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**EFFECT OF HEALTH EDUCATION AND HYGINE ON  
BLOOD LEAD LEVELS, AMONG LEAD BATTERY  
WORKERS IN NAIROBI AND ATHI RIVER, KENYA.**

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**A Thesis Submitted in Partial Fulfilment of the Requirements for the  
Award of the Degree of Masters of Public Health (MPH) in the School  
of Public Health, Kenyatta University.**

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**DECLARATION**

**This thesis is my original work and has not been presented for a degree in any other university or any other award**

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## DEDICATION

This thesis is dedicated to my loving parents for the appreciation of their great sacrifice, struggles and efforts to take me to school.

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**ABBREVIATIONS**

AAR	-Africa Air Rescue
ABM	-Associated Battery Manufacturers
AMREF	-African Medical Research Foundation
CMK	-Chloride Metals Kenya limited (Athi River)
FKE	-Federation of Kenya Employers
GOK	-Government of Kenya
ILO	-International Labour Organization
IQ	-Intelligent Quotient
LIA	-Lead in Air
LIB	-Lead in Blood
Mg	-Milligram's
MOH	-Ministry Of Health
OEL	-Occupational Exposure Limit
OSHA	-Occupational Safety and Health Agency.
PPE	-Personal Protective Equipment
RPS	-Rural Planning Services
SHE	-Safety Health and Environment
µg/dl	-Microgram's per Decilitre
UKAS	-United Kingdom Accreditation System
UNEP	-United Nations Environmental Programme
WHO	-World Health Organization

## ABSTRACT

Lead is a highly toxic, non-degradable metal that can result in damage to the brain, kidneys, blood, central nervous and reproductive systems. This study sought to identify the effect of health education and improvement on hygiene standard interventions on blood lead levels among factory workers at Associated Battery Manufacturers (Nairobi) and Chloride Metals Kenya (Athi-river). The study design was quasi experimental time series, where data on blood lead levels collected from April 2003 to December 2005, before the interventions were compared to the samples collected from April 2006 to December 2009, when the intervention measures were put in place. Purposive sampling technique was applied where a total of 97 respondents participated in the study. Data for this study was collected using four instruments: questionnaires, laboratory results on blood lead levels, interview to key informants and direct observation. The statistical package for the social sciences (SPSS) was used for data processing and analysis. The data was mainly analyzed using descriptive statistics in form of frequency distribution, cross tabulation and percentages. A 2 tail t- test at 95% confidence interval was performed on the mean of various variables. From the study results, a comparison was made on the mean blood lead levels in  $\mu\text{g/dl}$  before and after the intervention measures were put in place and the calculated t- value was 2.03 against the table value of 1.96 with a p-value of 0.045. It was concluded in general that, the intervention measures put in place brought significant change towards lowering the mean blood lead level value among factory workers. Specifically, the study revealed that there was statistical significant difference in the blood lead level mean values on the following tested variables; use of personal protective equipment with a calculated t- value of 6.66 against table value of 2.26. Average level of knowledge on lead and its effects on health with a calculated t-value of 2.05 against the table value of 1.96. Daily intake of water of up to one litre per day with a calculated t-value of 2.02 against the table value of 1.96, thus; just enough water is adequate in blood lead level reduction but not too much of it. Among the hygiene measures tested; daily bathing after work was significant with a calculated t-value of 2.36 against the table value of 1.96. For respondents who took alcohol, the calculated t-value was 2.04 against the table value of 1.96 with a p-value of 0.045, hence statistical evidence that alcohol consumers could have benefited more from the interventions especially with regard to hygiene interventions. Emanating from the findings and conclusions drawn from this study, the study recommends that the stake holders in the lead industry provide correct and adequate personal protective equipment (PPE) for its entire workforce, enhance health education to improve knowledge on lead and its ill health effects, provide bathroom facilities for the ladies working in the lead industry and to scrap off the use of rewards and warning letters as a form of intervention. Further research has been suggested to establish the role of vitamin C, fruits and alcohol on blood lead levels. It is important to carry out the same study on other battery manufacturing companies and lead industries for a bigger sample size and to compare results.

## **CHAPTER ONE**

### **1.1 Introduction**

This chapter is the preliminary phase of this study. It focuses on, background to the study, Statement of the problem, Objectives of the study, Research questions, Significance of the study, Scope delimitation and limitations of the study and the Assumptions of the study.

