lead trade workers (e. g., smelters, painters, and body and fender repairmen) have shown an increase in standard mortality rates, but others have not (Landrigan *et al*, 2000).

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Hypertension has been associated with acute lead poisoning, along with renal failure. At lesser exposures, both experimental and epidemiological evidence of interference with renal ~~fuction~~function and elevations in blood pressure have been reported. Using data from the third National Health And Nutrition Examination Survey (NHANES III), a recent reevaluation of blood pressure in relation to contemporary blood lead levels found out that black men and women had higher blood lead levels (5.4µg/dl, 3.4 µg/dl) than their white counterparts (4.4 µg/dl, 3.0 µg/dl).Black subjects, both men and women, had a statistically significant association of blood lead with blood pressure after covariate adjustment. The association was not seen in whites~~.~~(Vupputuri *et al*, 2003).

2.3.3 Effects on Children's Development

The outcome that has received the most attention and discussion is the potential effect of lead overexposure on the nervous system of children (Needleman and Landrigan, 2004). More specifically, studies have associated lead overexposure with decreased intelligence, reduced short-term memory, reading disabilities, and deficits in vocabulary, fine motor skills, reaction time, and hand-eye coordination. During the past two decades, there have been a number of epidemiological studies relating blood-lead levels at the time of birth, during infancy, and through early childhood with measures of psychomotor, cognitive, and behavioural outcomes.

(Pocock *et al*, 1994) reviewed the epidemiological evidence concerning environmental lead and effects on children's intelligence. They~~researchers~~ sought to quantify the magnitude of the relation between full-scale IQ in children aged 5 or greater and their body burden of lead. To assess this potential relationship, Pocock reviewed 26 epidemiological studies published since 1979 including prospective studies of birth cohorts, cross-sectional studies of blood lead, and cross-sectional studies of tooth lead.

F~~The f~~ive prospective studies with more than 1100 children revealed no association of cord blood lead or antenatal maternal blood lead with subsequent IQ performance. Blood lead at around age 2 had a small and significant inverse association with IQ, somewhat greater than that for mean blood lead during the preschool years.

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The 14 cross-sectional studies of blood lead (3499 children studied) indicated a significant inverse association overall, but revealed more variation in their results and their ability to allow for confounders. The 7 cross-sectional studies of tooth lead (2095 children studied) were more consistent in finding an inverse association, although the estimated magnitude was somewhat smaller. Overall synthesis of these studies, including a met analysis, indicates that a typical doubling of body lead burden (from 10 to 20 µg/dL) blood lead is associated with a mean deficit in full-scale IQ of around 1-2 IQ points. They ~~(Pocock, Smith et al. 1994)~~ concluded that while low-level lead exposure may cause a small IQ deficit, other explanations or influencing factors need to be considered, including (1) whether ~~are the~~ published studies are representative, (b) is there sufficient control for confounders, (c) are there selection biases in recruiting and following, and (d) do children of lower IQ adopt behaviour which makes them more prone to lead exposure and uptake (reverse causality)? Because of these uncertainties, they~~(Pocock, Smith et al. 1994)~~recommended that public health priority and attention be devoted to detecting and reducing moderate increases in children's blood lead while evaluating the social and biological detriments that impede intellect and influence behaviour in children.

2.3.4 Additional Consideration Concerning Lead and IQ

In the last one and a half decade, there has been this notion whether children's IQ is affected only by high blood lead levels. But recently, according to Canfield (Canfield, *et al*, 2003)blood lead concentrations even those below 10 µg/dl are inversely associated with children's IQ scores at three and five years of age, and associated declines in IQ are greater at these concentrations than at higher concentrations. These findings suggest that more U. S. children may be adversely affected by environmental lead than previously estimated. In reference to this, there is need to attest to how ~~to how far~~ Nigerian children's IQ is affected by the level of lead concentrations in their blood.

2.4. Appraisal of the Global Awareness of Lead

In this section, we review data and works on lead and its effects from different parts of the world.

2.4.1 Lead Exposure in Homes in America

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Approximately 42 million houses contain lead paint and 1.8 million children live in homes with deteriorating lead paint(Potula *et al*, 2001). About 3 to 4 million American children are affected by lead exposure leading to impairment of their growth and development (Hotz *et al*, 1998). Fifty two per cent of all residential housing units have lead paint at concentrations of 0.7mg.dl or higher.

2.4.2 Lead Exposure in the United Kingdom, Europe and Asia

Studies from several countries in Europe and U.K. confirm that lead exposure is a significant health problem (Gil *et al*, 1994; Maravelias *et al*, 1994; Pocock *et al*,1994; O'Donohoe *et al*, 1998). An evaluation of the blood lead levels of the general population in Taiwan also showed that the degree of lead exposure is similar to that in other developed and developing countries(Liou *et al*, 1994).In China, comprehensive epidemiological data relating to the prevalence of childhood lead poisoning are not available. However, existing data suggests that this disease may be widely pervasive as a result of rapid industrialization and the use of leaded gasoline. Several publications have reported elevated blood lead levels in children from different areas of the country. Children residing in industrial and busy traffic areas had average blood lead levels (BPb) of 21.8-67.9 mg/dL. The percentages of BPb values above 10 mg/dL, which is the definition of lead poisoning in children ranged from 64.9% - 99.5%. Even for "unexpected children, about 50% of them had BPb values above 10 mug/dL. From several retrospective pilot studies conducted in Shanghai, Shenyang, Fuzhou and Beijing to evaluate the health effects of lead at current degree of exposure. The link between low-leveled exposure deficits in IQ, neurobehavioural development and physical growth is remarkably consistent without exception. In summary, the harmful health effects of childhood lead poisoning in limited studies of exposed and unexposed children demonstrate that this totally preventable disease warrants considerable public health attention in Chinae.

2.4.3 Lead Exposure in the Middle East

In Egypt, the mean blood lead level (22.1 µg/dL) was significantly higher in urban children living in Alexandria than in rural children from Kafr El-Sheikh (14.2 µg/dL) and a major proportion of children in Alexandria have blood lead levels greater than 20 µg/dL(Omar *et al*, 2001). This was attributed to the greater

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industrialization of the city centre; exhaust fumes from cars, industrial emission and use of canned food and possible water contamination(Omar *et al,* 2001). In Saudi Arabia, children above 6 years of age, boys also had higher blood lead concentration than the similarly aged girls.(Alsaleh*et al,* 1994)

2.4.4 Lead Exposure in Africa and Nigeria

African children are particularly predisposed to environmental lead exposure, because of their lifestyle and socio-ecological factors\(Ankrah *et al*,1996; Mathee *et al,* 2003; Ozden *et al,* 2004;). But the true picture of childhood lead poisoning in Africa is poorly documented. Prevalence studies show that over 90% of the children in urban and rural communities of the Cape Province, South Africa have blood lead levels greater than or equal to 10 µg/dL(Grobler *et al,* 1996). Studies in other countries also suggest that childhood lead poisoning is a widespread urban health problem throughout the African continent(Nriagu *et al,* 1996). One study showed that adult Nigerians living in Ibadan have mean blood lead levels of 11.4 µg/dL (women) and 12.3 µg/dL (men)(Omokhodion, 1994), while a recent study showed that this has risen to a mean(SD) of 27.7(6.6) µg/dL with some variation in levels between Ibadan metropolis (mean[SD] of 30.1[1.47] µg/dL) and less urbanized towns like Iseyin, Shaki, Ogbomosho and Sokoto(mean[SD] of 28.8[1.22] µg/dL)(Anetor, 2001).This study is the first report in Africa on lead exposure in the home environment. (Clark *et al,* 2009)

2.5 Methods of reduction of exposure to lead

Because lead has no known useful function within living systems, it is necessary to protect individuals from excessive lead exposure and to educate the general population about how they can reduce their exposure. In the United States, major federal programmes have been introduced to reduce lead level in the environment(Mahaffey *et al,* 1982). Their success had been demonstrated by dramatically lower blood-lead levels in the U.S population(Stephenson, 2003). Approximately 95% of all young children in the United States currently have blood-

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lead levels under 10µg/dL supporting the CDC statement that childhood lead poisoning is not "a major environmental health problem in the United States but it remains a disease of the poor and under privileged" (Brody *et al,* 1994). The current mean blood-level in the U.S population is 2.3 µg/dL (1991-94 time periods) down from 2.8 µg/dL during 1988-1991 time periods(Center for Diseases Control, 1997). Current data indicate, however, that 430,000 U.S children are estimated to have blood-lead levels above 10µg/dL, a level at which significant effects are more likely to be clinically evident(Grigg, 2004).

2.5.1Reduction of Domestic Lead Exposure

Chelation methods have been proposed to reduce the amount of lead in the body, however, this has not been uniformly successful hence the importance of primary prevention and lead abatement activities(Ruff *et al,* 1993; Chisolm 2001; Shannon *et al,* 2001; Liu *et al,* 2002).

2.6Paint

Paint is a coloured substance which is spread over a surface and dries to leave a thin decorative or protective coating in form of a solid film. Paint can be referred to as a substance composed of solid coloring matter suspended in a liquid medium and applied as a protective or decorative coating to various surfaces. Paint can also be defined as a liquid suspension of a solid coloured material called the pigment, which is applied to surfaces for protection and decorative purposes (Allen, 1950).

Paints are applied on different surfaces, there are household paints used in painting different parts of a house, car paints, paints used for protection of ships, paints used for lane demarcation on roads, paints used for artistic and structural materials etc.

Household paints are of 2 classes:

- Orthodox, or oil-based paints, and
- Emulsion or water-based paints.

Orthodox paints are thinned wit organic solvents, while emulsion paints are thinned with water.It was initially thought that properties of orthodox and emulsion paints were superior for different applications (e.g. orthodox paints were suitable for external joinery, and emulsion paints for masonry). Recent discoveries have disproved this; it is now difficult to choose the class with superior properties.

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Paint is made up of pigment, binder and solvent. The pigment is the solid colouring matter, while the binder and solvent, both referred to as the vehicle are liquid medium in which the pigment is dispersed.

More than 35 000 years ago, ancient man described his hunts on cave walls using paint made from clay, chalks, and animal fat. Egyptians improved the paint technology by 2500BC, a blue pigment was made by grinding azurite; wax gums, and egg white were used as solvents and binders. The Greeks, by the first millennium BC developed the technique of blending paints with hot wax instead of water. As a result, they discovered the art of blending colours, and made thicker and easier to spread colours. Natural and synthetic sources of colours were used, the techniques were passed from one generation to the next, and in the 18th century, paint factories were established in Europe and America. In the 19th century, it became more affordable to paint houses as increased supply of paints reduced their prices. In the twentieth century, paint manufacture moved from being an art to a science as the chemistry of paint manufactured became clearer (Clark *et al*, 2012).The chemistry of these components is outlined below:

Binder: this is a component which is present as a liquid in the paint; it solidifies after the film has been applied. Binders are usually high molecular weight organic compounds; they hold the paint to the surface to which it is applied. They are polymeric substances that can either be dissolved in the paint or suspended in it by emulsifiers. The commonest binders are drying oils, they dry to form continuous skin when spread out in a film. Example of drying oil-Linseed oil, dries in 2-3 days; Soya bean oil dries in about 10 days (Clark *et al*,2012).Drying oils have been used as sole binders; they can also be converted to or combined with alkyds, epoxies, polyurethanes etc. to form binders with improved film properties. Whilst all oils used in binders have glycerol as a common polyol, the nature of the fatty acid can vary considerably. The chin length can vary from nine to twenty two carbon atoms; the degree of unsaturation can also vary. The configuration of the double bonds can also vary, where they are conjugated they are oxidized more readily thus giving more rapid and complete air-drying characteristics. All oils contain mixed fatty acids but a fairly constant ratio.

Binders can be converted to solids by any of the following processes:

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Auto-oxidation- the binder is oxidized by oxygen present in the air to form a higher molecular weight solid.

Solvent loss- evaporation of the solvent

Chemical cross-linking- the components of a binder can be cross-linked to form high molecular weight solid by the introduction of catalysts.

Binders have been classified into two based on the type of films they form:

(a) **Convertible-** the film is formed by solvent evaporation and can be resolves when the solvent is applied.

(b) **Non-convertible**- after the evaporation of the solvent, the film is formed by chemical reaction. Application of the solvent can't re-dissolve this film.

Pigments: are made up of tiny solid particles and they have the following functions:

- They provide colour, opacity and gloss;
- They refract due to their small size.
- They reinforce the durability of the binder;
- They provide protective functions to the surface underneath the paint from corrosion and weathering and the binder from destruction by UV.

The pigment has to be evenly dispersed throughout the solvent to be effective. Pigments are broadly classified as:

Organic- arylamide yellow, diarylide yellow, barium red 2B toner, nickel yellow, copper phthalocyanine, quinacridone red, dioxide, iron oxides, violet, perylene, thioindigo etc.

Inorganic- carbon black, titanium dioxide, iron oxides, zinc chromates, azurite, chromium oxide, cadmium sulphide, lithopone, lead antimony oxide, tin oxide, zinc oxide etc.

The colour of organic pigment is due to light energy absorbed by the delocalized electrons of a conjugated system. The electrons do not usually absorb all wavelengths of light, so some frequencies are allowed to pass through. It is this unabsorbed light that we see, so the colour of a given pigment is the opposite colour

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of the frequencies absorbed by the molecule. The greater the number of conjugated bonds in a system, the lower the energy of light absorbed, thus a molecule with little or no conjugation will absorb in the UV (and hence appear white), whereas one with more conjugation will absorb in the blue and appear yellow, or in the green and appear red etc. functional groups that absorb visible light (and hence appear coloured) are called 'chromophores'. Antimony was used as a hiding agent, opacifier, in glasses in the Roman and pre-Roman period. White lead was replaced by tin in glass around 400 A.D. tin oxide appears as the whitening material in glazes, forming the base of the Iznik and Majolica glazes. Lead has been used as inorganic pigment in paint for over 2000 years. It is stable and has good hiding power, it is also added to paint to speed up drying, increase durability, maintain a fresh appearance, and resist moisture that causes corrosion. The discovery of lead's toxicity led to its replacement with other pigment and driers.

Zinc oxides were introduced as a competitor to lead carbonate. They did not acquire a large market share of their poor ability to cover underlying layers of paint.Zinc white is less opaque and weaker in tinting strength than either titanium white or lead white. It is commonly used to lighten mixtures subtly while maintaining transparency. Zinc white dries slowly and creates a relatively inflexible paint film. It has been argued that its use leads to excessive cracking and delamination, even when used sparingly.

White lead was replaced with a less toxic substitute – titanium white (based on the pigment titanium dioxide). Titanium dioxide, a white pigment has been agreed to be the most important pigment in use today, it was introduced into the market in the very late 1910s – early 1920s but did not take large market share until after World War II. Titanium dioxide is considered safe enough to use as a food coloring, used in toothpaste, and in sunscreen. It is often coated with silicon or aluminum oxides for durability in paints (ATSDR, 2007).

Special pigments can be used to give metallic finishes (for example for car bodies), to be hard wearing (for road markings) etc. in choosing pigments, the following properties should be considered: durability, cost, opacity, toxicity, etc.

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Solvents: ensure even mixing of the paint components, and make then easy to apply, the solvent evaporate on drying, leaving behind, the binder and pigment. In certain cases, the solvents can actually react at the same time as the binder to form a solid. Solvent selection is dependent on the consideration of the rate of drying/evaporation rate required, cost, viscosity, specific gravity and chemical nature of the solvent. The solvents used also depend on the way in which the paint will solvents in spray paints need to evaporate much more quickly than those in brush-applied paints. In general, a blend of solvents is use to produce a paint that will surface and dry throughout at the correct rate without uneven shrinkage. White spirit and mineral turpentine are the most widely used solvents; others are toluene, methylethyl ketone, methyl isobutyl ketone, butylcetate, etc. (Clark *et al*, 2012). A solvent must be chosen that dries evenly, and in which the binder is soluble but not so soluble that it won't polymerise. For emulsion paints the solvent is simply water.

Additive: are included for specific properties such as improved flow, dispersion, stability, speed of reaction etc. example are abietic acid, phenolic resins, cobalt, lead, manganese, iron etc. Additives are introduced only when combination of primary ingredient does not give the precise properties required. For commercial purposes additives termed driers, anti-skin, catalysts, thickeners, fungicides or bactericides can be added.

Extenders: Paints are often formulated with extenders, which are mineral/organic compounds that do not provide any staining power or opacity. Extenders may be used to improve the application characteristics, as 'flatting agents' to provide flat or semi-gloss finishes, to prevent settlement of pigments or provide better keying (sticking) properties for subsequent coatings, and to provide properties such as durability, adhesion flow, gloss, etc. they are also used to reduce the high opacity of pigment such as titanium dioxide (Allen, 1950). Common extenders are-whiting ($CaCO_3$), talc, barytes/barium sulphate, kaolin, silica, mica, calcium sulphate, etc. (Clark *et al*, 2012).

The present emphasis on environmental friendliness has brought about a renewed interest in the use of non-edible Nigerian seed oils as binders in paint manufacturing. Attention is focused on these non-edible seeds due to the fact that they are indigenous, and their use will prevent them from being discarded as wastes.

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2.6.1 Lead in Paint

Lead is a highly toxic metal used by paint manufacturers to make paint glitter and last longer. Lead, a malleable metal is found in the earth crust. Lead is also produced during a variety of human activities like mining and the burning of fossil.

At low-level exposure, lead poisoning in children under six can cause IQ deficiencies, reading and learning disabilities, impaired hearing, reduced attention spans and hyperactivity. In adults it can cause reproductive problems and also impair development of fetuses in pregnant women. The most common way by which children get exposed to lead is through normal hand-to-mouth contact or from flaking paint. Adults and children can get exposed to the metal by ingesting food or water that contains lead. In developed countries paint manufacturers have replaced lead with Titanium white, a less toxic metal that is sometimes used in food colouring and toothpaste. Against popular opinion, pencils do not contain lead. The dark, tiny, long rods in pencils are made of graphite, a safe and harmless substance. Avoid toys containing lead and do not allow children to place their mouths on painted surfaces, since lead-based paints can't be identified by any other means than test conducted by experts. (Punch Newspaper, October 4th, 2007)

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CHAPTER THREE

MATERIALS AND METHODS

3.1 The Study Area

The study area is Ibadan, the Oyo State Capital, located in the Southwestern part of Nigeria. Ibadan comprises of eleven local government areas (LGAs) and five (5) of which are urban namely: Ibadan North (IBN), Ibadan North-East (IBNE), Ibadan North-West (IBNW), Ibadan South-East (IBSE) and Ibadan South-West (IBSW). These LGAs constitute the study area as shown in figures 1 to 4 and are surrounded by six (6) peripheral LGAs: Akinyele, Egbeda, Iddo, Lagelu, Oluyole and Ona-Ara. Ibadan is the largest indigenous city in West Africa with a population of about 2 million(Anon, 2004). It lies between longitudes 03^{0} 55 and 4 00 East of the Greenwich Meridian and Latitude 7^{0} 25 and 07 43 North of the Equator. The city has a high altitude ranging from 150 metres to 278 metres above sea level and isolated ridges and peaks rising to an elevation of 280 metres. The natural vegetation is made up of tropical rain forest. It has a tropical climate characterized by seasonal rainfall, high relative humidity and high temperature during the dry season. The annual rainfall ranges between 1270mm and 1524mm. The mean maximum temperature is 31^{0}C.

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Figure3. 1: Google Maps image of Ibadan South-East Area

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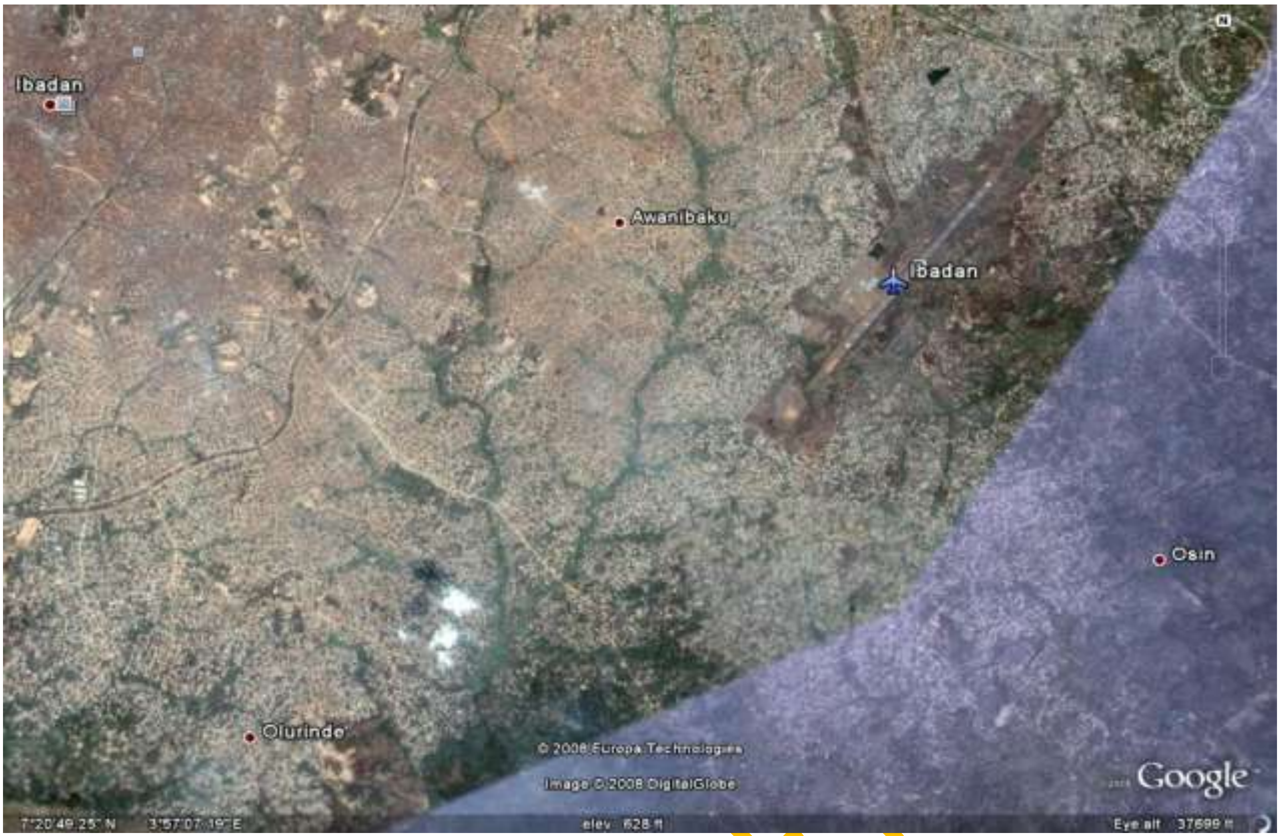

Figure3. 2: Google Maps image of Ibadan South-West Area

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Figure 3.3: Google Maps image of Ibadan North-West Area

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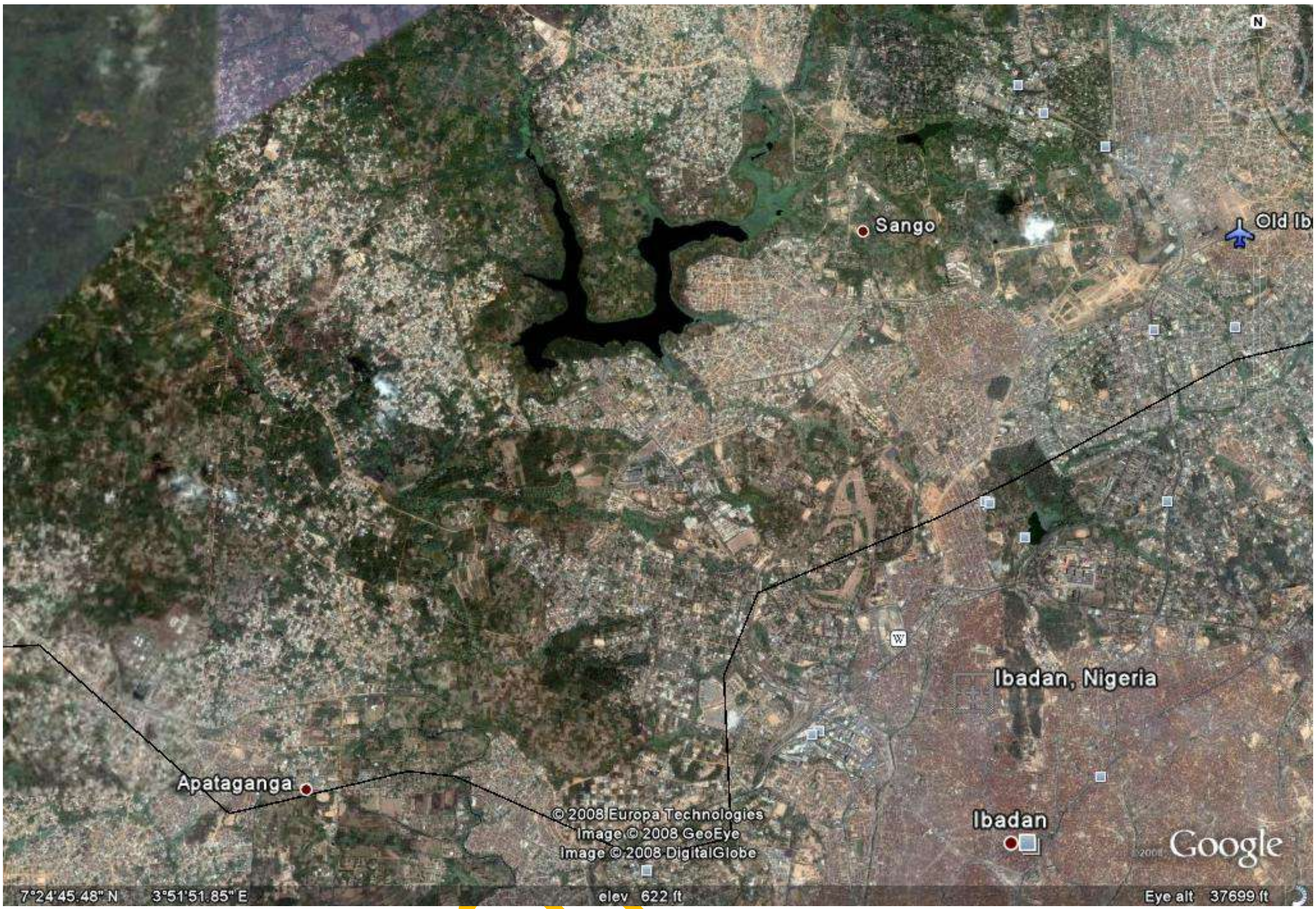

Figure3. 4: Google Maps image of Ibadan North-East Area

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3.2 Demographic Survey

The overall sampling site for this study is Ibadan metropolis with a population of about 2 million according to 1991 census. There were 300 samples taken purposively and randomly from homes built between 1960 and 2006 from the five urban administrative local government areas (LGAs) in Ibadan. But 293 were successfully analysed and returned from the laboratory. Another 25 samples from paint obtained from the market; making a ground total of 318 samples. The sample size in each LGA is shown in Table 3.1 below.

It was planned that 6 samples of dust from doorstep of house entrance, dust from window sills, paint chips from walls, soil from front and back of the house and potable water from wells and taps be collected from fifty homes; that would have made a total of three hundred samples. But in some LGAs, it was not possible to find homes last renovated in the decade of interest; so other homes were selected.

However, 259 samples were sent back from a standard laboratory in the University of Cincinnati, Ohio, USA. In the overall, the study had 259 home samples and 25 samples of paint sold in the market making a total of 283.

Table 3.1: Household Sample Size

	Households	Paint	Water	Soil	Dust	Sample Size (Survey)
Ibadan N.	10	10	10	19	18	57
Ibadan N.E.	10	8	9	16	16	49
Ibadan N.W.	8	8	8	16	14	46
Ibadan S.E.	8	9	9	18	18	54
Ibadan S.W.	9	8	9	18	18	53
TOTAL	45	43	45	87	84	**259**

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3.3 Focus Group Discussions (FGDs)

Knowledge, attitudes and practices with respect to knowledge about lead exposure in this environment in order to develop effective educational interventions that will alert the population about the dangers of lead was carried out. Focus group discussion is a scientific qualitative method that provides the opportunity to interview a group of individuals in a directed conversation concerning specific topics (Greenbaum, 1997; Morgan, 1997).

Focus Group Discussions may be used for triangulation purposes and are often employed in conjunction with other methodological techniques. In this study, 4 focus groups; 10 people per 3 groups, and 9 people for the fourth group, making 39 healthy individuals; were conducted with randomly selected members of the population of Ibadan ensuring that each of the 5 urban local government areas were represented as well as having people from a variety of social classes, religious affiliation, occupation and sex to identify issues and concerns related to lead exposure. A letter explaining the purpose of the FGD was sent to each person and the purpose of the FGD was verbally explained to them. Written consents were obtained from all the FGD participants. After arrival, participants were informed about study aim and objectives and told that each interview will last about 1½ hours. Trained facilitators conducted the sessions. Individuals younger than 18 years of age, those unable to communicate in English and Yoruba (the indigenous language of Ibadan) or those unable to give consent were excluded from the study. Participants were given gift worth seven hundred naira (₦700: 00) to cover transport and other expenses incurred in order to participate in the study. The discussion guide for the focus group discussion was developed based on the literature and knowledge of the area and the populace. Facilitators occasionally interjected in the discussions using a non-directive approach to focus participants on the topic of interest and move discussions along.

Following introduction, participants were encouraged to freely discuss along the themes in the discussion guide shown in appendix 1. The transcripts were then reviewed in a two-step process. First, major themes were identified and these were aggregated into lists. Phrases and quotations that highlighted these themes were identified. Sub-themes within the major themes were also identified and aggregated into lists. The major themes and sub-themes from each reviewer were there compared and the list merged. When there were disagreements between the raters, a third person

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was asked to review the pertinent sections of the transcript and a consensus reached on the substance. Coding began by identifying broad conceptual themes like, knowledge of lead and lead exposure, attitudes to lead exposure, health implications and practices regarding lead exposure. Specific attention was given to the knowledge about lead, lead level testing in the home, lead poisoning and the health impact of lead exposure. Focus groups were audio-taped and transcribed. Attention was given to the knowledge about lead, lead level testing in the home environment, lead poisoning, and the environmental health and health impact of lead exposure. See Appendix 1 for a copy of the Focus Group Guide used during the Focus Group Discussions. Ethical approval for this study was obtained from the Oyo State Ministry of Health and Ethics Committee.

3.4 Questionnaire Survey

The outcome of the Focus Group Discussions was used to develop a survey addressing subjects' attitude, knowledge and practice to lead exposure, and was conducted on a random sample of Ibadan residents representing people from all walks of life, religion, educational level, occupation and sex. Additional information from other studies of people's knowledge, attitudes and practices to lead exposure and subject matter expert knowledge was used in designing the questionnaire. Drawing on concepts from behavioral decision theory, this study has explored a range of issues including the subject's understanding of lead exposure, perceptions of risk of exposure, where such exposure can occur, what can be done about it and the health effects of chronic lead exposure. At least 600 Ibadan residents, with approximately 120 from each of the five urban local government areas that constitute Ibadan municipality, were interviewed and enrolled for this purpose. It was considered that this sample size was satisfactory to elicit information about the knowledge, attitudes and practices to lead exposure and is similar to sample sizes of similar studies internationally. Consent forms were also given to the participants.

As at the time this study was carried out, there were no previous empirical studies of knowledge, attitudes and practices to lead exposure in this environment and semi-structured or survey questionnaires containing both open-ended and fixed choice responses that have been used to evaluate participants knowledge, attitudes and practices to health and environmental pollution issues. In this study, the survey questionnaire included both open-ended and fixed choice questions. Standardized

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instruments developed in other environments were probably inappropriate for this assessment because the factors related to lead exposure vary significantly from one environment to another depending on types of buildings, materials used, specification of construction materials, and common method of managing open spaces within household etc.

Efforts were focused initially on the collection of basic information concerning peoples’ knowledge~~,attitude~~, attitudes and practices. Currently, little is known about lead exposure in Ibadan, Nigeria and the descriptive survey provided essential information for public policy, environmental engineering and health education for other investigators conducting research on this topic later. See Appendix 2 for a copy of the Survey Questionnaire used for the random survey.

3.5 Evaluation of Lead level in Paint Sold in the Market in Ibadan

Five (5) different colors of the most popular brands of paints, each from five different manufacturers sold in Ibadan Nigeria were purchased. To prepare each for sample space analysis the paint was stirred and applied by brush to individual clean and unused wood blocks. Each stirring utensil and paintbrush was used only once. After drying by exposure to ambient environment, the blocks were packed in individual Ziploc® bags and shipped to Heamatology and Environmental Laboratory of the University of Cincinnati, Ohio; United State of America. There, the paints were removed from pre-measured areas on the wood surfaces using a clean sharp paint scraper and care so as not to remove portions of wood (Plate 1).

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Plate 3.1: Paints sold in Nigerian Markets

3.6 Sampling of Household Dust, Paint, Soil and Water Samples

Six samples, (dust from door step of entrances into the houses and window sills, soil from front and back of the houses, paints chips from the walls of the houses and portable water) were taken randomly and purposively from buildings built between 1960 and 2006. 50 homes were visited; making a total of 300 samples. These were sent to the Heamatology and Environmental Laboratory of the University of Cincinnati, Ohio; United State of America. Due to shipping, transportation and laboratory errors, 293 was successfully analysed and return to Nigeria.

3.6.1 Selection of homes

Each home was visited by 2-person teams, one person conducted the interview and the other person collected samples. In each home, the sitting rooms were evaluated. Data were collected from bungalows and the ground floor of storied buildings.

3.6.2 Home Questionnaire survey and occupiers characteristics

Standard questionnaires were administered to the head of the household to determine the age of the building, renovation history, its ownership and age, occupation, hobbies and smoking history of the occupants. Data were also collected on number of occupants, how long they have been living in the house, age of occupants, household cleaning schedules, type of air conditioning, if any, presence of pets, presence of pests like cockroaches and rats, use of insecticides and rodenticides, history of asthma in occupiers, occupant income and other relevant information. See appendix 3 for a copy home questionnaire survey.

3.6.3 Collection of dust samples

Disposable commercially available toilettes moistened with distilled water were used to collect dust samples. The baseline lead levels in replicate moistened wipes were measured prior to use in the field. Single surface dust wipe samples were collected from interior windowsills and dust from doorstep from entrances according to Farfel's modification of Vostal Method(Environmental Protection Agency 1995). Disposable gloves were worn. One edge of the wipe was held between the thumb and the forefinger, draping the wipe over the fingers of the gloved hand. The fingers were held together, hand flat and the selected surface was wiped, starting from the furthest corner, using slow, side to side sweeping motion. During wiping, pressure is applied

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to the finger tips. A second pass is then made in the opposite direction using the reverse surface of the wipe. This can be repeated up to three times. The folded wipe is then inserted into a sample collection container.

One in ten ~~Blind~~ reference samples that were blinded to the researcher and the laboratory were collected throughout the sampling period to provide materials that can be used to identify potential systematic lead contamination that may occur during the sampling period. These samples are collected in the same way as the regular samples except that no surface is wiped. Quality control samples were derived from samples collected for which replicate consistent lead levels are available. Table 3.2

3.6.4 Collection of Paints Chips from walls

The living rooms in the households were inspected and samples of paint chips from walls were collected. In order to maximize the likelihood of finding lead if it is present, areas of the room with paint chips were selected for sampling (Plate 2).

TABLE 3.2: General Dust Sampling Strategy in Selected Housing Units in Ibadan, Nigeria March to June 2005

Rooms/Areas	**Surface Tested in Each Room/Area ***	**No. of Samples per Room ****	**Sample Location**
Sitting rooms	Floor Window sill and trough	1 1	Center of largest open area Sill and trough of random window

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Plate3. 2:Flaking wall paint

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Table 3.3- Calculation of Interior Area – Painted Components

Architectural Component	Calculation of Painted Area – Interior Component
Walls	Ceiling height times length of wall, minus total area of doorways, windows and other openings. Doorways were assumed to be 21 sq. ft., windows were assumed to be 12 sq. ft., and other openings were assumed to be 16 sq. ft. If this calculation resulted in a negative value, the result was forced to zero.
Window sills	Width and length are measured.
Window sash	Width and length are measured
Window casing	Width and length are measured
Window jamb	Width and length are measured
Door	Width and height are measured
Door jamb	Width and length are measured
Floor	Length of room times width of room. If opposite walls have different lengths, use the larger length.
Baseboard	Amount is sum of 4 wall lengths less doors widths (assume 3 feet per door), times representative baseboard width of 4 inches.
Ceiling	Same as floor area
Crown molding	Amount is the sum of all 4 wall lengths times representative width (7 inches)
Chair rail	Amount is sum of 4 wall lengths less door lengths and window widths (assume 3 feet per door and window), times representative chair rail width of 3 inches
Beam/column/joist	Assume each beam was 12 feet tall/long and has a cross section 6 inches square, of 24 square feet. Total area was product of number of beams times 24 square feet per beam.
Shelves	Assume shelf depth was 1 foot. Multiply by total shelf length.
Built-in cabinets	Assume each cabinet was 3 foot by 4 foot. Multiply by number of cabinets.
Stair rail	Amount was length of rail times representative diameter (8 square inches)
Stair tread	Amount was the representative size 10 inches by 3 feet times number of treads
Stair riser	Amount was representative size 7.5inches by 3 feet times number of risers
Air conditioner	Assume a radiator, not vent of representative size 18 square feet
Window trough	Amount = trough width x length x number of windows in room. Trough width is the lesser of the two trough dust wipe dimensions.

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3.6.5 Collection of Soil samples

Soil samples were collected using the scoop method. Disposable gloves were worn to prevent cross contamination between samples and 50 ml Falcon tubes were used to scoop up samples of soil by pushing the tube through the soil surface while maintaining scoop depth of about 0.5 inch into the soil. The tube was moved along for about 6 to 12 inches across the soil surface to complete the collection of soil into the tube. Excess soil was wiped off and the tube was re-capped. The bottle was labeled and gloved discarded.

Soil or wipe samples, depending on which were the most appropriate were collected from:

i. Main entrance. This represents soil that may be easily blown or tracked into the home. Deteriorated paint may also be swept into this area of the house and children tend to play near the main entrance of the home.

ii. Foundation/drip line. This represents soil that may have been contaminated by exterior lead-based paint, flashing, windows and troughs, etc., and is taken within 3 feet of the building foundation, uniformly along a randomly selected wall.

iii. Bare soil or surface of the mid yard area. This is midway between the drip line and the nearest property boundary or another building in the vicinity if there is no property boundary.

All sampling was done in accordance with the American Standards for Testing Materials (ASTM) E1728-95(ASTM 1995; ASTM 1995). For soil sampling, the top ½ inch of soil that is most accessible to children was studied. This is in accordance with international guidance and several previous studies around the world. All sampling was done in the dry season as there is more dust in the environment at that time. Topsoil is also likely to be more easily mobilized by surface winds and blown into homes, crevices and surfaces during the dry season. Heat also increases the bioavailability of lead, hence the preference for sampling during the dry season. Samples were collected and labeled with unique identification numbers that incorporated the area, house number and area sampled within the house. All samples were delivered within 24 hours to the processing laboratory. The distance of homes sampled to the main road was recorded but no samples from the main road was taken since the objective of this study is household lead exposure and not exposure through

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leaded petrol – the main source of lead in the environment, particularly in the vicinity of highways. The rooms were inventoried and the surface area computed as outlined in Tables 3.1 and 3.2 and plate 3.3

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Plate 3.3: Soil samples collection

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3.6.6 Collection of household water samples

A sample of water from the tap, where municipal water supply is present and used, or a sample from the family's source of drinking water was taken for lead level analysis.

3.7 Laboratory protocols

3.7.1. Analysis of Lead Levels in Paints from Survey of Paints sold in Ibadan

Paint scrapings were first extracted using nitric acid and hydrogen peroxide according to the method: Standard Operating Procedures for Lead in Paint by Hotplate or Microwave-based Acid Digestions and Atomic Absorption or Inductively Coupled Plasma Emission Spectroscopy, EPA, PB92-114172, September 1991 (US EPA, 2001b). Extracts were analyzed by flame-atomic absorption spectroscopy using a Perkin–Elmer 5100 spectrometer. This laboratory is accredited by the American Industrial Hygiene Association as an industrial hygiene laboratory and as an environmental lead laboratory under the National Lead Laboratory Accreditation Program. Consequently, the laboratory participates in the Proficiency Analytical Testing (PAT) and Environmental Lead Proficiency Analytical Testing (ELPAT) proficiency programs. Strict quality control procedures are maintained according to the accreditation guidelines. The laboratory is also a recognized facility through the National Environmental Laboratory Accreditation Conference and participates in the New York proficiency program for environmental sample analytes including lead. The lead contents were determined by Graphitefurnace Atomic Absorption Spectrometer (GBC–932Plus). Recovery was between 90 and 110 percent for different lots of digestions. Sample dilution was performed if required to fit into the calibration curve.

3.7.2. Analysis of Lead Levels in Dust from Homes in Ibadan

Dust samples were digested using hot plate digestion with 15 ml of 1:1 nitric acid and perchloric acid for oxidation of sample components and solubilization of lead. This was reconstituted to 30 ml with 3.5% nitric acid and sample digestates are brought to a final volume of 30 ml. Soil samples were dried and homogenized (by passing through a 2 mm sieve followed by a 500gm sieve), sub-sampling and digestion is done. Hot plate digestion is done with nitric acid and hydrogen peroxide

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acid for oxidation of sample components and solubilization of lead. On half gram of soil sample was digested and brought to a final volume of 50 ml. The detection limit of the analytical method was 0.5 microgram per dust wiped paper. Accuracy for the lead analysis of dust wiped paper was ± 5%, while the precision for the lead analysis of dust wiped paper was 10 ppb.

3.7.3. Analysis of Lead Levels in Paints Chips from walls of Homes in Ibadan

The paint chips were weighed and 1 gram from each surface wasare digested in turpentine to bring the volume to 50 ml. Paint scrapings were first extracted using nitric acid and hydrogen peroxide according to the method: Standard Operating Procedures for Lead in Paint by Hotplate or Microwave-based Acid Digestions and Atomic Absorption or Inductively Coupled Plasma Emission Spectroscopy, EPA, PB92-114172, September 1991 (US EPA, 2001b). Extracts were analyzed by flame-atomic absorption spectroscopy using a Perkin–Elmer 5100 spectrometer. This laboratory is accredited by the American Industrial Hygiene Association as an industrial hygiene laboratory and as an environmental lead laboratory under the National Lead Laboratory Accreditation Program. Consequently, the laboratory participates in the Proficiency Analytical Testing (PAT) and Environmental Lead Proficiency Analytical Testing (ELPAT) proficiency programs. Strict quality control procedures are maintained according to the accreditation guidelines. The laboratory is also a recognized facility through the National Environmental Laboratory Accreditation Conference and participates in the New York proficiency program for environmental sample analytes including lead.

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3.7.4. Analysis of Lead Levels in Soils Samples from the front and back of houses in Ibadan.

The homogenized composite soil samples were air dried, passed through a number 10 sieve (2 – mm mesh size), and analysed for their total lead contents using Atomic Absorption spectroscopy (AAS).

3.7.5. Analysis of Lead levels in Water Samples from Homes in Ibadan.

As soon as the samples arrived at the Laboratory; they were preserved by adding 0.5ml concentrated nitric acid (HNO_3 = 1.4g/ml) per each 100ml of Sample.

Atomic Absorption spectrometry using graphite furnace (GF – AAS) was used to measure the lead levels in the potable water samples.

3.8 Statistical Data Analysis

3.8.1 Focus Group Discussion: A coding system for thematic domains through a process of intensive review of the transcript data with the research team was developed. Conceptual categories were anticipated by the questions pursued in the focus groups. Coding began by identifying broad conceptual themes: a) knowledge of lead and lead exposure; b) attitude to lead exposure and its health implication; c) practices regarding lead exposure and its health implications. Thematic domains were further delineated as the content analysis of focus group data continues. Manual coding of the qualitative data was used for analysis.

The survey contains open-ended and fixed choice items. Open-ended items were recorded verbatim and discrete codes developed for categorization. A comparison of data to evaluate differential response between relevant groups was done. I used Wilcoxon rank-sum tests to compare continuous variables and χ^2 test for categorical variables.

3.8.2 Questionaire Population Survey

The survey contains open-ended and fixed choice items. Open-ended items were recorded verbatim and discrete codes developed for categorization. A comparison of data to evaluate differential response between relevant groups was done. Wilcoxon rank-sum tests were used to compare continuous variables and χ^2test for categorical variables.

3.8.3 Statistical Analysis of Dust, Paint chips and Water Lead Level Data

Data were analysed with MS. Excel® and STATA 8.2® (STATA Corporation, College Station, TX). Geometric and Arithmetic means were computed. Standard deviation and medians, and chi-square nonparametric test of the equality of medians because of non-normality of distribution of the data were performed. We set the level of significance at 0.05 and report data to 3 significant digits only. Generalized linear models were used to analyse factors that influence the geometric mean lead levels in the samples collected and correlation tests were done to compare

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the lead levels within each sampling unit and time period. Statistical significance was inferred if computed P-value is less than 0.05.

3.9 Geotechnical Investigation of Soils in Homes in Ibadan

3.9.1 Soil sampling

Disturbed soil samples were collected from homes from five LGAs in Ibadan by hand excavation with the aid of spade and digger t depth of 300mm. ten samples were collected together (two samples were collected at each LGA). All the samples retrieved were visually identified on site at the time of sampling, and taken to the Soil Mechanics Laboratory for more careful examination an detailed identification and classification. Relevant indices and engineering property tests including natural moisture content, atterberg limits, grain size analysis, compaction an CBR tests were later performed on samples from each LGA.

3.9.2 Laboratory Test Procedures and Specifications

The various geotechnical tests (natural moisture content, atterberg limits, bulk density, grain size analysis and compaction test) were done according to the British Standard BS 1377 (1990); Methods of Test for Soils for Civil Engineering purposes. The modified AASHO (modified Proctor) compaction test procedure with compaction energy of 2710.5 KJ/m^3 which is about five times that of the standard test was used for both the compaction and CBR test.

The California bearing-ratio (CBR) test was developed by the California Division of Highways in 1929 as a means of classifying the suitability of a soil for use as a sub-grade or base course material in highway construction. The laboratory CBR test measures the shearing resistance of a soil under controlled moisture and density conditions. The test yields a bearing-ratio number that is applicable for the state of the soil as tested. The CBR number (or simply, the CBR) is obtained as the ratio of the unit stress required to effect a certain depth of penetration of the standard (with an area of 19.35 cm^2) into a compacted specimen of soil at some water content and density to the standard unit stress required to obtain the same depth of penetration of the standard sample of crushed stone. The CBR is a percentage of the standard unit load. The Highway Manual (Design) Federal Ministry if Works and Housing

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specification of soil characteristics for flexible pavement design, specifies CBR value of 80% minimum (unsoaked) for road base materials, 30% minimum (soaked) for sub-base materials and 10% minimum (soaked) for sub-grade soil. The specification further recommends for sub-base and base materials:

Liquid limit (LL) not greater than 30%

Plasticity index (PI) not greater than 12%

Linear shrinkage (LS) not greater than 8%

All information in 3.9 (Fortune C. Emisiobi, 2000)

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CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Results of Qualitative study of Knowledge, Attitudes, and Practice about Lead exposure in the Home Environment

There were 39 participants overall, with one person failing to keep his appointment at the venue of the focus group discussions. The age of the participants ranged from 23 to 72 years with mean (SD) of 44.5 (12.8) years. There were 19 (49%) women and 20 (51%) men; 6 Muslims (15%) and 33 Christians (85%) and their occupations were students (9, 23%), teachers (6, 15%), drivers (6, 15%) and clerks (6, 15%). The rest belonged to a wide variety of occupations.