### **1.2 Background**

Lead is one of the useful materials in the world, but also recognized as one of the five most toxic metals (Riedel, 2005). At occupational level, the acceptable blood lead limits vary considerably from country to country. France and Germany have revised their national rules, each limiting lead in blood for men to 40 $\mu$ g/dl with effect from January 2006 (Wilson, 2006). In the USA the legal limit for lead in blood is 50 $\mu$ g/dl (Wilson, 2006). For Occupationally exposed women, lower limits than for men are usually set in order to protect any developing foetus. The United Kingdom, through the control of lead at work regulations 2006, has set 60 $\mu$ g/dl and 30 $\mu$ g/dl for employee working in the lead industry for men and women of reproductive age respectively as the occupational accepted limits (Wilson, 2006).

The current standards in Kenya, through the Kenya gazette notice supplement number 22 of April 1<sup>st</sup> 2005 on Occupational Safety and Health has set acceptable

blood lead levels upper limit to 70 $\mu$ g/dl for men and 50 $\mu$ g/dl for women (Appendix 3). In Kenya, there is lack of sufficient safety information but with enactment of occupational health and safety Act 2007, the health and safety of workers in Kenya may change for better (Martin, 2006).

**Table 1.1: Profile for Blood Lead Levels above 70 $\mu$ g/dl before the interventions:**

Range	2003	2004	2005	Total
71-80 $\mu$ g/dl	18	21	15	54
81-100	14	14	1	29
Total $\geq$ 70 $\mu$ g/dl	32	35	16	83
% $\geq$ 70 $\mu$ g/dl	15	29	7.5	24%

N=212

In the year 2003, 32 out of 212 or (15%) of workers both at ABM and CMK had blood lead levels above 70 $\mu$ g/dl (table 1.1). In the year 2004, 35 or (29%) of total workforce had blood lead levels above 70 $\mu$ g/dl. In the year 2005, 16 or (7.5%) of workers had total blood lead levels above 70 $\mu$ g/dl. In total, 24% of workers had blood lead levels above 70 $\mu$ g/dl in the period (April 2003 to December 2009) of the study before the intervention measures were put in place.

At Associated Battery Manufacturers Company (ABM), the battery manufacturing process involves handling of lead at various processes which emit lead in form of fumes and dust into the environment. The company has done a lot to ensure that as little lead as possible is emitted to the environment through the provision of various

engineering control measures (ABM, 2009). ABM operates a smelter plant known as Chloride Metals Kenya (CMK) in Athi- river. CMK is totally under the management of ABM, it has the same facilities as ABM hence workers enjoy the same benefits and working conditions. The major operation at CMK is smelting of lead from recycled batteries through various processes. After smelting, the lead ingots are transported to ABM for the battery manufacturing process (ABM, 2009).

### **1.3 Hygiene measures**

Hygienic measures already undertaken by the company include: provision of adequate bathing and laundering facilities, enough space for changing, and separation of clean and contaminated clothing. Work cloths which are changed before going home are cleaned in the plant. The company has provided correct and adequate personal protective equipment for its entire workforce. Lunch is provided by the company and the dining hall is located within the company premises at both Associated Battery Manufacturers (ABM) company Nairobi and Chloride Metals Kenya (CMK) Athi-river. Eating and drinking within the plant at both sites is prohibited and only allowed in the canteen. Smoking is allowed at designated areas only. There is a site medical clinic at ABM which offers medical services for its entire workforce. The Company acquired ISO 14001:2004 certification in October 2011. This is an international standard certification accredited with all environmental matters within the organization (ABM, 2011).

It was observed over a period of time that over 70% of workers whose blood lead levels were over  $70\mu\text{g}/\text{dl}$ , were the same group of people who were generally dirty, untidy, were smokers, took alcohol on regular basis, had long hairs and unkempt dirty finger nails (ABM report 2009). It is with this background in mind that this research sought to establish the role of health education and improvement on hygienic measure interventions as a way to further reducing blood lead levels among factory workers at ABM and CMK.

#### **1.4 Problem Statement**

Many workers who work in lead based industry are ignorant of the ill health effects of lead hence do not take proper precaution while handling it, further leading to higher level of exposure (Herman, 2007). Lead battery manufacture factories spend hundreds of thousands of dollars on expensive air cleaning systems only to overlook at the importance of some of the least expensive components of a blood lead control programme (Askin, 2011). In light with the current battery plant closings in china due to inability to comply with the international health and safety statutory regulations, the importance of industrial hygiene has become more apparent than ever (Askin, 2011). Lead exposure is particularly insidious hazard with the potential of causing irreversible health effects. Excessive occupational exposure to lead can cause syndrome of lead poisoning (Maureen, 2008).