4.1.1. Knowledge

What is lead and where can it be found?Most participants believed that lead is a metal which is used in soldering materials and it can be found in cooking pots, domestic and automobile batteries, pencils, cosmetics, fuel, local herbs and medications. Discussants thought that lead is poisonous. It can cause asthma, cancer, eye and chest diseases and can shorten lifespan. Many participants mentioned some of the commonly used canned foods and condiments in Nigerian markets,such as canned tomato puree, canned mackerel fish, tinned milk, cutlery and cooking utensils, as potential sources of lead.

Participant: My own understanding of lead is both abstract and physical. The physical is in form of gold, silvery in color, and usually heavy in substance. It is used for soldering flexible wires, radio and television (…) used by blacksmith, tinkers, and other likes (sic)*. The other one which is abstract so to speak is within the mineral sector and my own overall understanding of the thing is that it is poisonous because it is usually incubated through liquid water or sucking lead pencil or eating any kind of tinned food that has expired thereby secreting lead into the container which is made of tin as a component* (sic)*. There is another one that can be absorbed through water, depending on the kind of soil the water flows through* (sic).

Participant: In all this small small batteries we use for torch light, there is lead in it, it is like a rod (inside) the battery(sic)*…People also use it …like those selling herbs (alternative medicine practitioners). If you have itches, scratches or any infection in*

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the body, you go to buy soap for it; they will mix it with (the) soap and sell it to you. I even used it for my own granddaughter when she had rashes on her head.

Participant: ...lead is in this pencil that we use to write.

Participant: It is a heavy metal and we can find it in traces of fumes of vehicle (sic). *It affects the health of children, which is why if you see some children in the park ... they don't behave like normal children ... when they inhale it in large quantity it can affect health* (sic).

What risks are associated with exposure to lead?Most of the discussants stated that they believe that lead is poisonous and dangerous to health but there was no unanimity about which of the body's systems is vulnerable. Many of the participants thought exposure to lead can cause cancer.

Participant: It can affect the eyes that are why they (workers who use lead products) cover the eyes with face mask (sic).

Facilitator: Many of you mentioned pencil as a source of lead, has anyone noticed anything peculiar about children using pencil?

Participants: I see children playing with pencil. I have never paid attention and I have never met a mother in my life (who) complained about pencil apart from the sharpness (sic). *When I was a child I used to play with pencil and put (it) in my mouth, nothing has ever happened to me* (sic).

Participant: Yes, I have 2 experiences, one was with a child sucking lead pencil and it resulted in upset stomach (sic). *She was hale and hearty before sucking the substance. The other one also resulted in stomach upset by playing with battery and licking the head, thereby absorbing the water from the battery* (sic). *So in the two instances, it ultimately led to stomach pain.*

Participant: It can shorten life because it can affect any organ. We know it is bad, we don't know the exact thing it can cause in the body (sic).

Participant: I noticed this welder (who) uses lead ... it makes them lean (sic). *It affects their health.*

Participant: (Children) tend to be dull if they are exposed to lead.

Participant: It affects intelligence.

Where can we get information about lead and additional comments?Discussants felt that they can obtain information about lead exposure from welders, automobile

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battery repairers and automobile battery manufacturers. There was general agreement on the need for the government to do more to increase awareness of lead exposure while putting effective remediation measures in place.

4.1.2. Attitudes

What do you think of when you hear “lead poisoning”?The use of the term poison engaged the attention of the discussants, though they did not know specifically about lead poisoning. They were sure that the metal is poisonous. Overall, they felt that apart from specialists in the field, most people do not know what “lead poisoning” is about.

How do you think we are exposed to lead and how can we reduce it?Most of the discussants believed that one can be exposed to lead through petrol, pipe-borne water and pencils. Less commonly, they also mentioned soil, cooking utensils, soap and industrial pollution as sources of lead exposure. There was general agreement that there is a need to increase awareness of lead exposure and increase the role of regulatory agencies in ensuring that products sold on the market do not contain lead. Some participants suggested that people should return to the use of earthenware pots for cooking, out of concern that modern cooking utensils may be associated with lead exposure, though they acknowledged that such a move is not likely to be popular. Other participants thought that recent government efforts to reduce importation of old vehicles (used vehicles are commonly imported into Nigeria and constitute the majority of new vehicle purchases) will reduce the amount of lead pollution from exhaust of old cars with inefficient engines.

4.1.3. Practices

Have you tested the amount of lead in your environment? Would you accept to have your environment tested for lead?

Noneof the participants has ever tested their environment for lead. A participant, who works in the state government’s department in charge of housing and civil engineering works, was aware that the department has the capacity to test lead level in soil and does it for corporate bodies and large organizations before they are given building permits.

Participant: supposing what you are going to use to test the level is going to have a negative impact. (Secondly) what use will the test be to (an individual). …a man

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whose daily income depends on constant exposure to lead will have been exposed for too long and (he will say) I am now used to it. ... it needs ... education, letting them know why, is there going to be harm (sic).

Participant: Nowadays you can never know the purpose of research because we have read in some papers that some people will just bring something in their environment because they want to make money or name out of it (sic).

Participant: I think the first and best solution is awareness. I think the first solution is awareness for people to know that they have a lot of lead in their environment and they have to reduce it(sic).

Participant: The reason I am opposing awareness is that ... we have a lot of poverty(sic). *If you are saying there should be awareness, are you saying that the pot (we use for cooking) we have should be thrown away (if it is found to contain lead)?*

Participant: I think awareness should be done. Like in the primary and secondary school level, this kind of study should be included in the school curriculum so that the generation coming will be able to have proper knowledge of what is going on in their environment (sic).

Participant: paints in homes, because we are even advised that when you paint a house, if possible, let people not be there for a few days(sic).

Participant: ... thorough research (we) will be able to bring out certain results which I believe will be passed to the government and invariably ... legislation will result. There are some soap(s) that contain heavy metal, if we know such ones so as to avoid them (sic).

Some participants think that since lead is used for welding, pencils, paints, etc., it is needed and beneficial. Tables 4.1 to 4.3 provide more of the responses given by participants in the FGD discussions on knowledge attitude and practice to lead exposure.

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Table 4.1: Excepts from the Focus Group Discussion Guide used for the study of Health Effects and Knowledge attitudes and practices of Lead Exposure, Ibadan, 2004

Number	Questions	Probes
1.	What comes to mind when you hear the word "lead"?	What do you think it is? Where do you think it can be found? What risks do you think is associated with exposure to lead?
2.	Have you ever tested the lead level in your domestic environment? [IF "YES"] Why did you do the test?	What are the reasons you might participate to do a lead level test [or not]
3.	What images does the word "lead poisoning" bring up for you or what do you think of when you hear the word "lead poisoning"?	What about lead exposure? What other words have similar meanings for you?
4.	What impact do you feel lead or lead poisoning have on health? What (other) factors do you believe contribute to Health? What do you believe about lead exposure and how to Reduce it? Concerns? Perceived risks? Hopes? Perceived benefits?	
5.	What kinds of things would be important to you in deciding what to do about lead exposure?	What are the reasons you might participate [or be concerned about lead]? What are the reasons you might not be concerned about lead? Where do you think you can find information about lead exposure in your community?
6.	What kinds of methods of reducing lead exposure do you know?	

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Table 4.2: Participants' knowledge about lead exposure in Ibadan, Nigeria 2004

Domain	Responses	
	Common Responses	**Less Common Responses**
What comes to your mind when you hear the word lead? What do you think it is?	Lead is a metal Lead is used for soldering Lead is a mineral resource	Lead is used to make cooking pots Lead is used to write It is mixed with local soap for bathing Lead is used to make batteries Lead is poisonous
Where can lead be found? What do you think it is?	It can be found in battery(automobile and domestic)	Lead is pencil Lead is a heavy metal It can be found in cosmetics It can be found in soil It can be found in pencils It can be found in the quarries It can be found with welders It can be found in electric stove and cookers It can be found in fuel It can be found in cooking pots It can be found in chemical products It can be found in local herbs
What risks do you think is associated with exposure to lead?	It is poisonous It can cause cancer	It is dangerous to health It can shorten life span It can cause asthma It can cause cough It affects the eyes It affects the chest

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Continuation of Table 4.2

Domain	Responses	
	Common Responses	**Less Common Responses**
What do you think of when you hear the word lead poisoning?	Death Harm Danger to health	Disability Lumps, burns and cancer Blindness Apollo Retards physical growth Reduces children's intelligence
Where do you think we can be exposed to lead?	Fuel Pipe borne water Pencil	Soil Plates Tinned food Bathing soap Exhaust from industries
What other words have similar meaning to lead?	Metals	
What benefits can we derive from lead?	Used to manufacture car battery	To make electrical accessories Tinkering
Are there any reasons why we might not be concerned about lead in our environment?	Ignorance	
Where can we get information about lead?	Battery manufacturers Welders Battery Repairers	Internet Villages Libraries

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Table 4.3: Participants' attitudes and practices about lead exposure in Ibadan, Nigeria 2004

Domain	**Responses**	
	Common Responses	**Less Common Responses**
Have you ever tested the lead level in your domestic environment? If yes why did you do the test?	No	
What are the reasons you might do a lead level test?	If is going to be beneficial To be educated about lead I do not want to be at risk	For financial benefit
What are the reasons you might not allow a lead level test to be carried out in your environment?	Because lead is dangerous Because I think it will be harmful	For security reasons
What impact do you think lead or lead poisoning have on health?	We do not know It causes abdominal pain	It makes people pale It shortens life It affects anybody organ It affects breathing It affects intelligence It affects productivity
How can we reduce the risks of lead exposure?	NAFDAC (monitoring body for food and drug production in Nigeria) should monitor lead in the production processes Nothing can be done about it	By enlightenment through research and information Through public awareness Throw away all used batteries Painters should cover their nostrils when painting Government should sponsor and encourage lead research Government should ban importation on used vehicles

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4.2 Discussion of the result from the Qualitative study of Knowledge, Attitudes, and Practices about exposure to Lead in the Home Environment

There was some awareness of lead exposure among our study participants. Many of them were aware of the presence of lead in petrol but had little knowledge of domestic sources of lead exposure such as dust, paint, soil and water. Many of the participants confused the popular appellation for pencils, which is "lead pencil", to imply that the writing elements in pencils were made of lead. Several of our FGD participants were aware of lead exposure arising from car battery manufacture and repairs. There used to be a motor car battery manufacturing plant in Ibadan and many residents were aware of the environmental degradation associated with its operations. Participants were also aware of the presence of lead in some alternative medicines and in association with occupations such as welding. Some of our participants were aware of the health implications of lead exposure in children, suggesting that it may be responsible for "abnormal behavior" and "dullness". Nevertheless, none of the participants has ever tested their environments for lead.

At least one participant who works with the government department in charge of Civil Engineering was aware that facilities for testing lead level in the environment exists but added that this was usually done by large organizations and not individuals. Participants believed that there is need to increase awareness of lead exposure in the community. Many however agreed when another participant suggested that people are likely to be pragmatic in their response to any campaign to reduce exposure to lead, suggesting that alternative sources of income should be found for those whose occupation is likely to be affected by lead remediation activities, otherwise such campaigns will fail. Furthermore, it was suggested that alternatives should be provided for lead contaminated products. While some of the participants were hopeful that research results will lead to government intervention, others were not as optimistic, suggesting that previous experience does not support any expectation that the government will respond positively to such research. Most of the participants felt that they can obtain information about lead from those who are occupationally exposed to it.

There is increasing awareness of the risks posed by domestic exposure to lead, particularly to children. Children can be exposed to lead through dust inhalation and ingestion(Rhoads *et al*, 1999; Rothenberg and Rothenberg, 2005). In a survey of households in the United Kingdom, the total estimated lead intake of young children

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was 36 μg/day of which 1 μg/day was by inhalation and the rest by ingestion(Thornton, et al. 1990). Recent prevalence studies show that over 90% of children in urban and rural communities of Cape Province, South Africa have blood lead levels ≥ 10 mg/dl. Studies in other countries likewise suggest that childhood lead poisoning is a widespread urban health problem throughout the continent of Africa(Nriagu *et al*, 1996; Mathee *et al*, 2003). Reduction of childhood lead exposure will result in substantial economic gains, possibly to a greater degree than has been reported from developed countries(Schwartz, 1994; Rothenberg and Rothenberg, 2005).

This study has outlined the current knowledge, attitudes and practices of a cross section of Ibadan residents about lead exposure. To our knowledge, there is no previous report on the use of FGD to ascertain knowledge of health hazard posed by lead exposure in Nigeria or any other parts of Africa. Our participants were similar to the general Nigerian population in terms of age, sex and occupation(Central Intelligence Agency 2005); however the presence of a battery manufacturing company in Ibadan in the recent past may have increased the baseline knowledge of residents in this city to lead exposure compared to other parts of Nigeria. There is little or no enforcement of minimum standard for lead content of domestic environment in Nigeria. There has never been domestic lead abatement in Nigeria and none is planned.

Focus group discussions provide an opportunity to interview a group of individuals in a directed conversation about a specific topic and it can be used to generate new insights about attitudes and beliefs(Morgan 1997; Pope et al, 2000). The interaction among participants leads to the promotion of rich discussion and opportunity to present contrary opinions that are not limited by the constraints imposed by the limited choices in a quantitative study(Greenbaum 1997; Morgan 1997). In situations where little previous documentation exists, such as this topic, focus group discussions help to generate new ideas and hypothesis for further research. They can also be used in conjunction with other methodological techniques for triangulation purposes thus helping to validate research findings(Sidani and Sechrest 1996). However like other qualitative research methods, their results and conclusions must be treated with caution(Greenhalgh and Taylor, 1997).

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4.3Results of Questionnaire Survey about domestic lead Exposure

In all, 357 respondents representing 60% of the 600 questionnaires distributed; 239 (67%), were male while 118 (33%) were females. Their ages ranged from 17 to 72 years with mean (SD) of 38.4 (10.2) years. Men were significantly older than women in this survey (mean age (SD) were 39.9 (10.4) years for men compared to 35.6 (9.0) years for women, p-value < 0.001). Most of the respondents (262, 73%) were married, compared to 81 (23%) single, 9 (3%) divorced and 3 (1%) widowed. There was no significant difference in marital status comparing the men and the women (p-value = 0.60). Most (238, 67%) of the respondents said they were professionals, while others were traders (23, 6%), housewives (7, 2%), farmers (2%), artisans (2%), and the rest were unemployed (75, 21%). There was no significant difference in the distribution of the occupations according to sex (p-value = 0.12).

Most, 172 (48%), of the respondents have had more than 12 years of formal education, while 107 (30%) had between 7 and 12 years, and the remaining 78 (22%) had 6 years of formal education or less. Women in this survey, (64/118, 54%) were more likely than men (108/239, 45%) to have had more than 12 years of formal education. Furthermore, women (39/118, 33%) were more likely than men (68/239, 28%) to have received between 7 and 12 years of formal education. These differences were statistically significant (p-value of χ^2 = 0.01). Most respondents reported that they were in the middle social class (220/343, 64%), while others reported that they were in the high (63/343, 18%) and low (60, 17%) social classes respectively. There were no significant differences in social class according to sex (p-value = 0.75). Most of the respondents (263/337, 78%) rented rather than owned their homes and most (238/341, 70%) did not know when their homes were built. Neither of these responses varied significantly by sex (p-value for house rent = 0.72, p-value for when house was built = 0.42).

Most (280/357, 91%) of the respondents lived in homes that were either built or last refurbished in the 1990s, while others lived in homes that were either built or last refurbished in the 2000s (46/357, 13%), in the 1970s (16/357, 4%) and in the 1980s (15/357, 4%). Most of the respondent had not heard of lead abatement programs being conducted or planned in their homes (269/313, 86%), their communities (265/307, 86%) or in their state (261/302, 86%). These responses did not

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differ by sex (p-value for home lead abatement = 0.33, for community lead abatement = 0.72, for state lead abatement = 0.34). The homes of most of the respondents (159/324, 49%) were located within 5 minutes' drive of a major highway compared to 69/324 (21%) who lived more than 5 minutes but less than 30 minutes' drive from a major highway, 54/324 (17%0 who lived more than 30 minutes from a major highway and 42/324 (13%) who lived right on a major highway.

Table 4.4 shows the answers that the respondents gave to the questions in the CLKT. Most of the respondents either did not know the answers to the questions or answered 'no'. More 'true' responses were obtained in questions related to hand washing and oral manipulation while more 'don't know' responses were obtained with respect to questions that required specific knowledge. There were more 'no' responses to questions that seemed improbable such as whether lead can be removed from water by boiling and inhalation as a means of significant lead exposure. In multivariate linear regression models of the predictors of high scores in the sum of positive responses to the CLKT, the main predictors that achieved statistical significance were sex (p-value = 0.049), amount of years spent in school (p-value < 0.001) and age (0.068). Men scored mean (SD) of 5.6 (3.9) compared to 7.4 (4.6) scored by women in the CLKT. The mean scores for CLKT increased with amount of years of schooling obtained by the respondent.

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Table4.4: Knowledge about Lead Hazard in Homes in Ibadan, Nigeria 2004

No.	Question	Responses		
		True N (%)	False N (%)	Don't know N (%)
1.	Lead paint commoner in newer homes	95 (27.3)	55 (15.8)	198 (56.9)
2.	High lead affects child learning ability	90 (26.0)	73 (21.1)	183 (52.9)
3.	Lead paint chips poisonous when eaten	133 (38.4)	70 (20.3)	143 (41.3)
4	Child's highest BL* occurs around 5yrs	31 (8.9)	49 (14.1)	267 (77.0)
5.	Immediate symptoms if children have elevated BL* levels	62 (18.1)	72 (21.0)	209 (60.9)
6.	Living in renovated building increases child's exposure to lead	115 (33.2)	65 (18.8)	166 (48.0)
7.	Handwashing prevents lead poisoning	127 (36.7)	61 (17.6)	158 (45.7)
8.	Home cleaning with soap and water decreases lead in the home	105 (30.2)	87 (25.0)	156 (44.8)
9.	Iron- rich diet decreases a child's chance of lead poisoning	82 (23.7)	80 (23.1)	184 (53.2)
10.	Lead dust can poison a child through hand to mouth	125 (36.3)	56 (16.3)	163 (47.4)
11.	Lead in water can be removed by boiling	69 (19.9)	87 (25.1)	191 (55.0)
12.	Childhood lead poisoning is caused by drinking water that contains lead	89 (25.6)	66 (19.0)	193 (55.5)
13.	Warm tap water contains less lead than cold tap water	51 (14.8)	83 (24.1)	211 (61.2)
14.	Parents working with lead can bring lead home on their clothes	108 (30.9)	57 (16.3)	185 (52.9)
15	Lead in soil cannot harm children	56 (16.2)	82 (23.8)	207 (60.0)
16.	Some pottery contains lead, hence are not safe for eating or cooking	80 (23.3)	74 (21.5)	190 (55.2)
17.	Childhood lead poisoning is caused by exposure to lead-containing dust	126 (37.4)	48 (14.2)	163 (48.4)
18.	Lead from a pregnant woman can be transferred to the unborn baby	102 (29.7)	72 (21.0)	169 (49.3)
19.	Some herbal or traditional home remedies contain lead	57 (16.8)	76 (22.4)	207 (60.9)
20.	Childhood lead poisoning is caused by breathing in lead	72 (21.1)	89 (26.0)	181 (52.9)
21.	The human body needs a small amount of lead for good nutrition	59 (17.3)	84 (24.6)	198 (58.1)
22.	High calcium diet prevents lead poisoning	71 (20.8)	44 (12.9)	226 (66.3)
23.	Less lead is absorbed if a child eats balanced diet and less fatty foods	70 (20.4)	31 (9.0)	242 (70.6)

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4.4 Discussion on Questionnaire about domestic lead Exposure

In this questionnaire survey of randomly selected residents of Ibadan, a city in South Western Nigeria, it was discovered that there was poor knowledge of domestic sources of lead exposure. Most respondents lived in rented apartments, most of which were built in the 1990s. They also did not know about lead abatement nor were they aware if there were lead abatement programs in Ibadan. The main predictors of knowledge about lead exposure in childhood were sex and years of schooling.

Nigerian children are particularly predisposed to environmental lead exposure, because of their lifestyle and socio-ecological factors (Ankrah *et al*, 1996; Mathee *et al*, 2003; Ozden *et al*, 2004). However the true picture of childhood lead poisoning in Nigeria is poorly documented. Prevalence studies show that over 90% of the children in urban and rural communities of the Cape Province, South Africa have blood lead levels greater than or equal to 10 µg/dL(Grobler *et al*,1996). Studies in other countries also suggest that childhood lead poisoning is a widespread urban health problem throughout the African continent(Nriagu *et al*, 1996). One study showed that adult Nigerians living in Ibadan have mean blood lead levels of 11.4 µg/dL (women) and 12.3 µg/dL (men)(Omokhodion, 1994), while a recent study showed that this has risen to a mean(SD) of 27.7(6.6) µg/dL with some variation in levels between Ibadan metropolis (mean[SD] of 30.1[1.47] µg/dL) and less urbanized South Western Nigerian towns like Iseyin, Saki and Ogbomosho(Anetor, 2001).

In the United States, as in other industrialized countries, major federal programmes have been introduced to reduce lead levels in the environment (Mahaffey *et al*, 1982). Their success had been demonstrated by dramatically lower blood-lead levels in the U.S population(Stephenson, 2003). It was recently estimated that a reduction of the blood lead levels of children in the United States from 17.1 µg/dL to 2.0 µg/dL, in the period 1976 to 1999, resulted in public health benefits of $319 billion (Rothenberg and Rothenberg, 2005). The proportional impact of reducing childhood lead exposure in developing countries, where children's blood lead level is likely to be higher, would be much greater than this. Current data indicate, however, that about 430,000 U.S children are still estimated to have blood-lead levels above 10µg/dL, a level at which significant effects are more likely to be clinically evident (Grigg ,2004).

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The toxic effects of lead may involve several organ systems within the body and may vary from subtle biochemical effects to clinical features of lead poisoning (Goyer, 1993). Significant exposure affects the nervous, haematologic, renal and reproductive systems leading to anaemia, nephrotoxicity, developmental delays, hypertension and behavioural disorders etc. (Goyer, 1993; Goyer, 1995). While both adults and children can suffer from chronic low-dose lead exposure, the effect is more marked in children (Baghurst *et al*, 1992; Lidsky and Schneider, 2003; Bellinger, 2004; Needleman, 2004). Children can be exposed to lead chronically in the domestic environment through the use of lead-based paint, lead-contaminated water, and dust (Bernard, 2003). Very little information is available from Nigerian paint manufacturers about the levels of lead in their products.

Nigeria, like many developing countries, has been undergoing severe economic crisis. This has led to significant reduction in activity in all aspects of the economy including the construction industry. As a result many housing units are old and have not been renovated for many years. They are therefore likely to have old, flaking paint which is associated with increased risk of childhood lead poisoning. Pipe-borne water is another common source of chronic low-dose lead exposure in the domestic environment. Previous reports from Nigeria suggest that water lead levels has increased in the past years, from less than 0.05mg/l in 1993(Omokhodion, 1994) to 2.16 mg/l in 1997(Adogame, 1997) in Ibadan. In Nigeria, there is poor municipal water supply with significant proportion of the population reliant on ground water and run-offs for their source of potable water. The lead level in such sources of water is often unknown and the water is not usually treated before use Moreover lead pipes are still being used in some places. Several studies have shown that their lead levels were often above permissible levels (Sridhar and Okerearu, 1999; Sridhar *et al*, 2000; Sridhar 2001).

4.5. Results of Quantitative Evaluation of Lead levels in Samples of Household Paints sold in Nigeria market

Eight (8) different colors of paint, from 5 different manufacturers in Ibadan were analysed. Because some colors were not available from some of the manufacturers at the time of the purchase, it was not ensured that we obtained. Analysis showed that 96% of the paints had higher than the recommended 90 parts per million [ppm] and the mean lead levels was 14,500 ppm while the median was

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15,800 ppm. The lowest level was 84.8 ppm while the highest was 50,000 ppm. Only one out of the 25 samples (4.0%) had a level less than the 600 ppm recommended by the US EPA and Consumer Product and Safety Commission for new paint.(US Consumer Products Safety Commission 1977; Environmental Protection Agency 2001)

Figure 4.5 shows the lead levels of paint according to manufacturers. Pearson χ^2 for comparison of median lead level of paints was 2.56 with a p-value of 0.63. Figure 6 shows the lead levels according to color of paint. Pearson χ^2 for comparison of median lead levels according to paint color was 22.0 with a p-value of 0.003 indicating that the main determinants of different lead levels were the colors. With regards to the manufacturer whose white paint had lead below the recommended level, other paint from the same manufacturer had high lead levels with a mean (SD) of 17.000 ppm and (16,600) ppm if the sample with low lead level was excluded.