### **1.5 Justification**

The study results will provide information that can strategically guide the policy formulation in control and prevention of occupational health hazards related to lead and its ill health effects in lead battery manufacturing industries. Other researchers can utilize the results of this study as an opportunity to further into the topic.

The directorate of occupational health and safety and other regulatory bodies can use the results to set hygiene standards and occupational accepted limits of lead at the workplace. The research findings are also important for planning and policy formulation in the lead battery manufacturing industry and other occupational health regulatory authorities. The workers in the lead battery manufacture industry can use the results of this study to further find ways of reducing their blood lead levels as required by the statutory bodies controlling the industry.

### **1.6 Research Questions**

This research poses the following questions:

- 1) What is the level of coverage of health education and hygienic standards at ABM and CMK?
- 2) What is the level of compliance to the Occupational Safety and Health Act supplement No22 of 1<sup>st</sup> April 2005 at ABM and CMK?
- 3) What are the outcome of improvement on the standards of personal hygiene and health education on the blood lead levels among factory workers at ABM/CMK?

- 4) What is the outcome of implementation of Occupational safety and health Act on the blood lead levels among factory workers at ABM/ CMK.

### **1.7 Null Hypothesis**

- a) Health education and improvement on hygienic standards do not have effect on blood lead levels among factory workers.
- b) The implementation of Occupational Safety and Health Act supplement No 22 of 1<sup>st</sup> April 2005 has had no effect on the blood lead levels among factory workers.

## **1.8 Objectives:**

### **1.8.1 Broad Objective**

The main aim of this study was to investigate the outcome of health education and improvement on hygienic standards interventions, and the outcome of adherence to the Occupational Safety and Health Act on the blood lead levels among factory workers.

### **1.8.2 Specific Objectives**

- 1) To assess the coverage of health education and hygiene standard interventions at ABM and CMK.
- 2) Assess level of compliance to the Occupational Safety and Health Act at ABM/ CMK.

- 3) To determine the outcome of health education and hygiene standard interventions on blood lead levels among factory workers at ABM and CMK.
- 4) To establish the relationship between compliance to the Occupational Safety and Health Act and blood lead levels among factory workers at ABM and CMK.

### **1.9 Significant and Anticipated Output**

It is anticipated that the data and information generated from this study, will help find ways of reducing blood lead levels among factory workers through health promotion programmes; involving health education and on improvement of basic hygienic standards. Information obtained will be disseminated to the vulnerable population to help initiate strategies that will help combat the high blood lead levels among factory workers. It will also provide a basis for policy makers within the company, programme planners and other stake holders to design suitable strategic interventions for reducing blood lead levels among workers.

### **1.10 Limitations of the Study**

The limitations experienced in this study were due to several factors: The issue of industrial lead poisoning is very sensitive due to its medico-legal implications. It was therefore not easy task to get a company that would allow such a study to be carried out among its workers. Employers are afraid of being sued by workers who might have acquired occupational lead related ailments. The best study design for this kind of research could have been case control study, where; more than one motor battery

manufacturing company could have been involved (one as an experimental while the other as a control group); unfortunately, it proved very difficult for owners of the other battery manufacture companies to allow outsiders to conduct research in their respective companies due to the sensitivity of lead related issues.

Another limitation was the sample size: Ninety seven (97) respondents, who were directly working in high lead exposure area, was a relatively small number for this kind of study but due to the above factors, one was limited to utilize the available sample size. The researcher utilized the services of RPS laboratory in the United Kingdom; he had little control over the laboratory methods applied due to the distance and logistics involved. This was due to unavailability of a suitable laboratory in the country able to offer tests on blood lead levels accurately, adequately and cost effective.

### **1.11 Assumption of the Study**

The study assumed the following factors:

- That all other engineering factors capable of reducing lead in air emissions remained constant during the study period.
- That the workplace was the only other place the respondents were exposed to significant amount of lead in blood during the study period.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Introduction

Lead is one of society's oldest known and most thoroughly studied environmental hazards. The devastating effects of lead exposure can include serious damage to the central nervous system and red blood cells. High level of exposure can result in coma, convulsions, and death (Goodman, *et al.*, 2007). Lead is classified as a toxic metal and cumulative poison, according to the American National Institute of Occupational Safety and Health (NIOSH, 2007). Lead exposure is particularly harmful to children aged six years and under, whose developing nervous system and rapid metabolism are particularly vulnerable to adverse health effects of lead. In addition, certain industrial workers particularly those working in smelters may be exposed to lead and may take lead home on their cloths, skin, hair and tools in their vehicles potentially also exposing family members to lead (Goodman, *et al.* 2007).