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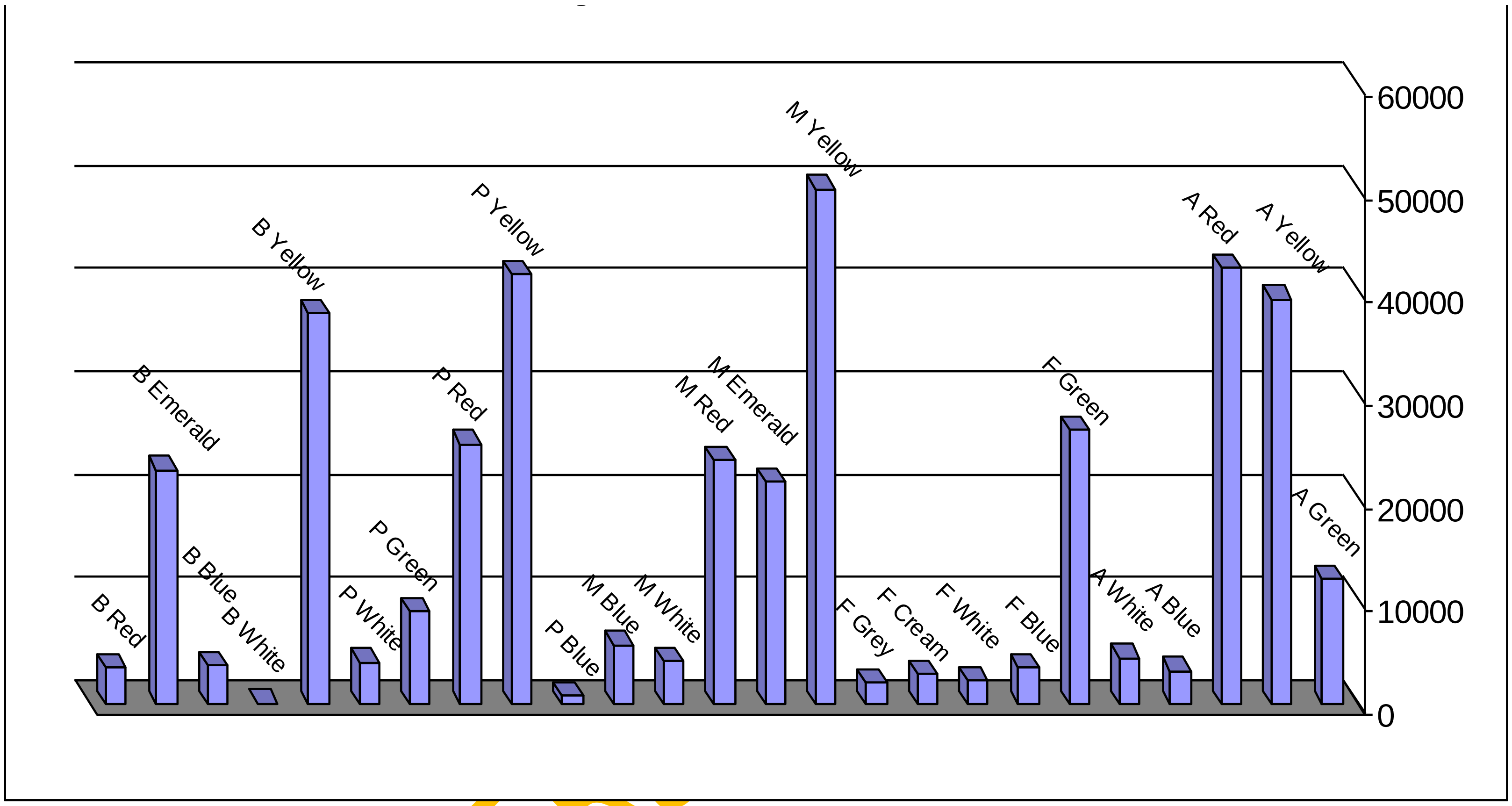

Figure 4.5: Lead levels in partsper million in domestic paint in Nigeria according to manufacturers, Ibadan, 2006

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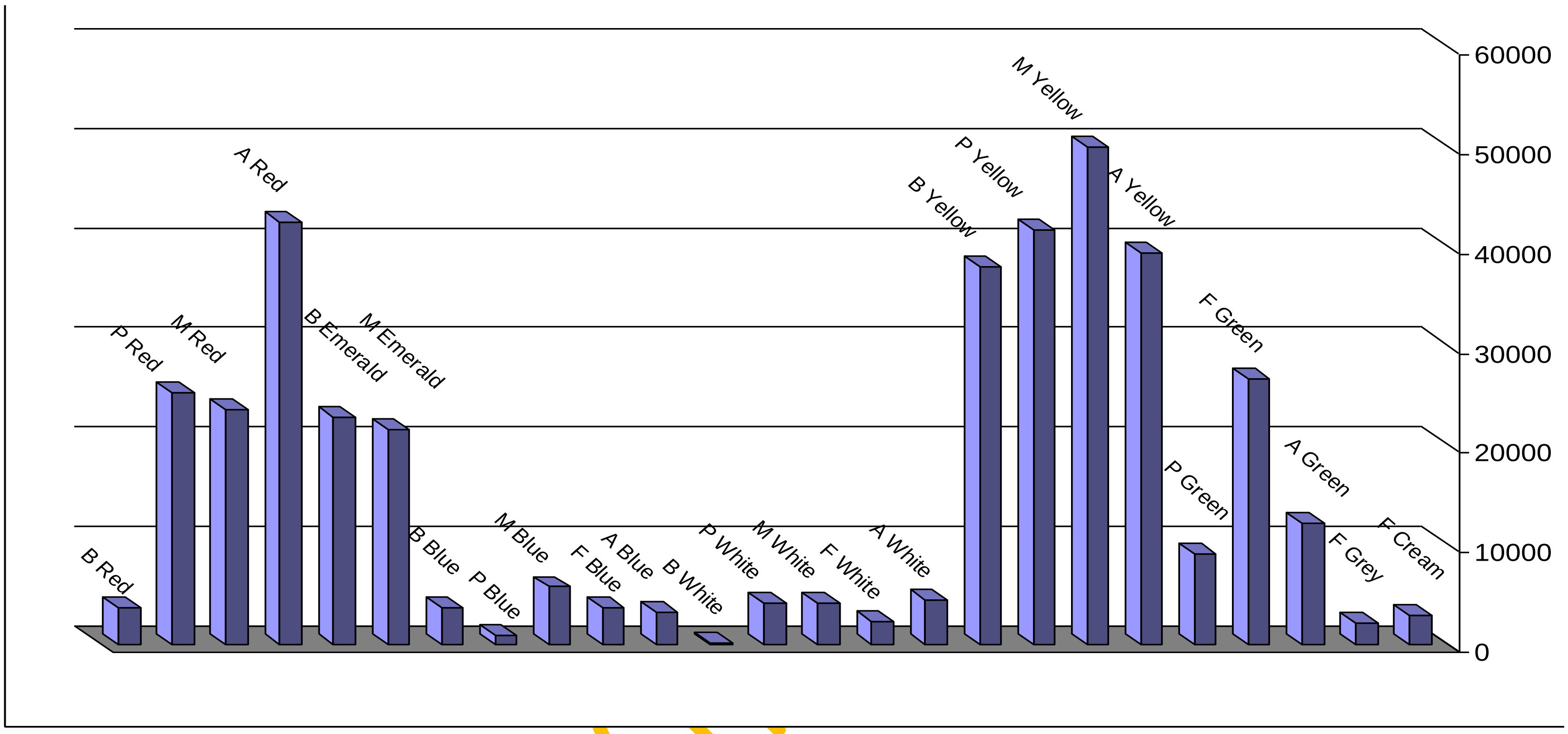

Figure 4.6: Lead levels in parts per million in domestic paint in Nigeria according to colors Ibadan, 206

Table4.5: Lead level in parts per million of different colors of paint sold in Nigerian and selected Asian countries, Ibadan, 2007

Color	Country									
	Nigeria		India		Malaysia		Singapore		China	
	Median N	Mean (SD)	Median N	Mean (SD)	Median N	Mean (SD)	Median N	Mean (SD)	Median N	Mean (SD)
Yellow	40515 4	42271 5393	114968 4	124892 46235	61582 14	57553 54500	9.2 8	498 1222	73440 1	73440 -
Red	24457 4	23744 (15877)	6804 3	36993 (55094)	25992 8	30227 (3364)	273 4	469 (626)	30725 2	30725 (869)
Green	12216 3	15976 9410	39155 3	31780 13041	33372 4	38556 33810	13.2 4	15.2 17.9	6037 1	6037 -
White	4110 5	3035 1864	1562 1	1562 -	124 1	124 -	3.1 2	3.1 4.3	185 1	185 -
Blue	3615 5	3457 (1729)	3366 1	3367 -	2033 3	2485 2574	48 1	48 -	-	

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4.6Discussion on Quantitative Evaluation of Lead levels sold in Nigeria market in Samples of Household paints

This is the first report of an examination of the lead levels in paint in Africa and it was found that 96% of all the paints tested had lead above the recommended level. It also found that while these levels varied significantly by color – with the highest levels occurring in bright colorful paints like yellow, red and green, they did not vary by manufacturer suggesting that all manufacturers were producing paint with above recommended lead levels and the main determinant of varying lead level was use of lead pigments to enhance colors in paint.

The health hazards of exposure to lead in the domestic environment have been understudied in developing countries though its importance as a source of morbidity is widely recognized (Nriagu *et al*, 1996). Lead exposure is associated with a wide variety of effects. (Agency for toxic Substances and Diseases Registry 1999) Recent studies show that even once thought safe blood lead levels are associated with increased risk of death from many causes (Menke *et al,* 2006) Adults tend to be exposed to lead through occupations and inhalation of fumes from combustion of leaded petrol, children are less likely to be exposed in this manner because they are not yet members of the workforce. Exposure to lead in the domestic environment is therefore a particular hazard for them.

Most countries have legislation setting the permissible limits of lead in domestic paints but these are often poorly enforced. Comparison of our data with that of some countries in Asia (India, Malaysia and China) show similarly high levels of lead in the paint sold in these countries while paint sold in a developed Asian country – Singapore – where regulations are enforced generally contained lower or no lead levels.(Clark *et al,* 2006) Recent economic recovery in Nigeria may lead to increased activity in the building industry and Nigeria like other African countries is increasing trade with Asia, particularly with China. It is therefore important that an international regulatory regime be in place to supplement local efforts to ensure that paints have lower than recommended lead levels, with the ultimate goal of eventually eliminating all lead from paint.Increasing globalization and outsourcing of manufacturing increases the likelihood that products with higher than permissible levels of lead may be traded across borders into countries with effective regulation of local paint industry.(Anon, 2007) One of the brands of paint tested in Nigeria is manufactured by a corporation that also produces paint in Asia. While its brand in Nigeria and India contained high levels of lead, the brand sold in Singapore did not.

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Lead in paints can be replaced by the use of other additives such as titanium dioxide or barium sulfate and their durability can be improved by adding silicon or aluminum oxides. The increase in cost resulting from these is relatively small and cannot be compared with the human cost of continued exposure to lead. In a recent report from South Africa, 20 % of the houses tested had at least one surface containing a hazardous level of lead (Mathee *et al,* 2003). High lead levels have recently been reported in new residential paints sold in China, India and Malaysia but not in a nearby country like Singapore with an enforced lead regulation (Clark *et al,* 2006). Previously, high lead levels had been reported in new paints in India.(Van Alphen, 1999; Clark *et al,* 2005)

A cross country analysis of lead content of paint also show that in all countries, paints of the color yellow, red and green were most likely to contain the highest lead levels - even in countries with lead content within permissible levels while colors like white and blue have generally lower lead contents. Banning the sale of leaded paints is clearly an immediately achievable public health goal that will benefit the present and future generations of children and adults. This is made more urgent by studies that show that there is no safe lead level. (Lanphear *et al*,2000; Canfield *et al*, 2003). In the interim, the use of bright colors such as yellow, red and green should be avoided by consumers in Nigeria because of the high risk that they contain non-permissible levels of lead. The results are in Table 4.6.

Table 4.6: Lead Levels in parts per million (ppm) in domestic paint sold in Nigeria according to Manufacturers.

Names of manufacturers	Red	Emerald	Blue	White	Yellow	Green	Grey	Cream
B	4350	24280	5300	84	40515	____	____	____
P	26346	____	1200	3080	40515	4300	____	____
M	24840	21480	6075	4106	50, 000	____	____	____
F	____	____	3080	2600	____	6820	4208	6820
A	42285	____	3420	5080	42271	11098	____	____

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4.7 Results of Quantitative Evaluation of Lead in Household Dust, Paint Chips, Water and Dust in Ibadan, Nigeria

The results of quantitative evaluation of lead levels of dust from door step of house entrances from the local government areas in households are presented in Table 4.7. The results of quantitative evaluation of lead levels of dust from window sills from the local government areas in households are presented in Table 4.8. The results of quantitative evaluation of lead levels in paint chips in ppm from the local government areas in households are presented in Table 4.9. The results of quantitative evaluation of lead levels in soil from front of the house from the local government areas in households are presented in Table 4.10. The results of quantitative evaluation of lead levels soil from the back of the house from the local government areas in households are presented in Table 4.11. The results of quantitative evaluation of lead levels in water in ppm from the local government areas in households are presented in Table 4.12.

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Table 4.7: Lead levels of Dust from Door step of house entrances from the Local Government Areas

Ibadan North LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	66.7	235.3	30.2	33.1	44.9
	-	53.6	2.6	32.5	44.4

Ibadan North –East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	-	111.0	241.4	95.1	393.6
	-	86.5	-	-	64.2
	-	74.0	-	-	
	-	29.7	-	-	

Ibadan North-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	24.1	-	77.5	133.4	665.1
		-	12.5	34.9	
		-			
		-			16.0

Ibadan South-East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	110.2	278.7	69.3	168.5	70.4
	77.0	108.2	61.1	143.3	-

Ibadan South-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	43.8	421.3	305.2	86.8	42.8
	-	48.2	127.1	66.0	28.9

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Table 4.8: Lead `levels of Dust from Windows Sills from the Local Government Areas

Ibadan North LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	6.7	9.2	5.1	5.9	57.9
	-	44.2	8.7	12.3	
	-	-	7.4	-	-

Ibadan North - East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	-	15.0	345.2	11.6	8.3
	-	19.3	-	-	52.2
	-	21.3	-	-	
	-	188.0	-	-	

Ibadan North-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	10.8	-	2	26.2	46.0
	-	-	-	73.4	62.8
	-	-	-	-	64.9

Ibadan South-East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	53.3	55.6	79.5	47.9	94.2
	61.6	103.3	811	244.4	-

Ibadan South-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	93.2	279	47.2	63.9	40.8
	-	69.5	29.5	22.7	19.3
	-	-	-	-	-

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Table 4.9: Lead levels in Paint chips in ppm from the local Government Areas

Ibadan North LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	492.2	11,131	211.0	218.8	0
	-	740.4	17.0	85.1	0
	-	-	14.7	-	-

Ibadan North - East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	-	15,326.9	2.8	32.9	13,705
	-	38.6	-	-	0
	-	20.1	-	-	-
	-	0	-	-	-

Ibadan North – West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	12.2	-	51.3	1346.4	1675
	-	-	41.4	668.6	126.6
	-	-	-	-	27.8

Ibadan South-East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	4698.2	96.1	43,273.5	129.3	2275.0
	177.4	70.2	69.0	72.6	0

Ibadan South-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	1352	13676	5207	150	49.3
	-		1915	40	45.8

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Table 4.10: Lead levels in Soil from front of the House from the Local Government Areas

Ibadan North LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	38.0	17.5	16.5	7.9	17.0
	-	381	23.7	22.6	19.3
	-		31.2	-	-

Ibadan North-East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	-	3028.0	94.0	43.3	18.5
	-	310.1	-	-	60.0
	-	164.0	-	-	-
	-	16.3	-	-	-

Ibadan North-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	20	-	32.9	52.1	77.8
	-	-	18.4	31.9	47.9
	-	-	-	-	9.8

Ibadan South-East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	85.8	160.9	61.6	141.9	59.3
	27.8	83.6	59.3	116.6	-

Ibadan South-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	40.5	132.1	130.3	107.6	16.5
	-	37.7	31.9	77.2	15

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Table 4.11:Lead levels in soil from the back of the House from the Local Government Areas

Ibadan North LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	12.7	92.4	79.9	21.8	28.7
	-	14.1	29.4	11.9	19.9

Ibadan North –East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	-	166.1	247.7	48.6	56.7
	-	80.9	-	-	23.9
	-	80.0	-	-	-
	-	15.0	-	-	-

Ibadan North-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	23.8	-	26.3	71.8	247.2
	-	-	23.0	48.2	14.1
	-	-	-		9.0

Ibadan South-East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	81.6	154.8	111.1	132.1	84.1
	41.4	107.6	72.6	59.2	-

Ibadan South-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	78.8	85.0	152.6	27.8	24.8
	-	75.6	95.7	25.6	15.6

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Table 4.12: Lead levels in water in ppm from Local Government Areas

Ibadan North LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	0.3	0.21	0.21	0.25	0.25
	-	0.21	0.21	0.33	0.33
	-		0.21	-	-

Ibadan North - East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	-	0.21	0.21	0.3	0.3
	-	0.28	-	1.23	1.23
	-	0.32	-	-	-
	-	1.23	-	-	-

Ibadan North-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	0.16	-	0.07	0.25	0.07
	-	-	0.16	0.25	0.16
	-	-	-	-	0.16

Ibadan South-East LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	0.07	0.16	0.16	0.16	0.07
	0.16	0.16	0.16	0.16	

Ibadan South-West LGA					
Decade	1960s	1970s	1980s	1990s	2000s
	0.07	0.07	0.07	0.07	0.16
	-	0.07	0.16	0.16	0.16

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4.7.1 Lead levels in Door step Dust

The amount of lead levels in the soil at the door step of house entrances ranged from 2.6 to 665.1 ppm with an arithmetic mean (SD) of 115.1 ± 128.5 ppm. Visually (figure 4.18) and by hypothesis testing p = 0.11. Figure 4.17 and 4. 18 show the comparison of the lead levels in dust from door step of the different homes by decade and LGA respectively.

4.7.2 Lead levels in Window Sill Dust

The amount of lead levels in window sills sampled in this study ranged from 5.1 to 811ppm with arithmetic mean (SD) of 83.3 ± 113 ppm. Here p = 0.72. Figures 4.12 and 4.13 show the comparison of the window sills dust lead levels from different homes by decade and by LGA respectively.

4.7.3 Lead levels in Paints Chips

The amount of lead levels in paint chips obtain from the houses ranged from 0 – 43,273.5 ppm with arithmetic mean (SD) of 2894.6 ± 7946.4 ppm. Figures 4.18 and 4.19 show the lead levels in paint chips from different home by decade and LGA respectively.

4.7.4 Lead levels in the Soil in front of the house

There was a wide range in values of the amount of lead levels in the soil in the front of houses in this study. This ranged from 7.9 to 3027 ppm with arithmetic mean (SD) of 135.3 ± 446.9 ppm. Here p = 0.42. Figures 4.14 and 4. 15 show the comparison of lead levels in soil from front of the house of the different homes by decade and LGA respectively.

4.7.8 Lead levels in the soil in back of the house

There was a more limited range in the values of the amount of lead levels in the soil in back of the houses sampled in this study. This ranged from 11.9 to 247.7 ppm with arithmetic mean (SD) of 69.4 ± 58.6 ppm. Here p = 0.14. Figures 4.16 and 4.17 show the comparison of lead levels in soil from the back of the different homes by decade and LGA respectively.

4.7.9 Water lead levels

Analysis of lead levels in water in the homes show the wide variation between the local governments in this study. The value ranged from 0.07 to 1.23 ppm with arithmetic mean (SD)

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of 0.21 ± 0.17 ppm. Figures 4.10and 4. 11 show the comparison of lead levels in water by decade and LGA respectively.

4.8 Discussion of Quantitative Evaluation of lead levels in Household Dust, Paint chips, Soil and water in Ibadan

In this study, there was a wide range of lead levels in all samples of household dust, paint chips, soil and water. The analyses showed that these lead levels did not vary significantly across decades covered by the period studied but there was statistically significant variation in the amount of lead found in dust, paint chips, soil and water samples in homes located in the different LGAs.

There was a seventeen fold difference in the level of lead in water from the households in this study. The lowest level was 0.07 ppm while the highest was 1.23 ppm. None of the homes had the United States required limit level. (The highest level of a contaminant that is allowed in drinking water) of 0.015 ppm.(United States Environmental Protection Agency, 2012). The Maximum Contaminant Level Goal (MCLG – The level of a contaminant in drinking water below which there is no known or expected risk to health) in the United States is 0 ppm. While the MCLGs allow for a margin of safety and are non-enforceable public health goals, the MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards. (United States Environmental Agency 2012) some 70% of the residents of Ibadan live in an area without access to municipal water supply hence their water supply is at risk from erosion of natural deposits of lead into ground water. (African Development Bank Group, 2009) while Ibadan is not known to have significant lead ore deposits, several parts of Nigeria-including the East, Central and Northern parts do. For example, recent changes in gold mining practices in Zamfara, Northern Nigeria exposed children to high doses of lead acute plumbism resulted in deaths. (Dooyema *et al,* 2012; Lo *et al,* 2012) people living in these areas are therefor likely to be exposed to significant amounts of lead from potable water.

Another veritable source of lead in drinking water in Nigeria is corrosion of household and municipal plumbing systems where these exist. Lack of investment in development of

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municipal water supply, lack of guidelines on specification of construction materials and lack as well as poorly enforced water supply policy are the reasons for exposure of citizens to lead contaminant of water supply. Nigeria has a National Water Supply and Sanitation Policy issued and adopted in 2000. However this document focuses more on increasing the supply of water and has little to say about it quality. (Federal Ministry of Water Resources of Nigeria, 2000). A Country Report on Rapid Assessment of Drinking Water Quality in Nigeria conducted by UNICEF in 2010 did not evaluate lead content. (Ince *et al*, 2010). Lead exposure from drinking water therefore remains a major problem for Nigerians that requires urgent attention. To reduce lead exposure form potable water in homes, non-leaded water pipes should be used for plumbing works, water quality measures and monitoring should be put in place and the National Water Supply and Sanitation Policy should be revised to include evaluation of lead levels as one of the requirement for water quality control.

There was wide range of values for the amount of lead in the dust from window sill (5.1 to 811 µgm/ft^2), soil from the front of the house (7.9 to 3027 ppm), soil from back of the house (11.9 to 257.7 ppm) and in the doorstep (2.6 to 665.1). Some of these levels are far in excess of the recommended limit of 40 ppm on floors and 100 ppm on window sills. These values confirm that dust and soil and around the house are an important source of exposure to lead. The lead contamination may have come from contamination with lead from lead-based paint, from fallout from lead currently used in gasoline or residue from when it was used and from industrial, occupational and other sources. (Lanphear *et al*, 1998) For example, the highest level of lead in this category of samples was seen in soil from the front of the house. Nevertheless soil and dust in the domestic environment are shown in this study to be important sources of lead exposure. A study of the impact of soil lead hazard control on interior dust led levels was conducted as part of the Boston component of the Environmental Protection Agency (EPA). Three Cities Urban Soil Lead Abatement Demonstration Project. (Weitzman *et al*, 1993; Aschengrau *et al*, 1994; Aschengrau *et al*, 1997) This project involved the removal of lead-contaminated soil and its replacement with low-lead soil, a method of soil lead hazard control known as "soil lead abatement" which resulted in reductions in soil lead concentration of more than 1100µg/g. Additionally regular home cleaning to remove dust, creating adequate setbacks from the road and landscaping household surroundings to reduce dust accumulation and movement will reduce dust and soil lead contamination of homes.

Paint chips had the highest lead levels of 43,274 ppm which far exceeded the recommended limit of lead levels in house paint. The highest lead levels were found in paint chips from homes built in 1980s. Our previous studies have shown that paints sold in Nigeria market have high lead levels and this has been confirmed in more recent studies. (Adebamowo *et al,* 2007; Clark *et al,* 2009) Paint chips from old and flaking paints that were originally high in lead content are major contributors to the lead levels in homes. (Bogden and Louria, 1975; Su et *al,* 2002) Houses should therefore be renovated and repainted with lead free paint often to avoid accumulation of lead levels in flaking wall paints.

In this study, there was poor correlation between the lead in water and other household sources. This is consistent with expectation about the source of the contamination of these different materials. As expected, there was correlation between the soil dust lead levels in the front, back and doorstep of the houses. The highest levels of lead contamination in and around the Ibadan North-East Local Government Area be related to industrial pollution from a battery manufacturing plant that used to be located in this area. Lack of industrial policy, poor regulation of industries and indiscriminate pollution of the environment by industrial waste remain major sources of lead exposure in Nigeria.

Random selection of homes in Ibadan was surveyed and they may not represent the entire spectrum of lead exposure in the domestic environment. However given that this is the largest study of homes conducted in Africa and the random mode of selection, the results are likely to approximate the true situation with domestic lead exposure. Within homes, only a proportion of household surfaces were sampled. These surfaces however represent internationally accepted standard for domestic lead levels exposure that have been used in other studies in different parts of the world. (Lanphear *et al,* 1998)

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4.9 Results andDiscussions of Geotechnical Investigation of Soils in Home Environment in Ibadan

The geotechnical results of the sampled soilsshowed that the results were within normal limits. Hence, the amounts of lead present in the soils do not affect the geotechnical properties of the soils. Geotechnical engineering is the branch of civil engineering concerned with the engineering behavior of soils. It is important in engineering concerned with construction on or in the ground. It uses principles of soil mechanics and rock mechanics to investigate subsurface conditions and materials; determine the relevant physical/mechanical and chemical properties of these materials; evaluate stability of natural slopes and man-made soil deposits; assess risks posed by site conditions; design earthworks and structure foundations.

Atterberg limits tests, water content measurements, and grain size analysis, for example, may be performed on disturbed samples obtained from thick walled soil samples. Properties such as shear strength, stiffness hydraulic conductivity, and coefficient of consolidation may be significantly altered by sample disturbance. To measure these properties in the laboratory, high quality sampling is required. Common tests to measure the strength and stiffness include the triaxial shear and unconfined compression test.

The proper design of civil engineering structures requires adequate knowledge of subsurface conditions at the sites of the structures. When structures are to consist of earth or rock-fill materials an adequate knowledge of the subsurface conditions at the possible sources of construction materials is also required. Failure to recognize this has resulted in the failure of many civil engineering structures.

In the tropics, soils frequently undergo a special evolution different from that encountered by soils of the temperate regions. This evolution, characterized by the establishment in their profiles of a horizon of more or less indurated accumulation composed of oxides and hydroxides of iron, aluminium and sometimes manganese, strongly influenced the geotechnical characteristics and engineering behaviour of these tropical red soils.

The performance of tropical red soils as foundations for engineering structures despite their peculiar properties was investigated (Agbede, 1992). They were found to provide good support for shallow strip and spread foundations.

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The results of the geotechnical investigation are presented in Table 4.13. The values of the geotechnical parameters obtained ranged from 1.8 – 2.0 g/cm^3(MDD), 8.5 - 13.8% (OMC), 17.8 – 29.6% (LL), 14.2 – 23.4% (PL), and 59 - 95% (CBR); all within normal recommended values. It was revealed that the lead levels in in the home environment do not affect the geotechnical characteristics of soil.

Table 4.13: Results of Geotechnical Investigations of soils

Test		Location										Remarks
		IB North		IB NW		IB SW		IB NE		IB SE		
		Front	Back	Front	Back	Front	Back	Front	Back	Front	Back	
	Natural Moisture Content	9.7	8.7	10.2	9.0	10.5	8.2	5.3	7.0	2.6	2.6	
Atterberg Limits	Liquid Limit	18.22	17.80	29.60	15.50	17.82	20.20	26.90	22.50	27.00	27.00	
	Plastic limit	0.00	14.15	16.15	0.00	0.00	0.00	17.71	0.00	23.35	23.35	
	Sieve Analysis											
Compaction Test	Maximum Dry Density	1805	1848	1756	1708	2075	2004	1928	1808	1848	1848	
	Optimum Moisture Content	9.5	8.5	8.7	10.8	10.0	9.2	12.4	10.8	13.8	13.8	
	CBR	10	3	87	59	94	95	90	4	62	62	

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4.10 Highlighting the Architectural and Engineering significance

Paint is an architectural building material; building professionals should ensure that homes environments are physically and psychologically save for habitation. The responsibility of the Architect can be seen in chapter five under conclusions and recommendations. Architect should specify lighter paint colour like green, light blue, light green, white that contain low lead levels as to brighter colours like yellow, red which have very high lead levels. There should beprovision of adequate landscape around the homesto sieve and prevent dust. Mechanical engineers should specify non-lead water pipes for usage in buildings. The geotechnical properties that were carried out are a character of Civil Engineering. Regulatory and enforcement agency in Nigeria should provide guidelines in the manufacturing of paints.

Moreover, Civil Engineers and Architects are allied professionals that work together during construction of building on site to ensure safety excellent habitat for homes residents. Soil analysis in chapter 3.7.4 is solely the job of a Geotechnics and Civil Engineers ensuring that non-lead pipes are not used in plumbing works are the role responsibility of the Service/Mechanical Engineer.

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Table 4.14: Lead Levels in Water in ppm

	Ibadan North					Ibadan Northeast					Ibadan Northwest					Ibadan Southeast					Ibadan Southwest				
Decade	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s
No	1	2	3	2	2		4	1	1	2	1		2	2	3	2	2	2	2	1	1	2	2	2	2
Mean	.3	.21	.21	.26	.29		.51	.3	.21	.77	.16		.12	.25	.13	.12	.16	.16	.16	.07	.07	.07	.12	.12	.16
SD	-	0	0	.06	.06		.48	-	-	.66	-		.06	0	.05	.064	.0	0	0	.-	-	0	.064	.06	0
Min	.3	.21	.21	.21	.25		.21	.3	.21	.3	.16		.07	.25	.07	.07	.16	.16	.16	.07	.07	.07	.07	.07	.16
Max	.3	.21	.21	.3	.33		1.23	.3	.21	1.23	.16		.16	.25	.16	.16	.16	.16	.16	.07	.07	.07	.16	.16	.16
Med	.3	.21	.21	.26	.29		.3	.3	.21	.77	.16		.12	.25	.16	.12	.16	.16	.16	.07	.07	.07	.12	.12	.16
G mean	.3	.21	.21	.25	.29		.390	.3	.21	.61	.16		.11	.25	.12	.106	.16	.16	.16	.07	.07	.07	.11	.11	.16
95% CI	- -	.21 .21	.21 .21	.03 2.42	.05 1.7		.11 1.36	-	-	.00008 4749	-		.0005 20.207	.25 .25	.04 .40	.0006 20.21	.16 .16	.16 .16	.16 .16	-	-	.07	.0005 20.21	.0006 20.21	.16 .16

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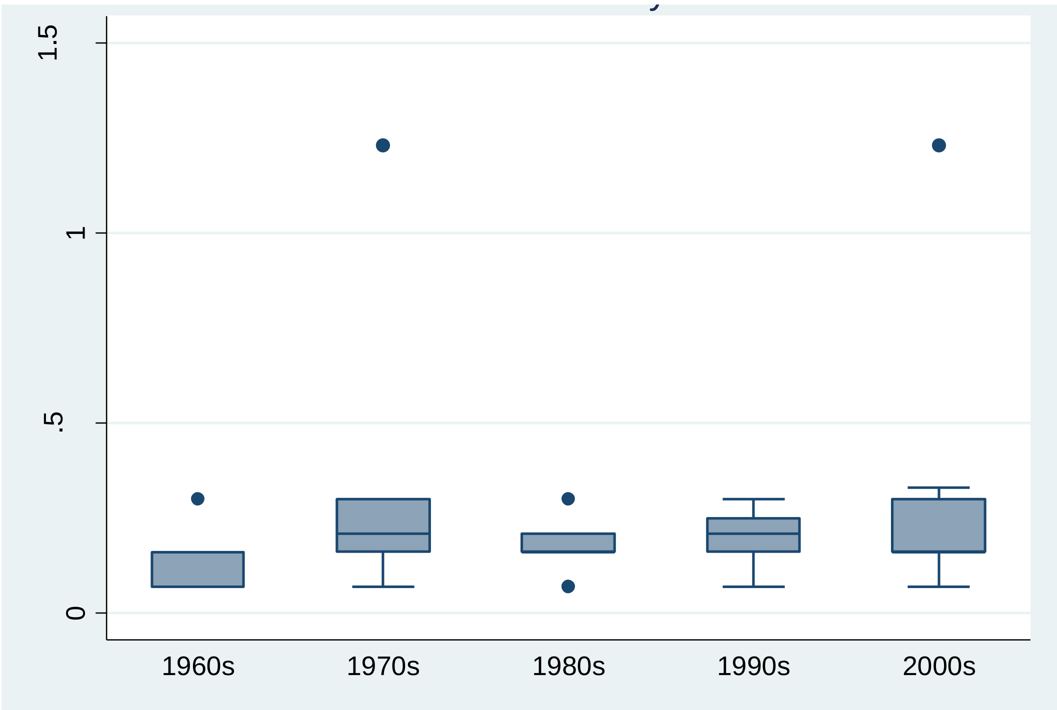

Figure 4.7: Lead levels in Water by Decades

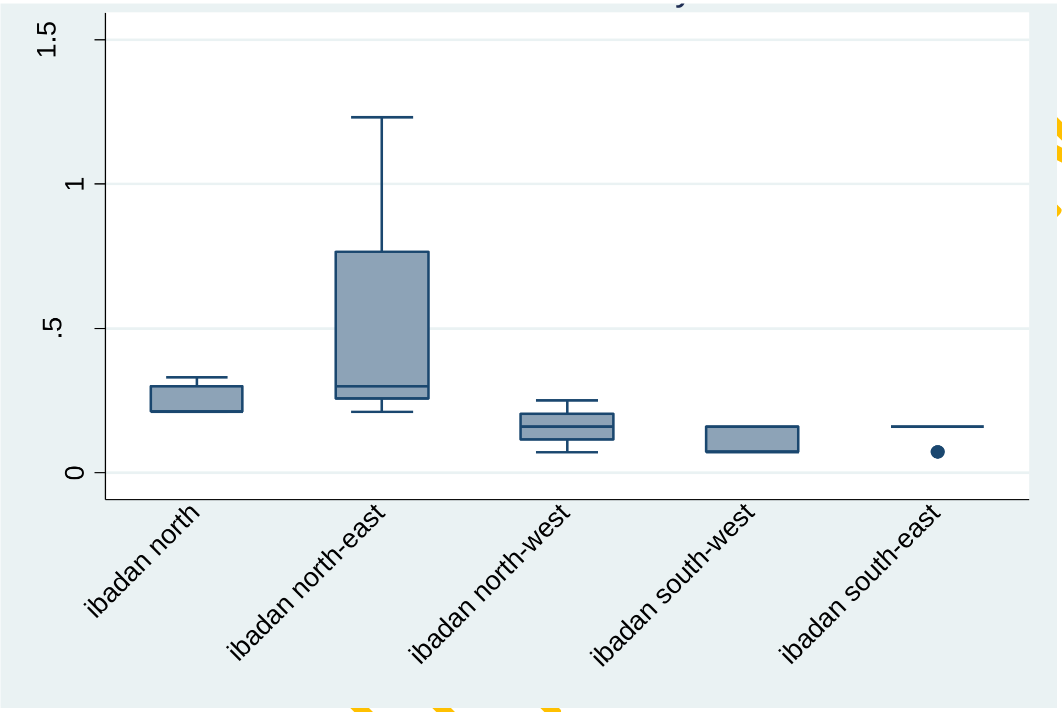

Figure 4.8: Lead levels in Water by LGA

Table 4.15: Window Sill Lead levels in ppm

	Ibadan North					Ibadan Northeast					Ibadan Northwest					Ibadan Southeast					Ibadan South		
Decade	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s
No	1	2	3	2	1		4	1	1	2	1		2	2	3	2	2	2	2	1	1	2	2
Mean	6.7	26.7	24.0	8.7	57.9		60.9	345..2	11.6	30.3	10.8		49.8	44.5	57.9	57.5	79.5	445..3	146..2	94.2	93.2	174..3	38.4
SD	-	24.7	30.0	5.09	-		84.8	-	-	31.0	-		33.4	17.5	10.3	5.9	33.7	517..2	138..9	-	-	148..1	12.5
Min	6.7	9.2	6.0	5.1	57.9		15.0	345..2	11.6	8.3	10.8		26.2	32.1	46	53.3	55.6	79.5	47.9	94.2	93.2	69.5	29.5
Max	6.7	44.2	58.4	12.3	57.9		188.0	345..2	11.6	52.2	10.8		73.4	56.8	64.9	61.6	103..3	811	244..4	94.2	93.2	279	47.2
Med	6.7	26.7	7.4	8.7	57.9		20.3	345..2	11.6	30.3	10.8		49.8	44.5	62.7	57.5	79.5	445..2	146..2	94.2	93.2	174..3	38.4
G mean	6.7	20.2	13.7	7.9	57.9		32.7	345..2	11.6	20.81	10.8		43.8	42.7	57.2	57.3	75.8	253..9	108..20	94.2	93.2	139..2	37.3
95% CI	- -	.0009 431617	. 312.40	.03 2126.9	-		5.0 212..5	-	-	.0002 2465549	-		.0630 30503.06	1.1 1603.25	35.7 91.6	22.8 143.7	1.5 3879	.00009 6.50e+08	.003 3394111	-	-	.02 952029	1.9 7039

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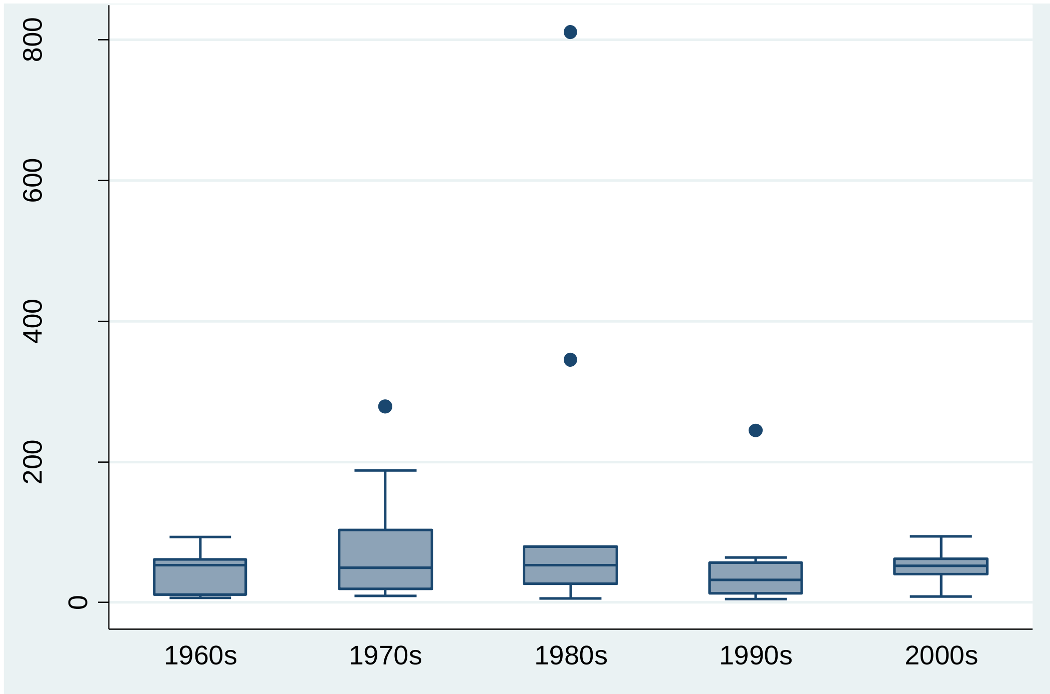

Figure 4.9: Window sill lead levels by Decades

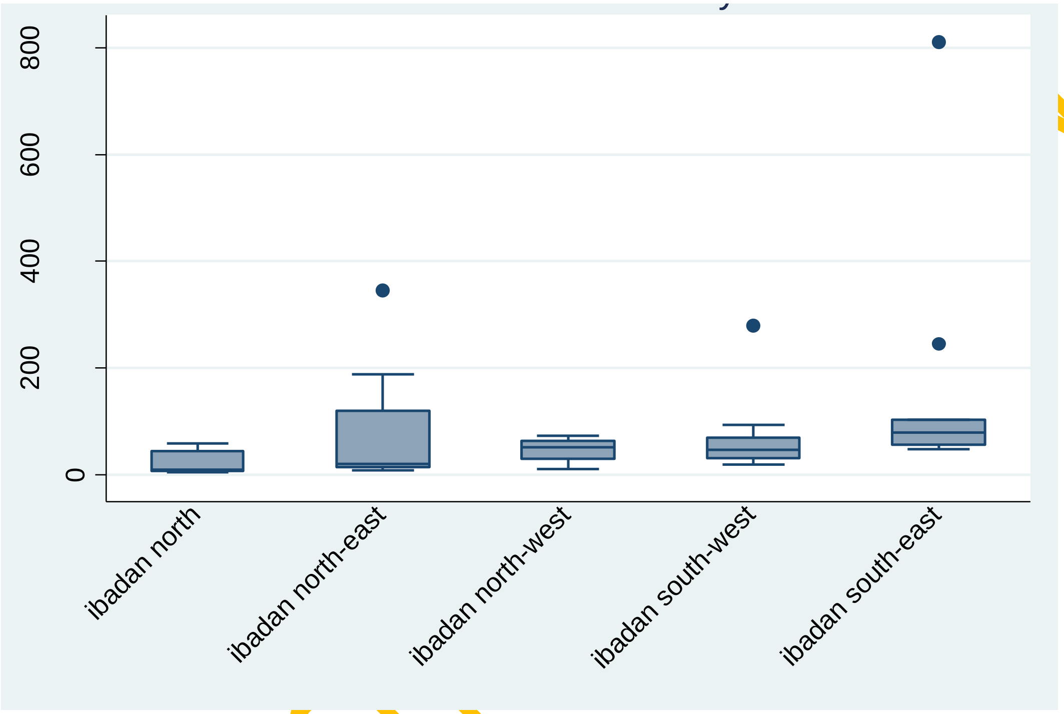

Figure 4.10: Window sill lead levels by LGA

Table 4.16: Lead in the Dust in front of the House in ppm

	Ibadan North					Ibadan Northeast					Ibadan Northwest					Ibadan Southeast					Ibadan Southwest				
Decade	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s
No	1	2	3	2	2		4	1	1	2	1		2	2	3	2	2	2	2	1	1	2	2	2	2
Mean	38	199	23.8	15.3	18.2		879.6	94	43.3	39.3	20		25.7	42	45.5	56.8	122..3	60.5	129.3	59.3	40.5	84.9	81.1	92.4	15.8
SD	-	257	7.4	10.4	1.63		1436	-	-	29.3	-		10.3	14.3	34.1	41.0	54.7	1.63	17.9	-	-	66.8	69.6	21.5	1.06
Min	38	17.5	16.5	7.9	17		16.3	94	43.3	18.5	20		18.4	319	9.8	27.8	83.6	59.3	116.6	59.3	40.5	37.7	31.9	77.2	15
Max	38	381	31.2	22.6	19.3		3028	94	43.3	60	20		32.9	52.1	77.8	85.8	160.9	61.6	141.9	59.3	40.5	132.1	130.3	107.6	16.5
Med	38	199	23.8	15.3	18.2		237.2	94	43.3	39.3	20		25.7	42	48.9	56.8	122.3	60.5	129.3	59.3	40.5	84.9	81.1	92. 4	15.8
G mean	38	81.7	23.05	13.4	18.1		228.9	93.7	43.3	33.3	20		24.604	40.8	23.4	48.8	116.0	48.8	128.6	59.3	40.5	70.6	64.47	91.1	15.7
95% CI	- -	2.58e-07 2.59e+10	710.42 51.01	.02 106 16	8.1 40.6		7.662 6838.35		-	.02 587 44	-		.6132 987.16	1.8 920. 1	2.2 497	.04 628 41	1.811 7428.26	.0380 62841	36.9 448	-	-	.0245 203365	.0084 492141.4	11.1 751	8.6 28.8

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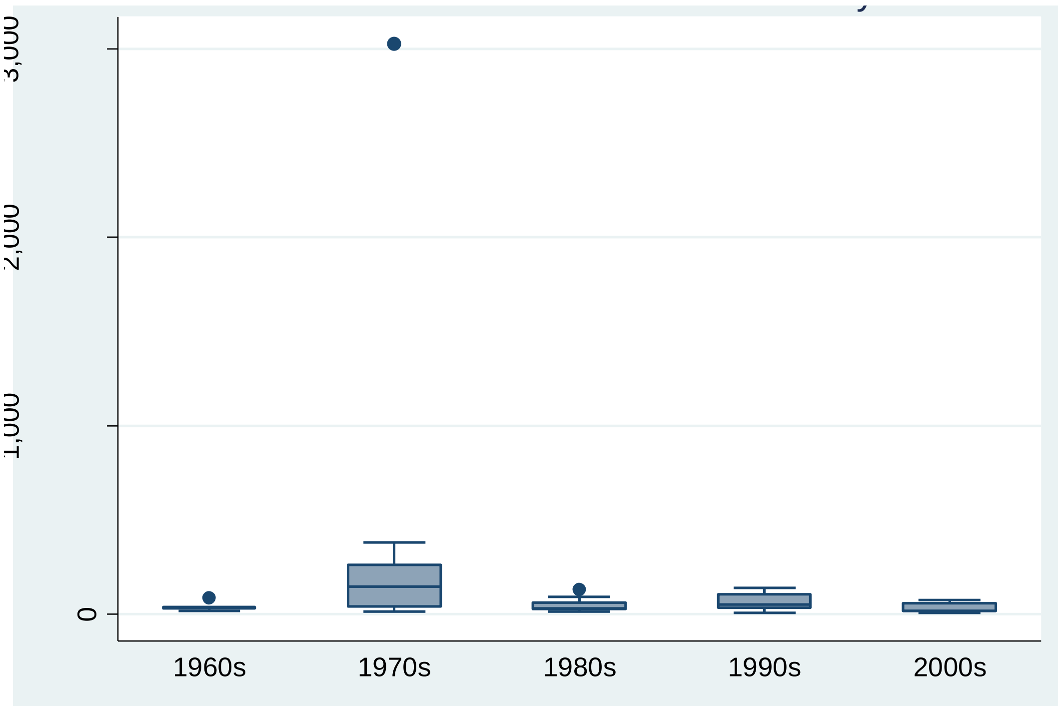