Human exposure to lead is from numerous sources and a myriad of pathways including; air, food, dust, soil and water. The common sources of lead exposure are use of certain products containing lead, such as lead soldered cans, traditional practices such as folk remedies, cosmetics and artisan ceramics. Environmental emissions containing lead and very importantly through occupations such as;

production, use and recycling of lead, lead smelting, refining, alloying and casting, lead acid battery manufacture and breaking, printing and jewellery making (Herman, 2007). Drinking water can also have dangerously high levels of lead. The water becomes contaminated as it moves through the water distribution system. The lead can come from lead pipes or connectors, lead solder used to connect pipes and fumes, brass fixtures and lead lined tanks in water coolers. The most serious problems come when the water is acidic. The acidic water will greatly increase the amount of lead that will leech from lead plumbing (Kinder, 2005). Previous study on the levels of lead in Nairobi, Kenya (table 2.1), reported high levels of lead far much above the WHO standards in soil and food stuffs within the central business districts of Thika and Nairobi and along the Nairobi-Thika highway (Mutuku, 2003).

**Table 2.1: Lead Levels in Nairobi and Thika (Mutuku, 2003).**

<b>SUBSTANCE ANALYSED</b>	<b><u>MEAN</u> LEAD NCBD*</b>	<b><u>LEVELS</u> TCBD*</b>	<b>WHO STANDARDS</b>	<b>UNITS</b>
Soil	265,918	133,790	110	µg/kg
Kale	5,053.6	2,243.0	300	µg/kg
Maize	1,941.1	1,352.0	200	µg/kg
Milk	46.0	44.4	20.0	µg/L

\*NCBD=Nairobi Central Business district. \*TCBD =Thika Central Business District

Concern over high concentrations of lead in kale (Sukumawiki) sold in Nairobi has evoked mixed reactions from various quarters. United Nations Environment Programme (UNEP) report through a study by (Mutuku, 2003), indicated that the Nairobi sukumawiki contains 5,000 micrograms of lead per kilo, which is way above the World Health Organization recommended standard of 300 $\mu$ g/kg. The vegetable, which is daily fare for the rich and poor alike, got its nickname from its being cheap and readily available, making it a fallback vegetable for especially cash-strapped urban dwellers. Any health hazards linked to its consumption are therefore bound to affect the majority of urban dwellers. A lot of it is grown along the Nairobi River, which is heavily contaminated with factory effluent and solid waste (Kweyu, 2003).

Lead has long been recognised to be highly toxic to humans. Although the environmental levels of the metal have been greatly reduced over the past few decades, due to in large measure; its elimination from the gasoline and paint; lead toxicity is still a major public health problem, especially in children who live in housing retaining lead based paint or those who reside in lead contaminated localities, such as areas close to smelters or battery factories (Frumkin, 2005).

## **2.2 Overview of Disease Burden Associated with Blood Lead**

Worldwide, about 120 million people have blood lead in the range of 5 to 10 $\mu$ g/dl levels. Fifty (50) to one hundred (100) million people are believed to have lead in blood exceeding 10 $\mu$ g/dl. About 10 to 30 percent of all children have blood lead levels above 5 $\mu$ g/dl, with 90 percent of all those afflicted living in the developing countries (Frumkin, 2005).

Worldwide, elevated blood lead levels are particularly a problem among the socially and economically deprived persons. Disease burden associated with lead exposure is difficult to quantify as the symptoms associated with lead, unless acute; are vague. Public awareness on lead intoxication is very low and has not been an issue of concern within the medical circles in Kenya (Njoroge, 2005). Many medical conditions that could be as a result of lead intoxication are misdiagnosed and or mismanaged. As measures are being instituted to combat the problem, the magnitude associated with lead is not known in Kenya. Many diseases mimic the symptoms caused by lead; hence mortality and morbidity studies become very difficult to quantify (Njoroge, 2005).

The world health organization (WHO) has determined and recommends a maximum weekly tolerable dose for lead. The current recommendation for lead is 25 $\mu$ g/kg body weight per week. So for 100 kg person for example, 2.5mg per week is considered tolerable dose. The weekly tolerable dose translates into 350 $\mu$ g in a 24 hour period (Askin, 2011). Children living near lead smelter areas are exposed to

lead by inhalation of lead particles in air, ingestion of soil and food cooked in lead-glazed ceramics. Poor people are more likely to live in substandard and overcrowded housing, be near industries and heavy traffic, exposed to lead dust brought home by lead workers, nutritionally deprived and therefore more vulnerable to lead poisoning (Carrizales, *et al.*, 2006).

### **2.3 Lead and Health**

Lead is one of the few natural substances that have no known use in the human body. At even very low levels, lead has been shown to cause health problems (Maureen, 2008). Exposure occurs when lead dust or fumes are inhaled or when lead is ingested via contaminated hands, food, water, cigarettes or clothing. Lead entering the respiratory and digestive systems is released to the blood and distributed throughout the body. More than 90% of the total body burden of lead is accumulated in the bones, where it is stored. Lead in bones may be released into the blood, re-exposing organ systems long after the original exposure (Maureen, 2008).

Once lead gets into the body, it is absorbed and distributed throughout the body. The amount the body absorbs depends on the route of exposure. In general, an adult will absorb 10-15% of the lead in the digestive system, while children and pregnant women can absorb up to 50%. When lead is inhaled, about 30% to 50% of the particles will reach the lungs, depending on the size of the particle (Maureen, 2008). The efficiency of inhaled lead dust is size dependant, respirable sizes of about

0.01microns and 10 microns are efficiently collected into the lungs where they remain until they are completely absorbed into the blood stream. It takes about a day and a half to three days for a lead particle to completely move from the lungs into the blood (Askin, 2011). Large particles land in the upper respiratory tract where they get trapped by the mucous lining and are moved out by the cilia. Unfortunately, the mucous is often swallowed, allowing these large particles to then go into the digestive system. Smaller particles can reach deeper in the lungs and from there, be absorbed into the bloodstream. This means that when there is burning or welding on lead-painted surfaces, the lead fumes can be especially dangerous. The small particles created as a fume will reach the blood if they are inhaled (Maureen, 2008).

Lead dust or particles cannot go through the skin if the skin is unbroken. Organic lead used in industry especially in petrol to improve the octane rating can be absorbed via the lungs and the skin. It has a particular predilection for the brain and cause psychiatric disturbance, headache, vomiting, dizziness, mania and coma. The blood is less affected than with the inorganic lead. Typically, exposure to organic lead is measured through urine analysis (Maureen, 2008). After prolonged exposure to pollutants, lead accumulates in several parts of the body, especially the bone marrow matrix. Lead has a half life of 25 days in human body, and thus blood lead level is a useful indicator of the total lead load in an individual (Hoekman, 2005).

The problem is exacerbated by the fact that lead accumulates in the body and that lead acquired early in life can be released into the blood stream to wreck physiological havoc much later in life. Environmental health scientists have determined that certain genes can make some individuals far more susceptible to the damaging effects of lead poisoning by affecting the absorption, accumulation and transport of the toxin (Frumkin, 2005).

More than 90% of body burden of lead is located in the bone where it has an average half life of about 10 years. During periods of increased bone turnovers, such as during pregnancy, lactation and menopause, these skeletal bone stores can be mobilized long after the external exposure, posing a hazard to the foetus at critical times in its organ development and to the nursing child (Frumkin, 2005). Significant inverse association have been demonstrated between blood lead levels and dietary intake of a number of micronutrients including, iron, zinc, calcium, vitamins C and D. In addition total calorie and fat intake have been positively associated with blood lead levels (Frumkin, 2005).

In a recent study in the United States, the association between the blood lead levels and increased cardiovascular mortality was observed at substantially lower blood lead levels than previously reported. Blood lead levels as low as 2 $\mu$ g/dl, currently considered safe, were associated with increased risk of mortality due to coronary heart disease and stroke (Menke, 2006). Despite the marked decrease in blood lead levels over the past three decades, environmental lead remains a significant

determinant of cardiovascular mortality in the general population. The study called for need for future research to identify the level of lead exposure that is no longer associated with adverse health outcomes (Menke, 2006).

In women exposed to high lead levels; miscarriages, premature births and stillbirths has been reported. Lead is transported in the blood and can cross the placental barrier in pregnant women and affect the unborn child (Kinder, 2005). Increasing evidence indicates that lead not only affects viability of foetus, but development as well. Developmental consequences of prenatal exposure to low levels of lead include reduced birth weight and premature birth. However, most studies in humans have failed to show a relationship between lead levels and congenital malformations (Kinder, 2005).

Lead is excreted in the urine, faeces, sweat, breast milk, ear wax, dead skin cells, hair, fingernails and toe nails. The kidney can remove between 25% and 50% of the total amount of lead that is excreted every day. Because lead is excreted in the urine, kidney damage is a likely long term effect. As lead builds up in the body, it can damage the brain, nerves and blood cells (Askin, 2011).