Figure 4.11: Lead In Dust From Front of house ppm by Decades

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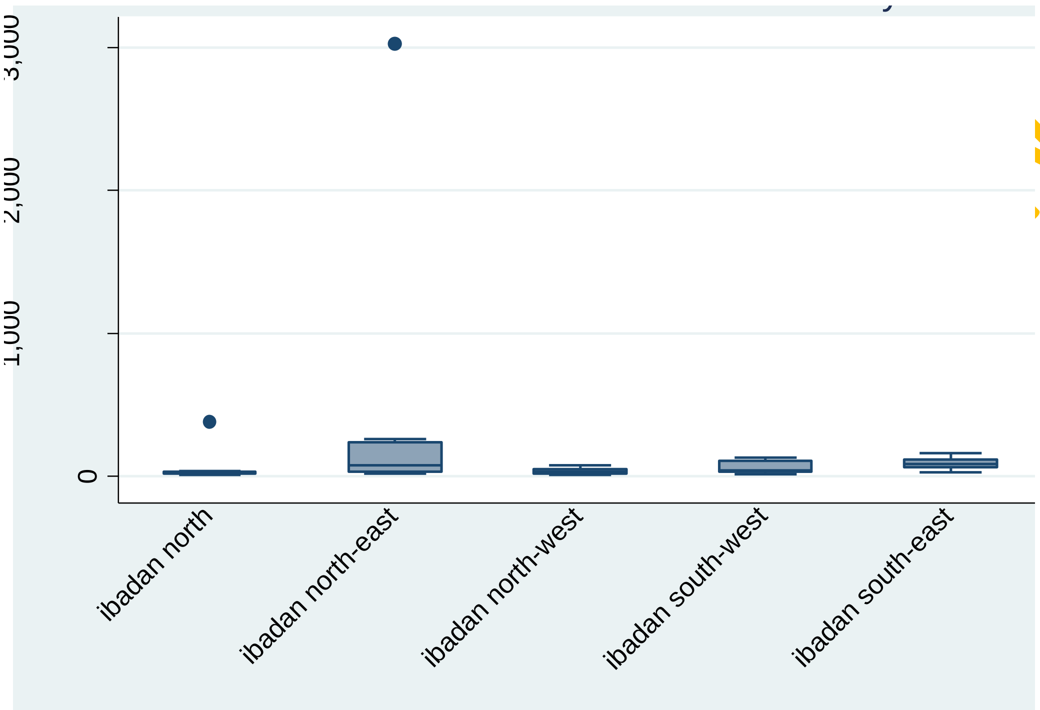

Figure 4.12: Lead In Dust From Front of house ppm by LGA

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Table 4.17: Lead in the Dust from the Back of the House inppm

	Ibadan North					Ibadan Northeast					Ibadan Northwest					Ibadan Southeast					Ibadan Southwest				
Decade	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s
No	1	2	3	2	2		4	1	1	2	1		2	2	3	2	2	2	2	1	1	2	2	2	2
Mean	12.7	53.3	54.9	16.9	24.3		85.5	247.7	48..6	40.3	23.8		24.7	60	90.1	61.5	131.2	91.9	95.7	84.1	78.8	80.3	124.2	25.6	20.2
SD	-	55.4	25.3	7.0	6.2		75.6	-	-	23.2	-		2.3	16.7	136.1	28.4	33.4	27.2	51.5	-	-	6.7	40.2	3.2	6.5
Min	12.7	14.1	29.4	11.9	19.9		15	247.7	48..6	23.9	23.8		23	48.2	9	41.4	107.6	72.6	59.2	84.1	78.8	75.6	95.7	23.3	15.6
Max	12.7	92.4	79.9	21.8	28.7		166.1	247.7	48..6	56.7	23.8		26.3	71.8	247.2	81.6	154.8	111.1	132.1	84.1	78.8	85	152.6	27.8	24.8
Med	12.7	53.3	55.3	16.9	24.3		80.4	247.7	48..6	40.3	23.8		24.7	60	14.1	61.5	131.2	91.9	95.7	84.1	78.8	80.3	124.2	25.6	20.2
G mean	12.7	36.1	50.64	16.1	23.9		54.9	247.7	48.6	36.8	23.8		24.95	58.8	.4	58.1	129.06	89.8	88.4	84.1	78.8	80.2	120.84	25.5	19.7
95% CI	-	.0002 55552059	14.42 177.85	.3 754	2.3 245		8.397 359.24	-	-	.15 8904	-		10.493 57.64	4.7 740	2740	.7801 4331	12.801 1301.12	6 1340	.5 14494	-	-	38.1 168.8	6.234 2342.3	8.3 78.2	1.0 374

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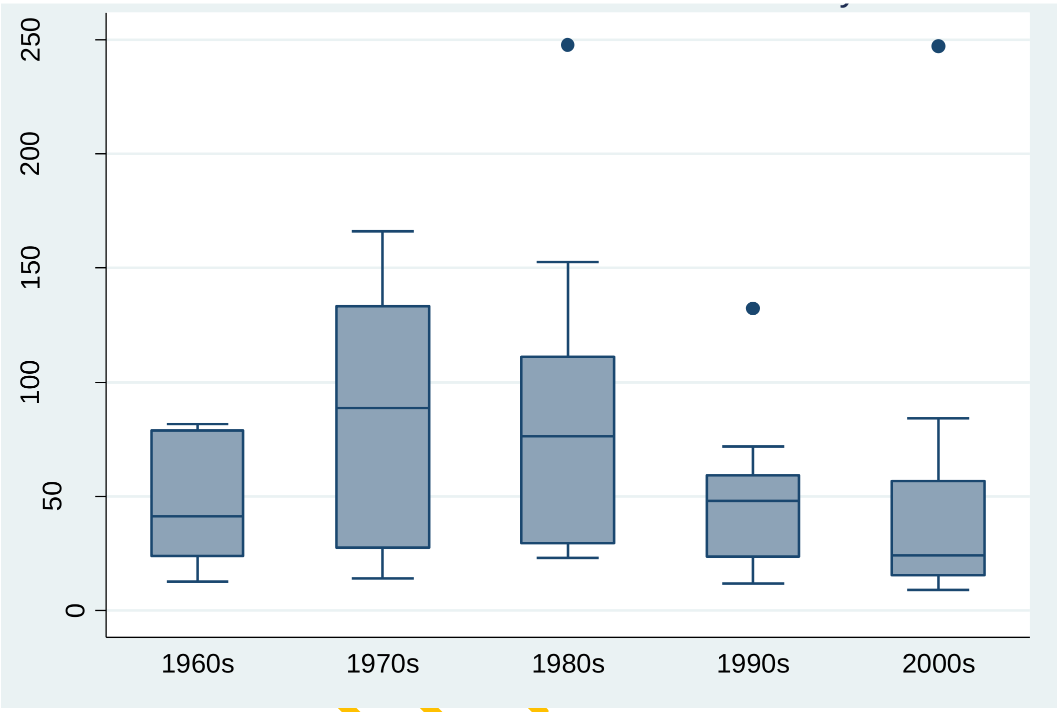

Figure 4.13: Lead Levels in Dust From Back of house ppm by Decade

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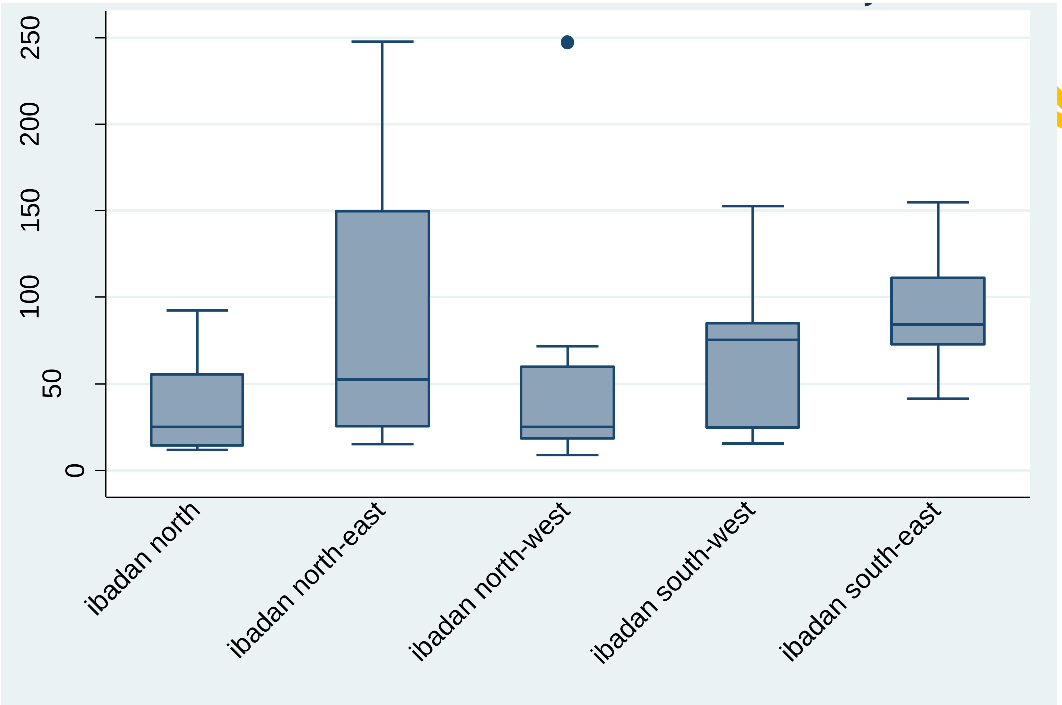

Figure 4.14: Lead In Dust From Back of house ppm by LGA

Table 4.18: Lead levels in Paint Chips from Households in ppm

	Ibadan North					Ibadan Northeast					Ibadan Northwest					Ibadan Southeast					Ibadan Southwest				
Decade	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s
No	1	2	3	2	2		4	1	1	2	1		2	2	3	2	2	2	2	1	1	2	2	2	2
Mean	492.2	5935.7	80.9	151.95	0		3846.3	2.8	32.9	6852.3	12.2		46.4	1008	609.8	2437.8	73.2	21671.3	101	2275	1352	13676	3561	95	47.6
SD	-	7347.3	112.7	94.5	0		7653.8	-	-	9690.5	=		7.0	479.3	923.8	3196.7	4.2	30550.2	40.1	-	-	19177	2327	78	2.5
Min	492.2	740.4	14.7	85.1	0		0	2.8	32.9	0	12.2		41.4	668.6	27.8	177.4	70.2	69	72.6	2275	1352	115.2	1915	40	45.8
Max	492.2	11131	211	218.8	0		15326.9	2.8	32.9	13705	12.2		51.3	1346.4	1675	4698.2	96.1	43273.5	129.3	2275	1352	27236	5207	150	49.3
Med	492.2	5935.7	17	152	0		29.1	2.8	32.9	6852	12.2		46.4	1008	126.5	2437.8	73.2	21671.3	101	2275	1352	13676	3561	95	47.6
G mean	492.2	2870.8	37.49	136.5	-		224.1	2.8	32.9	13705	12.2		46.08	948.8	180.6	913	73.09	1728	96.9	2275	1352	1771.3	3157.96	77.3	47.5
95% CI	-	1000.9 55 8.63e+ 10	.9079 1548. 77	.3 5501 9	-		.0241 20871 22	-	-	-	-		11.8 0 179. 94	11..1 8101 4	1.1 310 78	8.32e- 07 1.00e+ 12	43.7 7 122. 04	2.92e- 15 1.02e+ 21	2..5 379 1	-	-	1.47e- 12 2.13e+ 10	5.49 18135 34	.02 3553 70	29. .8 75. .9

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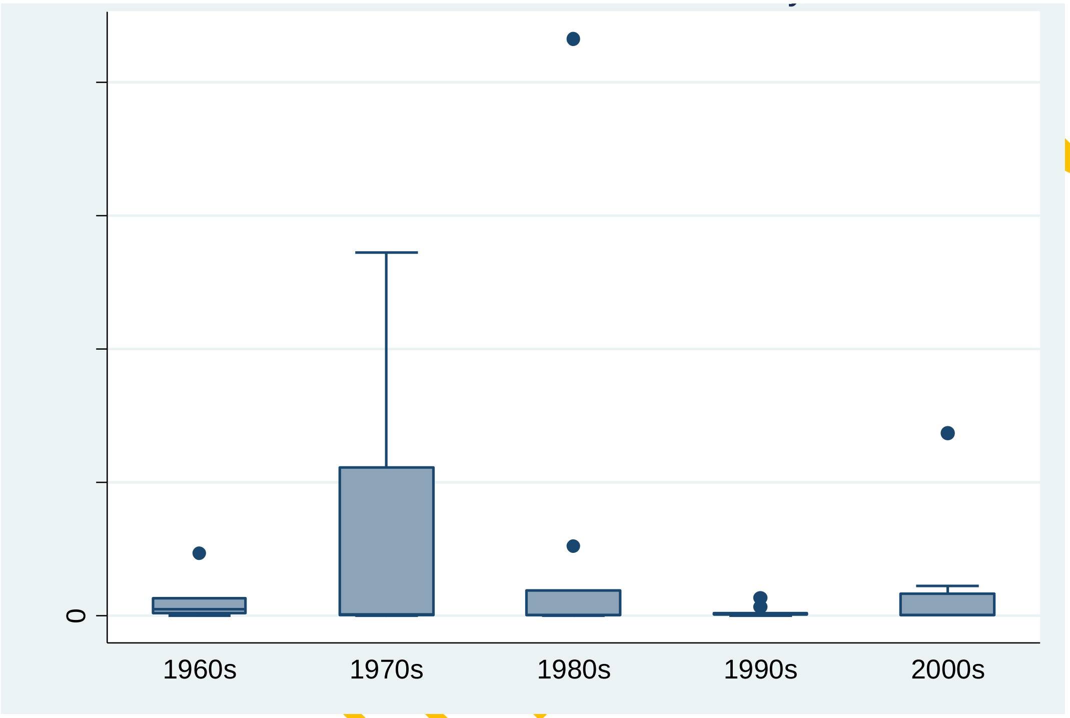

Figure 4.15: Lead levels in Paint Chips in ppm by Decades

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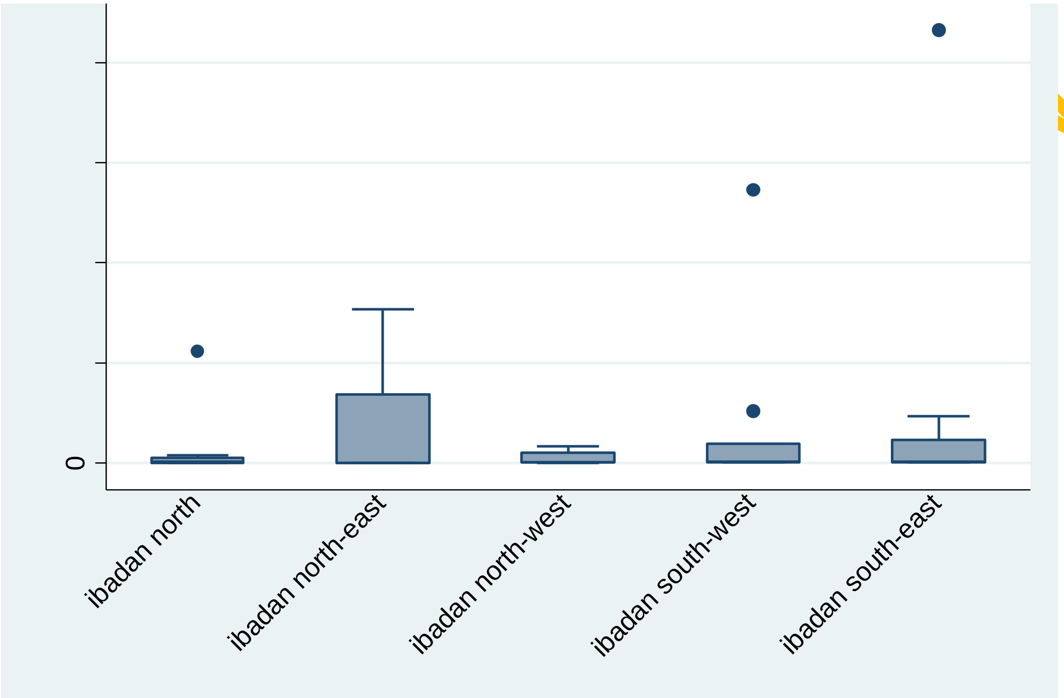

Figure 4.16: Lead levels in Paint Chips in ppm by LGA

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Table 4.19: Lead in Doorstep Dust ppm

	Ibadan North					Ibadan Northeast					Ibadan Northwest					Ibadan Southeast					Ibadan Southwest				
Decade	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s	1960s	1970s	1980s	1990s	2000s
No	1	2	2	2	2		4	1	1	2	1		2	2	3	2	2	2	2	1	1	2	2	2	2
Mean	66.7	144.5	16.3	32.8	44.7		75.3	241.4	95.1	229	24.1		45	84.2	234.5	93.6	193.5	67.7	156	70.4	43.8	234.8	216.2	76.4	35.9
SD	-	128.5	19.4	.42	.35		40.6	-	-	233	-		46	69.7	373	23.5	120.6	2.3	17.8	-	-	264	126	14.7	9.8
Min	66.7	53.6	2.6	32.5	44.4		29.7	241.4	95.1	64.2	24.1		12.5	34.9	16	77	108.2	66.1	143.3	70.4	43.8	48.2	127.1	66	28.9
Max	66.7	235.3	30	33.1	44.9		111	241.4	95.1	393.6	24.1		77.5	133.4	665	110.2	278.7	69.3	168.5	70.4	43.8	421.3	305.2	86.8	42.8
Med	66.7	144.5	16.3	32.8	44.7		80.4	241.4	95.1	229	24.1		45	84.2	22.4	93.6	193.5	67.7	156	70.4	43.8	234.8	216.2	76.4	35.9
Gmean	66.7	112..3	8.83	32.8	44.7		65.8	241.4	95.1	159	24.1		31.12	68..2	62	92.1	173.65	67.7	155.4	70.4	43.8	146.5	196.95	75..7	35..7
95% CI	-	.01 13551 56	1.58e-06 4.94e+07	29.2 36.9	41.6 47.9		24 18 0	-	-	.002 1.6e+07	-		0.000 2 33670 64	.01 3416 61	. 37 103 92	9.4 4 898 .4	.4257 7083 2.7	50.1 91.4	55..5 343.9	-	-	.0001 1.37e+08	.7540 5144 3.7	13..3 431.4	2..9 426.3

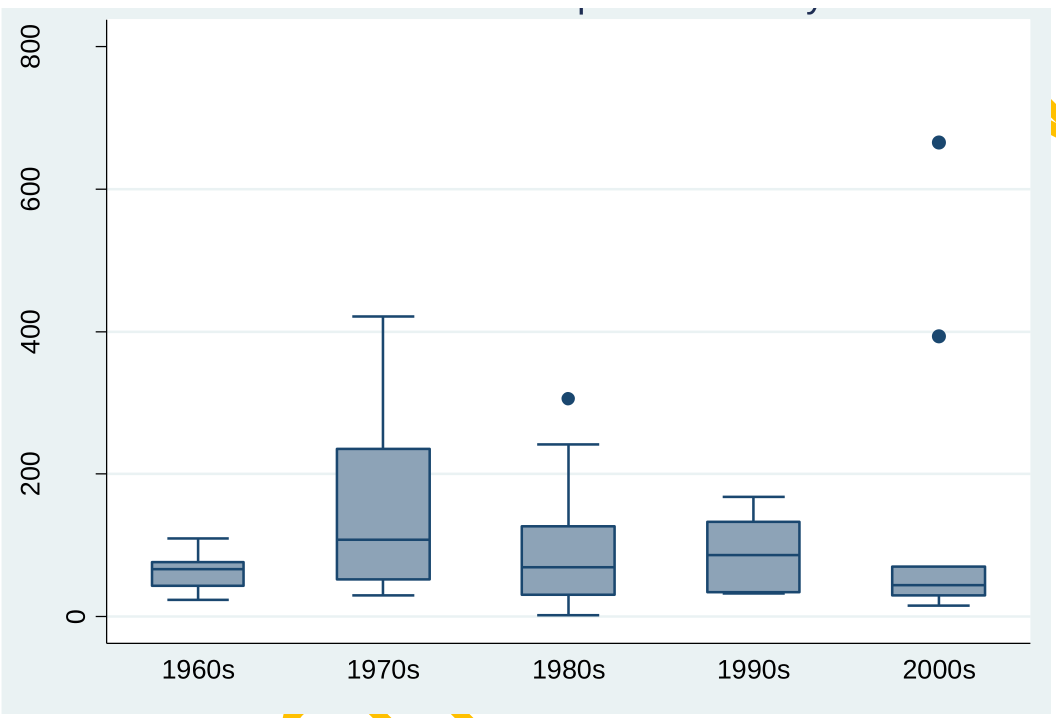

Figure 4.17: Lead levels in doorstep dust by Decades

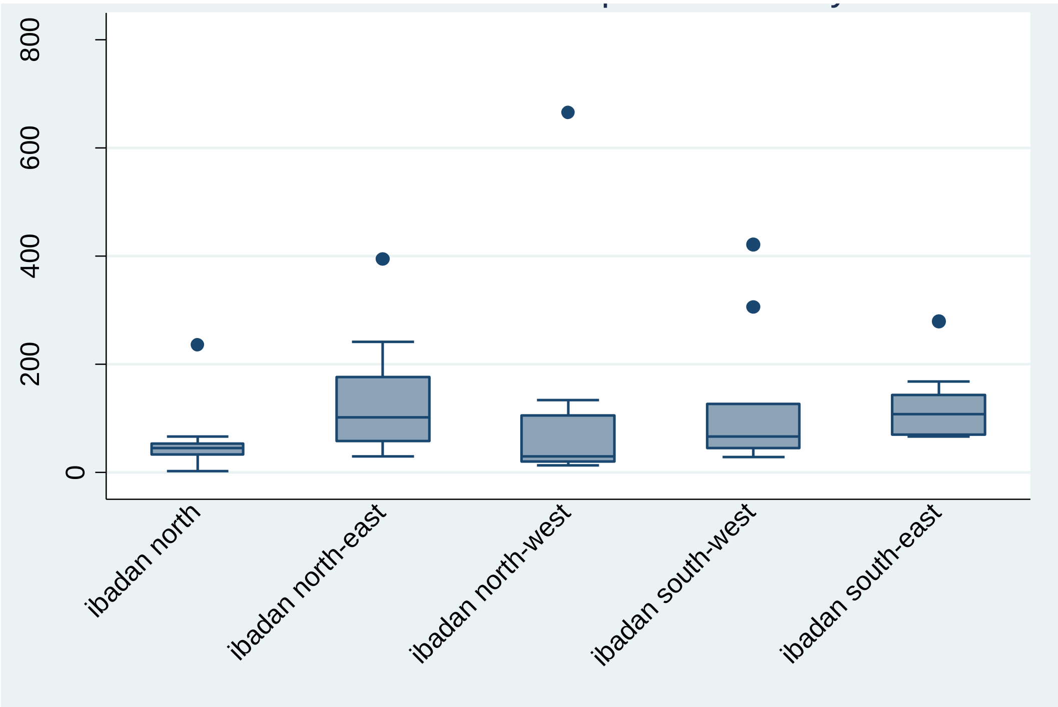

Figure 4.18: Lead levels in doorstep dust by LGA

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CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The indoor and built environments in Ibadan have been found to be highly affected by high lead levels. Hence, lead levels in paint used in homes should be reduced to minimize human morbidity and mortality. The usage of non-lead water pipes is highly recommended. Lead levels in soil in the home environment do not affect the geotechnical characteristics of soil. The soil in the home environment is safe to be used for small construction works around the house, since the geotechnical properties of the soil around the house is not affected by the presence of lead levels in it.

This study showed that there was no satisfactory level of knowledge and awareness of domestic sources of lead exposure and its health effect in Nigeria. Most samples investigated contained lead levels exceeding the recommended level. This study has established the need for improved quality control in the production of brighter colour paints. Non-regular cleaning and repainting were generally responsible for high lead deposits in dust of some homes. The study established the need for landscaping to prevent lead deposits on exposed soil surfaces. The use of non-lead water pipes is also beneficial.

There is need to increase people's awareness of the harmful effects of lead in the domestic environment, in household paints, similar to what has been done for leaded petrol. A public health agenda leading to elimination of lead in paint should be formulated and systematically prosecuted. There is an urgent need to determine the extent of leaded paints in existing housing stock in Nigeria and other developing countries, its effect on children's blood lead levels, and to develop programs to reduce the risk of exposure.

This study showed that there was limited knowledge and awareness of domestic sources of lead exposure and its health effects in Nigeria. The origins of popular misconceptions about lead exposure and effective means of correcting them need to be explored. The findings suggest that more studies are needed to fully understand the knowledge, attitudes and practices of this population to lead exposure in order to develop appropriate health intervention.

There is a need to increase awareness of the harmful effects of lead in the domestic environment in household paints. A public health agenda leading to elimination of lead in paint should be formulated and systematically prosecuted. There is an urgent need to determine the

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extent of leaded paints in existing housing stock in Nigeria and other developing countries, and to develop programmes to reduce the risk of exposure.

The study also showed that lead levels in soil in the home environment do not affect the geotechnical characteristics of soil as the values were within the recommended units.