#### **2.4 Occupational Lead Exposure**

Worldwide there are thousands of primary and secondary lead smelters, battery plants and other industrial facilities emitting significant amounts of lead in to the environment. These emissions pose serious risks to workers, their families and

nearby populations (Oakley, 2003). In the occupational setting, blood lead levels above  $40\mu\text{g}/\text{dl}$  have been repeatedly demonstrated to be associated with increased risk of elevated blood pressure, impaired renal function and cancer. Small businesses in particular have difficulty setting a lead safety program and need education and direct assistance. Many employers are not providing adequate PPE to lead exposed workers as required by the regulatory bodies (Askin, 2007).

In the United States, California state battery industry has a state of the art programme in lowering blood lead levels among factory workers through the occupational lead poisoning preventive programme. In 1993 there were seven workers with blood lead levels of  $60\mu\text{g}/\text{dl}$  or greater. In 1994 there were two and in 1995 there was only one. Between 1996 and 1999 no worker in California had a level above  $60\mu\text{g}/\text{dl}$  (Bonta, 2002). This is in sharp contrast to another study done in Lagos Nigeria in 2009, where results showed that no battery charger in Lagos had less than the permissible maximum of  $80\mu\text{g}/\text{dl}$  total blood lead levels. Only five battery chargers in Ibadan had values slightly lower than this permissible maximum of  $69\text{-}79\mu\text{g}/\text{dl}$  (Abiola, 2009).

OSHA standards require that PPE, training, medical surveillance, signs and labelling, engineering controls are all put in place when the active blood lead level of  $30\mu\text{g}/\text{dl}$  is exceeded (Clayton, 1994).

## **2.5 Hygiene and Health Education in Lead Exposed workers**

Factories spend hundreds and thousands of dollars on expensive air cleaning systems and water treatment equipment only to see those same plants overlook the importance of some of the least expensive components of a blood lead control programme (Askin, 2011). Lead that is on the skin can both be inhaled and ingested. If one wipes his nose with lead in the fingers, some of the particles will be inhaled while others will be swallowed. When a worker grabs and pull off the respirator from ones face, he creates a vacuum at the instant the face seal is broken. Lead from these edges of the mask is then vacuumed straight into the mouth and then inhaled or swallowed (Askin.2011).

Removing sweat from the skin for a worker in lead industry is also beneficial, provided it is done in a sanitary way. Clean single use towels are effective in removing some of the lead in sweat before it can be ingested (Askin 2011). When a worker comes to work without first eating, the body will absorb more of the lead they ingest than the worker who had a good meal first. When lead is not diluted by food, it has more contact with the walls of the intestines where it is absorbed more quickly and thoroughly (Askin, 2011). In order for the kidneys to operate efficiently, workers need to be well hydrated to the point of their urine being nearly colourless (Askin, 2011). Prevention of occupational lead poisoning is a textbook illustration of the principles of industrial hygiene and personal protective equipment. Changing rooms and shower must be provided by the employer. This is very important to prevent possible contamination to the home causing possible harm to children (last,

2000). Education of the workers about the importance of cleanliness (washing hands to get rid of lead dust and paste before eating), good housekeeping in the workplace to avoid building up of toxic concentration of dust, the use of exhaust ventilation in work processes and to exclude workers from contact with lead fumes, all play a part towards reducing blood lead levels (Last, 2000). Surveillance of potentially exposed workers is also important. Women of reproductive capacity are at risk of miscarriage as a result of lead intoxication, and thus protection of women who are or could become pregnant is especially important (Last, 2000).

The potential health hazards of lead poisoning still exist and are rising due to the lack of education regarding the dangers of working with lead. In a developing country like India where over 80% of used lead is recycled by unorganized sector who do not comply with any of the government specified regulations (Herman, 2007). The lack of a safe workplace and limited awareness among workers in some unorganized industries has resulted in high blood lead levels. Workers in these industries were observed to have poor personal hygiene during and after work; they were observed in the dining area wearing work clothes and working without wearing proper respiratory protection, gloves and mask (Herman, 2007).

## **2.6 Lead Poisoning**

Acute poisoning from single exposure to metallic inorganic lead is extremely rare but may result from ingestion of solutions of soluble lead salts (Lead acetate or lead carbonate). Sub acute inhalation exposure to inorganic lead dust or fumes such as

lead oxide or lead sulphide may also occur. Lead is a cumulative poison, and acute symptoms are more commonly of sub chronic poisoning (Apostoli, *et al.*, 2006).

In developed countries, lead poisoning no longer occupies predominant position it once did and physicians will see a case during their working lifetime. By contrast, in developing countries, lead poisoning is still commonplace and on the worldwide scale it remains the most common of the occupational poisonings (Baxter, *et al.*, 2000). Poor people are more likely to live in substandard and overcrowded housing, be near industries and heavy traffic, exposed to lead dust brought home by lead workers, nutritionally deprived and therefore more vulnerable to lead poisoning (Caririzales, *et al.*, 2006).

Factors that determine the toxicity of lead to an individual exposed to the metal include; dose and duration of exposure, mode of contact and other chemicals one is exposed to, age, sex, diet, lifestyle and state of health. Low dietary intake of calcium, iron deficiency, zinc and ingestion on an empty stomach also enhances the absorption of lead into the gastrointestinal tract (Goyer, 1996). For a variety of reasons, children are more susceptible to the effects of chemical exposures than adults. Children live closer to the ground, maximizing their contact with toxic substances that collect indoors. Children come into greater contact with dangerous chemicals simply because they eat more than adults in proportion to their body weight (Kinder, 2005). The most sensitive target of lead poisoning is the nervous system. Exposure to lead can have a wide range of effects on a child's development and behaviour. Even when exposed to small amounts of lead levels, children may

appear inattentive, hyperactive and irritable. Children with greater lead levels may also have problems with learning and reading, delayed growth and hearing loss. At high levels, lead can cause permanent brain damage and even death (Kinder, 2005).

During the month of March 2010, over 400 children died from lead poisoning in North West Nigeria. Local residents had been illegally mining gold from the nearby ore source. The material which turned out to be laced with high lead was brought back to the villages in sacks and processed inside people's compounds with the residue discarded haphazardly into the soil. Children who were playing nearby as the women worked to extract from the inside of the ore become the first victims of lead poisoning. The health professionals noted unusual cases of abdominal pains with vomiting, nausea with some children presenting with convulsions. While carrying out blood tests, the experts noted very high blood lead levels among the children tested (Public Radio International, 2010).

At high doses of exposure, no human organ is immune to lead toxicity and the domino effect may progress to coma and even death. At moderately and low lead level exposure, the following organs can be damaged; the central nervous system, renal, cardiovascular, haematological and reproductive systems (Frumkin, 2005). Epidemiological studies have found out that children lead exposure is associated with neuropsychiatric disorders including lowered IQ, impaired mental and physical development, and hyperactivity, hearing loss, reduced attention span, aggression, somatic complaints and antisocial and delinquent behaviour (Frumkin, 2005).

In Kenya, according to a leading occupational health specialist, Dr William Sakari, lead per se is not poisonous. It is when it is exposed to the environment that fumes and dust from the smelting process combine with oxygen to form the poisonous lead oxide. Lead levels in the general population are rarely above 40µg/dl and rarely above 55µg/dl among industrial workers (Kweyu, 2003).

Excessive tiredness and loss of appetite are among the symptoms of lead poisoning. For men, high exposure to lead can lead to reduced sexual libido; a condition Dr Sakari, (former director of Occupational health in Kenya) finds to be quite prevalent among lead-related factory workers. "Fortunately, it is temporary because once you take off for one week, the body gets rid of it and the sexual function becomes normal," he says. Signs of lead poisoning include anaemia the metal suppresses the formation of haemoglobin which is the pigment in the red blood cells responsible for carrying oxygen (Kweyu, 2003).

Clinical symptoms of lead poisoning in adults that occur at blood lead levels above 80µg/dl could include abdominal pains, headache, irritability, joint pains, fatigue, short memory and hypertension (Williams *et al.*, 1999) other toxicity syndromes include central nervous system dysfunction, circulatory disorders such as hypertension, aborted pregnancies and renal failure (Whiten *et al.*, 2001).

## 2.7 Lead and Environment

One of the largest contributors to lead in air has been from leaded gasoline. This was before various regulating bodies restricting the use of lead in gasoline were put in place. Much of this lead is still present in the environment as lead in soils and lead in dust. Beside lead paints, lead is emitted into the air from industrial emissions. These industrial sources include; smelters, refineries, incinerators, power plants, manufacturing operations and recycling efforts (Kider, 2005). The difficulty with lead is that once it is mined from the earth, there is no known way to destroy or make it harmless. This makes it extremely important that we reduce our use of lead and dispose of it properly (Maureen, 2008).