The results of this study could assist government (state and local) to identify areas of lapse on environmental exposure to lead in the home environment. Moreover, regulatory agencies of Nigeria may find the demographic and results analysis in this study useful consideration for health advocacy.

5.2 Recommendations

The following recommendations are proposed:

1 The Federal, State and Local Governments and communities should organize public awareness lectures, seminars and workshops about lead, lead exposure and lead poisoning in the home environment.

2 Regulatory Agencies of Nigeria should propose a regulation for the amount of lead in paint being manufactured in Nigeria or imported into the country.

3 Architects should propose maintenance policy on house renovation: especially regular repainting of houses before the paints get flaky. In this wise, houses painted in the 1960s and before should be repainted. Through urban renewal programmes.

4 Home environments should be landscaped to cover exposed top soil with vegetation in order to reduce dust generation and the associated exposure to lead particles borne in dust.

5 Architects should consider designing homes in ways that reduce dust and paint chip accumulation, particularly in window wells (loose paint is especially likely to be found on window sills and wells, since opening and closing windows tend to damage paint), so that this potential source of lead exposure can be controlled. For now, Architects should specify lesser bright coloured paints likes cream, white etc, instead of the brighter colours like yellow and red.

6 Urban renewal programmes should be carried out; for example the re-painting of old homes with lead-free paint and consideration should be given to lead-abatement programmes.

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7 Regular dust control and lead level screening programs should be conducted so that safe level of exposure can be maintained.

8 Municipal water supply should be restored and old leaded pipes should be replaced with PVC pipes.

9 Legislation that enforces safe lead levels in paint should be enforced.

10 Encourage lead control programmes through continued research, educational effects, and community awareness.

11 Chelation methods should be propose to reduce the amount of lead in the body, and lead abatement activities should carried out where and when necessary.

12 The soil in the home environment can be used to for small construction works around the house, since the geotechnical properties of the soil around the house is not affected by the presence of lead levels in it.

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REFERENCES

Adebamowo E.O, Agbede O. A, Sridhar M.KC and Adebamowo C.A (2006) An examination of knowledge, attitude and practices related to lead exposure in South Western Nigeria. BMC Public Health 6(1): 82.

Adebamowo E.O, Agbede O. A, Sridhar M.K.C and Adebamowo C.A (2006). Questionnaire Survey of Exposure to Lead in the domestic environment in Nigeria." Sci Total Environ 372 (2006) 94-99.

Adebayo, A. O., Ed. (1997). Effects of Lead poisoning and vehicular emissions on road traffic workers. Lagos, Friends of the Environment.

Adeyemi, O. A., Ed. (1998). Effects of Lead Poisoning and Vehicular Emissions on road Traffic Workers and Petrol Vendors. Lagos, Friends of the Environment.

Adogame, A. L. (1997). An assessment of Lead and some heavy metals in the outdoor environment of Ibadan City.Department of Preventive and Social Medicine. Ibadan, University of Ibadan, Ibadan, Nigeria**:** 60 - 65.

Agbo, S., Ed. (1997).Effects of Lead Poisoning In Children. Lagos, Friends of TheEnviroment.

Alsaleh, I., E. Devol, et al. (1994). "Distribution of blood lead levels in 1047 Saudi Arabian children with respect to province, sex, and age,." Arch Environ Health**49**: 471-476.

Anetor, J. I. (2001). High blood lead levels in the generalised Nigerian population: causes and complications. National conference on the phase-out of leaded gasoline in Nigeria, Abuja, Nigeria.

Ankrah, N. A., (1996). "Lead levels and related biochemical findings occurring in Ghanaian subjects occupationally exposed to lead." East Afr Med J**73**(6): 375 - 379.

Anon. (2004). "Ibadan." 2004. Retrieved 20th January, 2005.

UNIVERSITY OF IBADAN

Anon (2007). Shoppers concerned about Chinese goods. The New York Times. New York, http:www.nytimes.com:http://www.nytimes.com/aponline/business/AP-Made-in-China.html?pagewanted=print.

ASTM (1995). Standard Practice for Field Collection of Settled Dust Samples Using Wipe Sampling Methods for Lead Determination by Atomic Spectrometry Techniques. West Conshohocken, PA, American Society for Testing Materials.

ASTM (1995).Standard Practice for the Field Collection of Soil Samples for Lead Determination by Atomic Spectrometry Techniques.West Conshohocken, PA, American Society for Testing Materials.

Baghurst, P., (1992). "Environmental exposure to lead and children's intelligence at the age of seven years.The Port Pirie Cohort Study."N Engl J Med**327**(18): 1279-1284.

Bellinger, D., A.(1987). "Longitudinal analyses of prenatal and postnatal lead exposure and early cognitive development."N Engl J Med**316**(17): 1037-1043.

Bellinger, D. C. (2004)."Lead."Pediatrics**113**(4): 1016-1022.

Benton, D. and J. P. Buts (1990)."Vitamin/mineral supplementation and intelligence."Lancet**335**(8698): 1158-60.

Bernard, S. M. (2003). "Should the Centers for Disease Control and Prevention's Childhood Lead Poisoning Intervention Level Be Lowered?" Am J Public Health**93**(8): 1253-1260.

Blackfan, K. D. (1917). "Lead poisoning in Children with especial references to lead as a cause of convulsions."Am. J. Med. Sci.**53**: 877-887.

Brody, D. J., (1994). "Blood lead levels in the U.S. population: Phase 1 of the Third National Health and Nutrition Examination Survey (NHANES III, 1988-1991)." JAMA**272**: 277 - 283.

UNIVERSITY OF IBADAN

Byers, R. K. and E. E. Lord (1943)."Late effects of lead poisoning on mental development."Am. J. Dis. Child.**66**: 471-483.

Canfield, R. L., C. R. Henderson, Jr., et al. (2003). "Intellectual Impairment in Children with Blood Lead Concentrations below 10 {micro}g per Deciliter." N Engl J Med**348**(16): 1517-1526.

Center for Diseases Control (1997). "Update: Blood lead levels - United States 1991 - 1994." MMWR**46**: 141 - 145.

Central Intelligence Agency (2005).World Fact Book.Central Intelligence Agency, Central Intelligence Agency.**2005**.

Chisolm, J. J. (2001). "The road to primary prevention of lead toxicity in children."Pediatrics**107**(3): 581 - 583.

Clark, C. S., (2006). "The lead content of currently available new residential paint in several Asian countries."Environmental Research**102**: 9 - 12.

Clark, C. S., V. (2005). "Lead in paint and soil in Karnataka and Gujarat India."J. Occup. Environ. Hyg.**2**(38 - 44).

Coste, J.,(1991). "Lead-exposed workmen and fertility: a cohort study on 354 subjects." Eur J Epidemiol**7**(2): 154-8.

Elwood, T. and A. Fischbein (1980). "Greater contribution to blood lead from water than from air." Nature**310**: 138 - 140.

Environmental Protection Agency (1986).Air Quality Criteria for Lead.Research Triangle Park, NC, Office of Air Quality and Standards, U.S. Environmental Protection Agency.

Environmental Protection Agency (1995).Sampling house dust for lead: Basic concepts and literature review.Washington, D.C., U.S. Environmental Protection Agency.

Environmental Protection Agency (2001).Lead; Identification of Dangerous Level of Lead; Final rule, Environmental Protection Agency, Washington DC.**40 CFR Part 745**.

Environmental Protection Agency (EPA) (1990)."U.S. Department of Housing and Urban Development (HUD): Lead-based paint: Interim guidelines for hazard identification and abatement in public and Indian housing, Appendix A."Fed Register**55**: 14556 - 14614.

Ernhart, C. B. (1992). "A critical review of low-level prenatal lead exposure in the human: 2. Effects on the developing child." Reprod Toxicol**6**(1): 21-40.

Fahim, M. S., (1976). "Effects of subtoxic lead levels on pregnant women in the state of Missouri." Res Commun Chem Pathol Pharmacol**13**(2): 309-31.

FEPA (1991). Guidelines and Standards for Enviromental Pollution Control in Nigeria**:** 71-73.

Gibson, J. L. (1892). "Notes on lead - poisoning as observed among children in Brisbane." Proc. Intercolonial Med. Congr.Austr.**3**: 76-83.

Gil, F., (1994). "Dental lead levels in the Galician population, Spain." Sci Total Environ**156**(2): 145 - 150.

Gilfillan, S. C. (1965). "Lead poisoning and the fall of Rome."J. Occup. Med.**7**: 53-60.

Goyer, R. A. (1971). "Lead toxicity: a problem in environmental pathology." Am J Pathol**64**(1): 167-82.

Goyer, R. A. (1993). "Lead toxicity: current concerns." Environ Health Perspect**100**: 177-87.

Goyer, R. A. (1995)."Nutrition and metal toxicity."Am J ClinNutr**61**(3 Suppl): 646S-650S.

Goyer, R. A. (1996). "Results of lead research: prenatal exposure and neurological consequences." Environ Health Perspect**104**(10): 1050-4.

Grandjean, P. (1979). "Widening Perspective of Lead Toxicity."Environmental Research**17**: 303-321.

UNIVERSITY OF IBADAN

Greenbaum, T. L. (1997). The Handbook for Focus Group Research.Thousand Oaks, CA, Sage Publications.

Greenhalgh, T. and R. Taylor (1997). "How to read a paper: Papers that go beyond numbers (qualitative research)." BMJ**315**: 740 - 743.

Grigg, J. (2004). "Environmental toxins; their impact on children's health."Arch. Dis. Child.**89**(3): 244-250.

Grobler, S. R., (1996). "Evidence of undue lead exposure in Cape Town before the advent of leaded petrol."S Afr Med J**86**(2): 169 - 171.

Hotz, M., K. Kniepmann, et al. (1998)."Occupational therapy in pediatric lead exposure prevention."Am J Occup Ther**52**(1): 53 - 59.

Hu, H., (1996). "Determinants of bone and blood lead levels among community-exposed middle-aged to elderly men. The normative aging study."Am J Epidemiol**144**(8): 749-59.

Hu, W. Y., (1992). "A toxicological and epidemiological study on reproductive functions of male workers exposed to lead." J Hyg Epidemiol Microbiol Immunol**36**(1): 25-30.

Human Rights Watch. (2012). "Nigeria: Child Lead Poisoning Crisis." Retrieved 20 Feb, 2012, from http://www.hrw.org/news/2012/02/07/nigeria-child-lead-poisoning-crisis.

Kaiser, R., (2001). "Blood lead levels of primary school children in Dhaka, Bangladesh." Environ Health Perspect**109(6)**: 563-566.

Koo, W. W., (1991). "Serum vitamin D metabolites and bone mineralization in young children with chronic low to moderate lead exposure." Pediatrics**87**(5): 680-7.

Lancranjan, I., (1975). "Reproductive ability of workmen occupationally exposed to lead." Arch Environ Health**30**(8): 396-401.

Landrigan, P. (2000). "The reproductive toxicity and carcinogenicity of lead: a critical review." Am. J. Ind.Med.**38**: 231-243.

Landrigan, P. J. and J. W. Graef (1987). "Pediatric lead poisoning in 1987: the silent epidemic continues." Pediatrics**79**(4): 582-3.

Lanphear, B. P., K. N. Dietrich, et al. (2000). "Cognitive deficits associated with blood lead concentrations less than 10 mg/dL in U.S. children and adolescents." Public Health Rep**115**(6): 521 - 529.

Lenihan, J. and W. W. Fletcher (1991)."Environment and Man: In the Chemical Environment."Blackies and sons ltd**6**: 66-74.

Lidsky, T. I. and J. S. Schneider (2003). "Lead neurotoxicity in children: basic mechanisms and clinical correlates." Brain**126**(1): 5-19.

Liou, S. H., (1994). "Blood lead levels in the general population of Taiwan, Republic of China." Int Arch Occup Environ Health**66**(4): 255 - 260.

Liu, X., (2002). "Do Children With Falling Blood Lead Levels Have Improved Cognition?" Pediatrics**110**(4): 787-791.

Mahaffey, K. R. (1990). "Environmental lead toxicity: nutrition as a component of intervention." Environ Health Perspect**89**: 75-8.

Mahaffey, K. R., (1982). "National estimates of blood lead levels: United States, 1976-1980: association with selected demographic and socioeconomic factors." N Engl J Med**307**(10): 573-9.

Maravelias, C., S. (1994). "Lead exposure of the child population in Greece."Sci Total Environ**158**(1-3): 79 - 83.

Mathee, A., (2003). "Childhood lead exposure in South Africa."S Afr Med J**93**(5): 313.

UNIVERSITY OF IBADAN

Menke, A., P. (2006). "Blood lead below 0.48 micro-mol/L (10 micro-g/dL) and mortality among US adults." Circulation **114**(13): 1388 - 1394.

Morgan, D. L. (1997). Focus Groups as Qualitative Research. Thousand Oaks, CA, Sage Publications.

Ndiokwere, C. C. (1984). "A study of heavy metal pollution from motor vehicles emissions and its effects on road side soil, vegetation and crop in Nigeria environment." POH serv: 33-43.

Needleman, H. (2004). "Lead Poisoning." Annual Review of Medicine **55**(1): 209-222.

Needleman, H. L. and C. A. Gatsonis (1990). "Low-level lead exposure and the IQ of children. A meta-analysis of modern studies." Jama **263**(5): 673-8.

Needleman, H. L. and P. J. Landrigan (2004). "What level of lead in blood is toxic for a child?" Am J Public Health **94**(1): 8-.

Nriagu, J. O. (1979). " Global Inventory of Natural and Anthropogenic Emissions of Trace Metals To the Atmosphere." Nature **279**: 408-411.

Nriagu, J. O., (1996). "Childhood lead poisoning in Africa: a growing public health problem." Sci Total Environ **181**(2): 93-100.

O'Donohoe, J., S. (1998). "Blood lead in U.K. children - time for a lower action level?" Clin Science **95**: 219 - 223.

Omar, M., (2001). "Teeth and blood lead levels in Egyptian school children: Relationship to health effects." J Appl Toxicol **21**(4): 349 - 352.

Omokhodion, F. O. (1994). "Blood lead and tap water lead levels in Ibadan, Nigeria." Sci Total Environ **151**(3): 187-90.

UNIVERSITY OF IBADAN

Ozden, T. A., H. (2004). "Longitudinal Analyses of Blood-Lead Levels and Risk Factors for Lead Poisoning in Healthy Children under Two Years of Age."Indoor and Built Environment**13**(4): 303-308.

Ozden, T. A., (2004). "Blood Lead Levels in School Children." Indoor and Built Environment**13**(2): 149-154.

Pocock, S. J., (1994). "Environmental lead and children's intelligence: a systematic review of the epidemiological evidence." BMJ**309**(6963): 1189-1197.

Pope, C., (2000). "Qualitative research in health care: Analysing qualitative data." BMJ**320**: 114 - 116.

Potula, V., (2001). "Blood lead levels in relation to paint and dust lead levels: The Lead-Safe Cambridge Program." Am J Public Health**91**(12): 1973 - 1974.

Pounds, J. G., (1991). "Cellular and molecular toxicity of lead in bone."Environ Health Perspect**91**: 17-32.

Rhoads, G. G., A. S. (1999). "The Effect of Dust Lead Control on Blood Lead in Toddlers: A Randomized Trial." Pediatrics**103**(3): 551-555.

Rosen, J. F. and M. E. Markowitz (1980). "D-penicillamine: its actions on lead transport in bone organ culture." Peadiatrics Res**14**(4 Pt 1): 330-5.

Rothenberg, S. J. and J. C. Rothenberg (2005)."Testing the dose-response specification in epidemiology: Public health and policy consequences for Lead."Environ Health Perspect**113**(9): 1190 - 1195.

Ruff, H. A., (1993). "Declining blood lead levels and cognitive changes in moderately lead-poisoned children."JAMA**269**(13): 1641-6.

UNIVERSITY OF IBADAN

Sanborn, M. D., (2002). "Identifying and managing adverse environmental health effects: 3. Lead exposure." CMAJ**166**(10): 1287-1292.

Savory, G. (1989)."Lead in Clinical Chemistry."Newsis: 7-17.

Schoof, R. A., (1993). "Assessing the validity of lead bioavailability estimates from animal studies." Toxicologist**13**: 478.

Schwartz, B. S., W. F. Stewart, et al. (2000). "Past adult lead exposure is associated with longitudinal decline in cognitive function." Neurology**55**(8): 1144-1150.

Schwartz, J. (1994). "Societal benefits of reducing lead exposure." Environ. Res.: 105-124.

Shannon, M., A.(2001). "Chelation Therapy in Children Exposed to Lead."N Engl J Med**345**(16): 1212-1213.

Sidani, S. and L. Sechrest (1996)."Analysis and use of qualitative data."NIDA Res Monogr**166**: 292 - 309.

Sittig, M. (1991).Handbook of Toxic and Hazardous chemicals and carcinogens.

Sokol, R. Z., (1994). "Lead exposure in vivo alters the fertility potential of sperm in vitro." Toxicol Appl Pharmacol**124**(2): 310-6.

Sridhar, M. K. C. (2001). Environmental lead levels in African cities. Regional Conference on the Phase-out of Leaded Gasoline in Sub-Saharan Africa. The World Bank Clean Air Initiative in Sub-Saharan African cities, Hotel Meridien President, Dakar, Senegal.

Sridhar, M. K. C. and I. R. Okerearu (1999). "Exposure to indoor lead in Lagos Metropolis: A Nigerian experience." Epidemiology**10**(4): 227.

Sridhar, M. K. C., (2000). Lead in the Nigerian environment: Problems and prospects. 11th Annual International Conference on Heavy Metals in the Environment, University of Michigan, Ann Arbor.

UNIVERSITY OF IBADAN

Stephenson, J. (2003). "CDC Report on Environmental Toxins: Some Progress, Some Concerns." JAMA**289**(10): 1230-1231.

Thornton, I., (1990). "Lead exposure in young children from dust and soil in the United Kingdom." Environ Health Perspect**89**: 55-60.

Tong, S., (2000). "Environmental lead exposure: a public health problem of global dimensions." Bull World Health Organ**78**(9): 1068-77.

Tuohimaa, P. and L. Wickmann, Eds. (1985).Sperm production.production of men working under heavy metal or organic solvent exposure.In occupational hazards and reproduction.Hemisphere, New York.

US Consumer Products Safety Commission (1977). Notice reducing allowable levels of lead. Final Rule, US Consumer Products Safety Commission.**Final Rule Fed. Register 42:** 44199.

Van Alphen, M. (1999). Lead in paints and water in India. Proceedings of the International Conference on Lead Poisoning Prevention and Treatment: Implementing a National Program in Developing Countries, February 8 - 10. A. M. George. Bangalore, India, The George Foundation**:** 265 - 272.

Vupputuri, S., (2003). "Blood lead levels is associated with elevated blood pressure in blacks." Hypertension**41**: 463-468.

Wedeen, R. P. (1982). "The role of lead in renal failure."ClinExp Dial Apheresis**6**(2-3): 113-46.

World Health Organisation (1989). Epidemiologic Notes and Reports on Lead Poisoning Association with. Copenhagen, World Health Organisation Regional Office for Europe**:** 1 - 2.

World Health Organisation (1995).Inorganic Lead. Geneva, World Health Organisation.

UNIVERSITY OF IBADAN

Zielhuis, R. L. (1983). "Lead Alloys and Inorganic Compounds." Encyclopaedia of Occupational Health and Safety **2**: 1200-1225.

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APPENDIX 1

FOCUS GROUP DISCUSSION GUIDE

Each focus group session will last for about 2 hours and will be facilitated by the project coordinator and/or other trained field staff at each site.

Introduction

Thank you for participating in this discussion group. We are interested in learning about your beliefs and attitudes regarding domestic exposure to lead and its impact on children's health. We would like to hear what everyone thinks, so please feel free to express your views, even if you disagree with someone else. All of your comments – both positive and negative- are important. The discussion will be taped- recorded so that we don't loose any of your comments. A report will be prepared from the transcripts, but the report will not identify anyone by name. Every effort will be made to keep the information you provide confidential.

Lead

What comes to mind when you hear the word "lead"?
PROBES: What do you think it is?
Where do you think it can be found?
What risks do you think is associated with exposure to lead?
Have you ever tested the lead level in your domestic environment? (IF " YES") Why did you do the test?
PROBES: What are the reasons you might participate to do a lead level test ~~{or not}~~

Lead and lead poisoning

What images does the word "lead poisoning" bring up for you or what do you think of when you hear the word "lead poisoning"?
PROBES: What about lead exposure?
What other words have similar meanings for you?

What impact do you feel lead or lead poisoning have on health?
What (other) factors do you believe contribute to
Health? What do you believe about lead exposure and how to
Reduce it? Concerns?Percieved risks? Hopes? Perceived
benefits?
What kinds of things would be important to you in deciding what to do about lead exposure?
PROBES: What are the reasons you might participate { or be concerned about lead}?
What are the reasons you might not be concerned about lead?
Where do you think you can find information about lead exposure in your community?

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What kinds of methods of reducing lead exposure do you know?

Does any one have anything they would like to add?

THANK YOU FOR PARTICIPATING!!!

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APPENDIX 2

Questionnaire on the knowledge attitude and practice to lead and lead poisoning

This study is designed to assess your knowledge, attitude and practice to lead and lead poisoning. The form should be filled as completely as possible. All information provided are strictly confidential and no third party will have access to it without your express permission. Please round up all figures to the nearest whole number. If you have any questions contact Arc. (Mrs.) E. Adebamowo, Department of Civil Engineering, University of Ibadan, Ibadan, Oyo State, Nigeria. Phone Number 08034115448. Thank you.

Date:..

1. Name: ....

2. Contact Address: ....

   ....

3. Serial Number:................................

4. Age (in years):............................... Date of birth (dd/mm/yy) __/__/__

5. Sex: 1. Male ( ) 2. Female ( )

6. Ethnic Group:................................

7. Marital Status: 1. Married ( ) 2. Single ( ) 3.Divorced ( )
   4. Widow ( ) 5. Widower ( )

8. Occupation: 1. None ( ) 2. Housewife ( ) 3. Trader ( )
   4. Farmer ( ) 5. Artisan ( ) 6.Professional ( )

   Please obtain detailed information occupation:...

   ....

9. Highest grade of schooling completed: 1. None ( ) 2. Elementary ( )
   3. Secondary ( ) 4. Tertiary ( ) 5. Others ( ) Specify..

10. Religion: 1. Christian ( ), 2. Moslem ( ) 3. Others ( )

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11. Social Status: 1. Low ( ); 2. Middle ( ); 3. High ( )

12. Do you currently own or rent the house you live in 1. Own ( ) 2. Rent ( )

13. Do you know when the house was built or last refurbished (whichever is most recent) 1. Yes ( ) 2. No ( )

14. If yes, when was it built or last refurbished (state year only)
……………………………………

15. Do you know if any attempt at lead abatement has been made:

a. In your home 1. Yes ( ) 2. No ( )

b. In your community 1. Yes ( ) 2. No ( )

c. In your state 1. Yes ( ) 2. No ( )

16. How far is your home from the nearest major highway (Circle appropriate answer)

On a major highway
Within 5 minutes drive without any other traffic
More than 5 minutes but within 30 minutes without any other traffic
More than 30 minutes

After the first part of the questionnaire has been completed, ask the following questions and circle the respondents answers

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MODIFIED CHICAGO LEAD KNOWLEDGE TEST*

INSTRUCTIONS: CIRCLE WHETHER YOU THINK EACH STATEMENT IS TRUE, FALSE, OR IF YOU DON'T KNOW FOR SURE. *Mehta, Binns *Arch PedAdolesc Med* 1998:152;1213-1218

Lead paint is more likely to be found in newer homes than in older homes.

1. True 2. False 3. Don't know

High lead in the body can affect a child's ability to learn.

1. True 2. False 3. Don't know

Lead paint chips can be poisonous when eaten.

1. True 2. False 3. Don't know

A child's highest blood lead level generally occurs around 5 years of age.

1. True 2. False 3. Don't know

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Most children have symptoms right away if they have an elevated blood lead level.

1. True 2. False 3. Don't know

Living in a building during renovation/remodeling can increase a child's exposure to lead.

1. True 2. False 3. Don't know

Washing a child's hands often helps prevent lead poisoning.

1. True 2. False 3. Don't know

Cleaning a home with soap and water decreases the lead in the home more than dusting or sweeping.

1. True 2. False 3. Don't know

A diet with a good amount of iron-containing foods will help decrease a child's chance of becoming lead poisoned.

1. True 2. False 3. Don't know

One way for children to get lead poisoned is by having lead dust on their hands and then putting their hands in their mouth.

1. True 2. False 3. Don't know

Lead in water can be removed by boiling.

1. True 2. False 3. Don't know

Most cases of childhood lead poisoning are caused by drinking water that contains lead.

1. True 2. False 3. Don't know

Warm tap water usually contains less lead than cold tap water.

1. True 2. False 3. Don't know

Parents who work with lead at their jobs can bring lead home on their clothes.

1. True 2. False 3. Don't know

Lead in soil cannot harm children.

1. True 2. False 3. Don't know

Some pottery (ceramic, breakable or "broken" plates) is not safe to use in cooking or for eating, becauseit contains lead.

1. True 2. False 3. Don't know

A child can become lead poisoned during exposure to lead-containing dust.

1. True 2. False 3. Don't know

The lead a pregnant woman takes into her body can be transferred to the unborn baby.

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1. True 2. False 3. Don't know

Some herbal or traditional home remedies contain lead.

1. True 2. False 3. Don't know

Most children get lead poisoned by breathing in lead, rather than by eating or swallowing lead.

1. True 2. False 3. Don't know

The human body needs a small amount of lead for good nutrition.

1. True 2. False 3. Don't know

A diet with enough calcium helps prevent lead poisoning.

1. True 2. False 3. Don't know

Less lead is taken up by the body if a child eats a balanced diet, without too many fatty foods.

1. True 2. False 3. Don't know

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ANSWERS

False Lead paint was prohibited for use in residential buildings by the United States government in 1978. Therefore, buildings built prior to 1978 are more likely to have lead. For example, it is estimated that 99% of the homes built before 1940, 55% of the homes built between 1940 and 1959, and 20% of the homes built between 1960 and 1979 contain lead, with paint as the primary source.

True Lead can cause learning difficulty, behavior and growth problems, and hearing loss.

True Lead is well absorbed when eaten and can be very harmful to children.

False Usually, a child's highest blood lead level occurs around 2 years of age. Very young children generally play on the floor more, put their hands in their mouths, have bottles or pacifiers, and have a greater chance of direct exposure to lead in dust or soil.

False Usually symptoms, especially learning difficulties, take time to develop.

True Renovation activities can create large amounts of dust and other debris, which can be inhaled or eaten. This is harmful if the dust or debris is from lead-containing paint.

True Lead in dust and dirt can "stick" to children's hands and be ingested if the child puts their hand in their mouth. Washing children's hands is an excellent way to reduce a child's exposure to lead. Children who suck their fingers are especially at risk.

True Dusting and sweeping pushes small lead and paint particles into the air and around the house. If water and soap are used, the lead and dirt can be removed more completely.

True Iron-containing foods, like meats and spinach, help provide a child with enough iron. Enough iron helps lower absorption of lead. So if a child eats enough iron in foods, then less lead will be taken up by the body.

True If a child's hands have lead dust on them and then the child licks them, then the lead will get into the body.

False Lead cannot be removed from water by boiling.

False Although water with lead in it is one way to poison children, water is usually safe. Most cases of lead poisoning are a result of lead paint dust or chips being ingested by children.

False Some water pipes have lead in them. Warm tap water tends to have more lead than cold tap water. *Use cold flushed tap water for drinking and cooking.*

True Lead from the job site can come back to the home on clothing, in hair, or on shoes. Parents should take care to wash their hair and clothes and wipe their shoes before entering their home.

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False When children play in dirt, the lead that has contaminated the ground from house paint and past use of leaded gasoline can be absorbed if children put dirty hands in their mouths.

True Some countries, other than the U.S., still allow use of lead paints for pottery. The lead enters foods, especially if the pottery is used for cooking or storing foods.

True If children are exposed to lead-containing dust, like dust from lead-paint surfaces in the house, dust brought home from work, or dust from remodeling/renovating, they can get dust on their hands and ingest it, causing lead poisoning.

True Lead given to a pregnant woman can enter the unborn baby and cause harmful effects before the baby is even born.

True Some herbal and traditional home remedies, like Greta, an Azarcon, contain lead.

False The major way adults get lead poisoning is by breathing in lead, but most of the lead poisoning cases in children are due to swallowing lead.

False Lead is not needed for any body function. The body does not need lead for good nutrition.

True Having a diet with enough calcium helps lower the absorption of lead by the body.

True Diets higher in fat have been associated with a greater chance of childhood lead poisoning. Meals and snacks at regular intervals decrease lead absorption by the body (i.e., don't skip meals).

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APPENDIX 3

Home Questionnaire Survey

Interviewer Name: ___________________________ Date: _____________________

Result code: _________________________________ Time Begun: ______________

INTRODUCTION: Hello. We have an appointment to do some environmental testing here today. My name is (INTERVIEWER NAME). This is (NAME OF TECHNICIAN). We are with U.I and UCH. We spoke to you sometime ago and invited your household to participate in a research study for the Department of Civil Engineering, Department of Environmental Health, and the Department of Surgery, University College Hospital and the University of Ibadan.

Before we can begin our work I would like to ask you please read and sign the informed consent from which explains the study in detail and gives us permission to collect dust, paint chips water and soil samples in this home. I will go over each item of the form with you so that you know exactly what we are going to do. You will be given a copy of the informed consent to keep.

Thank you, now I would like to begin with some questions about your house/apartment. (NAME OF TECHNICIAN) will be preparing our sampling equipment and forms in the meantime.

Q1. What years was your home/apartment built?

YEAR OF CONSTRUCTION ……………….. |___|___|___|___|

DON'T KNOW …………………………….. 9998

Q2a. How long has anyone in the household lived in this home?

NUMBER …………………………….. |___|___|___|___|

YEARS……………………………….... 1

WEEKS ……………………………….. 2

MONTHS ……………………………....3

DON'T KNOW …………………………8

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Q2b. How long have you lived in this home

NUMBER…………………………….|___|___|

YEARS ……………………………..1

WEEKS ……………………………2

MONTHS…………………………..3

Q3. How many stories are in the house/building, including the basement? (IF SPLIT LEVEL, OR PARTIAL BASEMENT, COUNT THE GREATEST NUMBER OF STORIES ON TOP OF EACH OTHER.)

NUMBER OF STORIE …………………………. |___|___|

DON'T KNOW ………………………………..98

Q4. How apartments/housing units are in this building?

NUMBR OF HOUSING UNITS ……………………….|___|___|___|___|

DON'T KNOW ………………………………………..98

Q5a. Does your home have air conditioning system?

Yes ………………………………………. 1

No ………………………………………2

Q5b. How often have you used air conditioning in the past month? Would you say ….?

Everyday ………………………………1

20 to 30 days ……………………………2

10 to 19 days ……………………………3

1 to 9 days ………………………………4

Not at all? ………………………………5

DON'T KNOW …………………………8

Q6. In the past month, approximately how many hours a day did you keep the window or doors open in your home? Was it ….

Less than I hour per day ………………………….. 1

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1-3 hours per day ………………………….. 2

4-12 hours per day …………………………..3

More than 12 hours per day, or ……………..4

Not at all? ……………………………………5

DON'T KNOW ……………………………..….8

Q7. What kind of cooking do you have?

GAS….. …………………………..…………… 1

ELECTRIC ……………………………………..2

KEROSINE STOVE ……………………………..3

NO STOVE ……………………………………...4

OTHERS ………………………………………..5

(SPECIFY ______________________________)

DON'T KNOW ……………………………..….8

Q8. Is there a fan that draws air from the stove out of the building?

YES ……………………………………………1

NO ……………………………………………...2

DON'T KNOW ………………………..8

Now I have some questions about things that can affect the levels of allergen in peoples' homes.

Q9. During the past 12 months, has there been water or dampness in your home from broken pipes, leaks, heavy rain, or floods?

YES ………………………………1

NO ………………………………2

DON'T KNOW …………………8

Q10. Does your home frequently have a mildew odor or musty smell?

YES ………………………………1

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NO ………………………………..2

DON'T KNOW …………………8

Q11. In the past six months have you had any of the following pets living in your home? Please answer Yes or No for each of pet listed.

	YES	NO	DK
a. Cat ……………..………………1		2	8
b. Dog ……………….…………….1		2	8
c. Hamster…………...……………….1		2	8
d. Gerbil …………...………………....1		2	8
e. Guinea pig………………………..1		2	8
f. Rabbit………………………..….1		2	8
g. Bird………………..……………1		2	8
h. Any other pets …..…..……………1		2	8

(SPECIFY) ______________________________

Q12. Of the pets you just mentioned, which are currently living in your home?

NONE …………………………. 01

CAT……………………………..02

DOG ……………………………03

HAMSTER ……………………..04

GERBIL …………………..…05

GUINEA PIG …………………06

RABBIT ………………………07

BIRD …………………………08

OTHER………………………..09 (SPECIFY)____________________

DON'T KNOW ………………98

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Q13. Do you use any specific methods to "allergy-proof" your home?

Please answer Yes or No to each method listed.

	YES	NO	DK
a. Tannic acid or other mite control chemical ……………..	1	2	8
b. Impermeable mattress or pillow covers …………………	1	2	8
c. Any other methods (SPECIFY)…………………………	1	2	8

____

Q14. In the last 12 months, have you had any problems with cockroaches in your home?

YES …………………………………….1

NO ……………………………………….2

DON'T KNOW ……...……………………8

Q15. When was the last time you saw cockroaches inside your home? Was it ….

Within the last week, ……………………………..…1

Within the last months …………………………….2

2 - 4 months ago …………………………………..3

5– 12 months ago …………………………………4

DON'T KNOW ………………………………..8

Q16. Approximately how many cockroaches do/did you see per day on average in your home?

Less than 5 …………………………1

5-50 ………………………………2

More than 50 ………………………3

DON'T KNOW ……………………..8

Q17. In the past 12 months, have you used any <u>insecticides,</u> bug sprays or roach motels to control cockroaches in your home?

YES ……………………………1

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NO……………………………….2

DON'T KNOW …………………8

QI8. In the past 12 months, have you used a professional exterminator to control cockroaches in your home?

YES …………………………….1

NO……………………………….2

DON'T KNOW …………………8

Q19. In the past 12 months have you had any problems with mice or rats in your home?

YES …………………………….1

NO……………………………….2

DON'T KNOW …………………8

Q20. In the past 12 months, have you used any traps, bait stations or rat poison to control mice or rats in your home?

YES …………………………….1

NO……………………………….2

DON'T KNOW …………………8

Q21. In the past 12 months, have you used a professional exterminator to control mice or rats in your home?

YES …………………………….1

NO……………………………….2

DON'T KNOW …………………8

Now I need to ask a few questions about the people who live in this home.

Q22. How many people live in the household?

NUMBER OF PEOPLE |___|___|

REFUSED ……………97

DON'T KNOW ………98

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Q23. For each person, tell me his or her first name, gender and age.

NO	a.	b.	c.	f.	g.	h.	i.	j.
	First Name	Gender	Age	Education Code (s)	Have you (Has next) ever had any wheezing or whistling in the chest?	Have you/ (has next) had any wheezing or whistling in the chest… Y N DK	Has a Doctor ever diagnosed you/(next with any allergies)	Did the Doctor say you have/(next has)….. Y N DK
1		Male 1 Female 2		None Islamic Primary Secondary university	Y 1 N 2 DK 8	In the past month 1 2 8 In the past year 1 2 8	Y 1 N 2 DK 8	Hay fever (allergic rhinitis)?1 2 3 Skin allergies?1 2 3 Food allergies? 1 2 3 Any other allergies? 1 2 3
2		Male 1 Female 2			Y 1 N 2 DK 8		Y 1 N 2 DK 8	Hay fever (allergic rhinitis)?1 2 3 Skin allergies?1 2 3 Food allergies? 1 2 3 Any other allergies? 1 2 3
3		Male 1 Female 2			Y 1 N 2 DK 8		Y 1 N 2 DK 8	Hay fever (allergic rhinitis)?1 2 3 Skin allergies?1 2 3 Food allergies? 1 2 3 Any other allergies? 1 2 3
4		Male 1 Female 2			Y 1 N 2 DK 8		Y 1 N 2 DK 8	Hay fever (allergic rhinitis)?1 2 3 Skin allergies?1 2 3 Food allergies? 1 2 3 Any other allergies? 1 2 3
5		Male 1 Female 2			Y 1 N 2 DK 8		Y 1 N 2 DK 8	Hay fever (allergic rhinitis)?1 2 3 Skin allergies?1 2 3 Food allergies? 1 2 3 Any other allergies? 1 2 3
6		Male 1 Female 2			Y 1 N 2 DK 8		Y 1 N 2 DK 8	Hay fever (allergic rhinitis)?1 2 3 Skin allergies?1 2 3 Food allergies? 1 2 3 Any other allergies? 1 2 3
7		Male 1 Female 2			Y 1 N 2 DK 8		Y 1 N 2 DK 8	Hay fever (allergic rhinitis)?1 2 3 Skin allergies?1 2 3 Food allergies? 1 2 3 Any other allergies? 1 2 3
8		Male 1 Female 2			Y 1 N 2 DK 8		Y 1 N 2 DK 8	Hay fever (allergic rhinitis)?1 2 3 Skin allergies?1 2 3 Food allergies? 1 2 3 Any other allergies? 1 2 3
9		Male 1 Female 2			Y 1 N 2 DK 8		Y 1 N 2 DK 8	Hay fever (allergic rhinitis)?1 2 3 Skin allergies?1 2 3 Food allergies? 1 2 3 Any other allergies? 1 2 3

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Q24. Has a doctor ever diagnosed anyone in your household with asthma including adult that had childhood asthma?

YES ……………………………1

NO …………………………….2

DON'T KNOW ………………8

Q25. Please tell me the names of the people in your household who have been diagnosed with asthma. For each person I have some questions concerning Severity of his or her asthma.

	a.	b.	c.	d.	e.	f.	g.
	Name	Has (name) had any asthma symptoms in the past year	Does (name) currently take medication for asthma	How often has (name) been hospitalized for asthma in the past	How often has (name) visited an emergency room for asthma in the past year?	How often has (name) awaken from sleep with asthma or wheezing in the past year?	How often has (name's) activity limited because of asthma in the past year?
1		Y 1 N 2 DK 8	Y 1 N 2 DK 8	Never 1 1-2 times 2 3- 10 times 3 > 10 times 4 DK 8	Never 1 1-2 time 2 3- 10 times 3 > 10 times 4 DK 8	Every night 1 A few times a week 2 A few times a month 3 A few times a month 4 Never 5 DK 8	Every night 1 A few times a week 2 A few times a month 3 A few times a month 4 Never 5 DK 8
2		Y 1 N 2 DK 8	Y 1 N 2 DK 8	Never 1 1-2 times 2 3- 10 times 3 > 10 times 4 DK 8	Never 1 1-2 time 2 3- 10 times 3 > 10 times 4 DK 8	Every night 1 A few times a week 2 A few times a month 3 A few times a month 4 Never 5 DK 8	Every night 1 A few times a week 2 A few times a month 3 A few times a month 4 Never 5 DK 8
3		Y 1 N 2 DK 8	Y 1 N 2 DK 8	Never 1 1-2 times 2 3- 10 times 3 > 10 times 4 DK 8	Never 1 1-2 time 2 3- 10 times 3 > 10 times 4 DK 8	Every night 1 A few times a week 2 A few times a month 3 A few times a month 4 Never 5 DK 8	Every night 1 A few times a week 2 A few times a month 3 A few times a month 4 Never 5 DK 8

Q26. Do any members of your household smoke cigarettes?

YES ………………………………………1

NO ………………………………………..2

DON'T KNOW …………………………..8

Q27. How often are cigarettes smoked insidethe house?

Less than once a day ……………………………………..1

1-3 times a day …………………………………………...2

4-10 times a day ………………………………………….3

More than 10 times a day …………………………………4

Do not smoke inside the house …………………………..5

DON'T KNOW …………………………………………8

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Q28. Do any members of your household smoke cigars, pipes or other types of tobacco products?

YES ……………………………………………1
NO ……………………………………………..2
DON'T KNOW …………………………….8

Q29. How often are cigars, pipes or other type of tobacco products smoked inside the house?

Less than once a day ……………………………………..1
1-3 times a day ………………………………………...2
4-10 times a day ……………………………………….3
More than 10 times a day ………………………………..4
Do not smoke inside the house …………………………..5
DON'T KNOW …………………………………………8

Q30. This card has a list of work activities. In the last six months or since you moved to this address, have you or has anyone in your household worked on any of these activities at their work place? (CIRCLE ALL THAT APPLY)

CONSTRUCTION/PAINT ACTIVITIES

01. BUILDING DEMOLITION
02. PAINT REMOVAL (INCLUDING SANDING OR SCRAPING)
03. PLUMBING
04. SANDBLASTING

INDUSTRY ACTIVTIES

05. BATTERY MANUFACTURING OR SALVAGE WORK
06. EXPLOSIVES OR AMMUNITION WORK
07. FOUNDRY WORK
08. GLASS WORK
09. LEAD SMELTER WORK
10. OIL REFINERY WORK
11. OTHER LEAD-RELATED INDUSTRY WORK

MISCELLANEOUS (LEAD)

12. CAR RADIATOR REPAIR
13. MAKING OR SPLICING CABLE
14. WORK AT A FIRING RANGE OR POLICE WORK
15. WELDING OR TORCH CUTTING

ANIMAL CARE

16. ANIMAL CARE WORKER/VETERINARIAN
17. EXTERMINATION OF PESTS

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18. NONE
19. DON'T KNOW

Q31. How often does anyone who does this work wear or bring his or her work clothes home?

Never …………………………………. 1 → (SKIP TO Q32)
Rarely …………………………………2
Often ………………………………….3
Always ……………………………….4
DON'T KNOW………………………8 → (SKIP TO Q32)

Q32. The card list several activities that can be done at home. in the last six months or since you moved to this address, have you or anyone in your household participated in any of these activities here at home ? (CIRCLE ALL THAT APPLY)

01. MAKE BULLETS OR FISHING SINKERS
02. PAINT CARS OR BICYCLES
03. RELOAD BULLETS, TARGET SHOOT, OR HUNT
04. REMOVE PAINT FROM ANY PART OF THE HOUSE
05. REMOVE PAINT FROM FURNITURE
06. SAND OR PAINT ANY PART OF THE HOUSE
07. SOLDER ELECTRONIC PARTS
08. SOLDER PIPES OR METAL
09. USE ARTISTS' PAINT (JEWELRY, PICTURES)
10. WORK WITH STAINED GLASS
11. WORK WITH POTTERY OR GLAZES
12. NONE
13. DON'T KNOW

These next few questions are general questions to help us categorize your home for the survey.

Q34. Do you own or rent this home

OWN …………………………………1 → (SKIP TO Q36)
RENT ………………………………….2
REFUSED ……………………………..3
DON'T KNOW ………………………..8

Q35. Is this house/apartment privately owned or does a public housing authority own it?

OWNED PRIVATELY ……………………………..1
PUBLIC HOUSING …………………………………2
REFUSED ……………………………………………7
DON'T KNOW ………………………………………8

Q36. Does the government pay some of the cost of the unit?

YES …………………………………1
NO ……………………………………2 → (SKIP TO 37)
REFUSED ……………………………7

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DON'T KNOW ……………………….8

Q37. Do the people living here have to report the household's income to some agency every year so they can set the rent or mortgage?

YES …………………………………1
NO ……………………………………2
REFUSED ……………………………7
DON'T KNOW ……………………….8

Q38. I need to ask about your 2004 household income. This information will never be associated with your household. Was the total 2004 income for the household below or above ₦200, 000?

Based on the room inventory we completed on our last visit, we have scientifically selected the rooms where we will sample dust and paint. We have just a few more questions about these rooms. [THE SELECTED ROOMS ARE LISTED ON THE HOUSING UNIT COVER SHEET]

THE FOLLOWING QUESTIONS CONCERN THE SELECTED ROOMS, MAKE SURE TO PUT THE CORRECT CODE FROM THE HOUSING UNIT COVER SHEET IN THE SPACE PROVIDED.
ASK EACH QUESTION FOR THE SELECTED ROOMS AND EACH PERSON IN THE HOUSEHOLD THAT IS LISTD IN Q25.

Q39. We are trying to understand how long people are likely to be exposed to lead or allergens in their homes.
On average, how many hours per day does [NAME OF HH MEMBER] spend in [NAME OF ROOM]? Please tell me the letter corresponding to the time category on the card.
[HAND RESPONDENT THE GREY TIME CODES CARD]
[INCLUDE TIME SLEEPING]

TIME CODES
A: LESS THAN 1 HR
B: 1 – 4 HOURS
C:5 – 8 HOURS
D: 9 – 12 HOURS
E: MORE HAN 12 HOURS
98: DON'T KNOW

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		a.	b.	c.	d.	e.
		KITCHEN	SELECTED COMMON LIVING ROOM	SELECTED BEDROOM	BASEMENT	ADDITIONAL ROOM
	HOUSING UNIT COVER SHEET CODE	1___	2___	3___	___	___
	HOUSEHOLD MEMBER NAME	[redacted]				
1						
2						
3						
4						
5						
6						
7						
8						
9						

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These next questions provide us with information that help us when we analyzing the dust samples.

		1.	2.	3.	4.	5.
		KITCHEN	COMMON LIVING ROOM AREA	BEDROOM	BASEMENT	ADDITIONAL ROOM
	HOUSING UNIT COVER SHEET CODE	1___	2___	3___	___	___
Q40a	How long ago was the floor or carpet last cleaned?	____ Days _____weeks DON'T KNOW 8	____ Days _____weeks DON'T KNOW 8	____ Days _____weeks DON'T KNOW 8	____ Days _____weeks DON'T KNOW 8	____ Days _____weeks DON'T KNOW 8
Q40b	How was the floor or carpet last cleaned? (CIRCLE MOST RECENT METHOD)	Vacuumed 1 Mopped 2 Swept 3 DON'T KNOW 8	Vacuumed 1 Mopped 2 Swept 3 DON'T KNOW 8	Vacuumed 1 Mopped 2 Swept 3 DON'T KNOW 8	Vacuumed 1 Mopped 2 Swept 3 DON'T KNOW 8	Vacuumed 1 Mopped 2 Swept 3 DON'T KNOW 8
Q40c	When was the last time the carpet or rug was shampooed or steamed cleaned?	1-4 weeks 1 1-6 months 2 7 – 12 months 3 >1 year 4 Never 5 No carpet/rug 6 DON'T KNOW 8	1-4 weeks 1 1-6 months 2 7 – 12 months 3 >1 year 4 Never 5 No carpet/rug 6 DON'T KNOW 8	1-4 weeks 1 1-6 months 2 7 – 12 months 3 >1 year 4 Never 5 No carpet/rug 6 DON'T KNOW 8	1-4 weeks 1 1-6 months 2 7 – 12 months 3 >1 year 4 Never 5 No carpet/rug 6 DON'T KNOW 8	1-4 weeks 1 1-6 months 2 7 – 12 months 3 >1 year 4 Never 5 No carpet/rug 6 DON'T KNOW 8
Q41	When was the last time the upholstered sofa or chair was shampooed or steam cleaned?		1-4 weeks 1 1-6 months 2 7 – 12 months 3 >1 year 4 Never 5 No carpet/rug 6 DON'T KNOW 8			1-4 weeks 1 1-6 months 2 7 – 12 months 3 >1 year 4 Never 5 No carpet/rug 6 DON'T KNOW 8
Q42a	When was the bedding last washed?			____ Days _____weeks DON'T KNOW 8		____ Days _____weeks DON'T KNOW 8
Q42b	What was the wash water temperature?			Hot 1 Warm 2 Cold 3 DON'T KNOW 8		Hot 1 Warm 2 Cold 3 DON'T KNOW 8

Thank you, now we will begin sampling dust and paint. We would very much appreciate if you could accompany us.

TIME ENDED: _______ (AM/PM)

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Appendix 4

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