Emissions from vehicles fuelled by lead contaminated gasoline were the major source of public exposure of lead to the environment. Elimination of lead in the gasoline worldwide gradually since 1990 was a major public health success (Johnson, 2007). In addition, lead based paints were restricted in use in the US and a voluntary programme removed lead solder from food cans. Among US adults, the geometric mean blood lead level decreased from 13.1 $\mu\text{g}/\text{dl}$  in 1978 to 1.6 $\mu\text{g}/\text{dl}$  in 2002. Currently 99% of US adults have blood lead levels below 10 $\mu\text{g}/\text{dl}$  (Menke, 2006). Emissions of lead from smelting operations in developing countries are an ongoing concern. These smelters often employ outdated technology or are equipped with inefficient pollution control devices. Secondary smelters, involved in the recycling of lead in car batteries are disproportionately sited in developing countries, because they cannot meet pollution control regulations in the developed countries

(Frumkin, 2005). Atmospheric lead is entirely a product of human industrial activity. The lifestyles and occupational options of those exposed to risk determine the result of physiological damage (Brown *et al.*, 2005). As measures to control the transfer of lead to the environment are implemented in most developed countries through, for example, the phasing out of lead in the fuel, paints and other consumer products and tighter controls in industrial emissions, environmental exposure to lead in general continue to increase in developing countries. Air lead limits, like blood lead limits vary from country to country. Most countries employ limits in the range of 0.05 mg/m<sup>3</sup> to 0.15mg/m<sup>3</sup> (Wilson, 2009).

In order to isolate lead from the environment, factories should plant trees, saw grass or whatever tall vegetation well in the local soil between them and their neighbours. This is known as green screen and the plants help and remove lead dust from the air (Askin, 2011). Environmental Justice is the right to a safe, healthy, productive and sustainable environment for all, where environment is considered in its totality to include the ecological (biological), physical (natural and built), social, political, aesthetic and economic environments (Kinder, 2005).

Sub-Saharan states assented to the phasing out of leaded gasoline by 2006. The decision commonly referred to as Dakar declaration was signed at a regional conference in Dakar Senegal in June 2001 and binds 25 countries among them Kenya; to stop the use of leaded fuel by January 1 2006 (Mungatana, 2004). The Kenya Gazette Supplement No.22 of 1<sup>st</sup> April 2005 on Occupational Safety and

Health Act sets stringent rules; on among other issues, lead (Appendix 4) Page 94 (10) refers to workers exposed to lead and its compounds. The Act sets a  $70\mu\text{g}/\text{dl}$  of lead in blood as the upper limit for men and  $50\mu\text{g}/\text{dl}$  for women. Workers scoring more than this figure should be re-deployed and the Director of Occupational Health and Safety notified. For lead workers, periodic medical examination is a statutory requirement (GOK, Occupational Health Act, 2007).

## **CHAPTER THREE**

### **METHODOLOGY**

#### **3.1 Introduction**

This chapter presents the methodology that the research adapted. It focuses on: Research design, intervention measures, variables, location of the study, target population, sampling techniques and sample size, research instruments, quality of data assurance, data collection techniques, data analysis and ethical considerations.

#### **3.2 Study Design**

The study design adapted was quasi- experimental, time series design. Data on individual mean blood lead levels which had been collected between April 2003 and December 2005 (pre-intervention phase) were compared to the ones' taken from April 2006 to December 2009 (post-intervention phase), when the interventions on health education and hygiene measures were put in place.

#### **3.3 Intervention Measures**

In January 2005, Safety, Health and Environmental (SHE) committee came in to place at ABM and CMK. This was a committee composed of twenty people; ten workers from the shop floor and ten from the management. The SHE committee came out with a programme to help combat the increasing blood lead levels among factory workers. The program has been ongoing continuously up through the present time. However data for this study was collected from April 2003 to December 2009.

All factory workers directly exposed to lead, through work environment were included in the program. The program involved health education on lead and its ill health effects on human body, importance of putting on the correct personal protective equipments (PPE) and issues on personal hygiene practises. To spear head the program was an environmental consultant who was fully employed by the company and was attending all the quality work group meetings. (Quality work group was a team composed of members from the same section in the work station).

Each and every quality work group meets once monthly to deliberate on issues related to their respective work section. Health education was conducted during the monthly quality work group meetings, by the researcher, members of the health and safety committee and the environmental consultant. Other avenues for conducting health education were lectures during lunch and tea breaks and on a one to one basis with the health personnel at the staff clinic when workers came for treatment. Handouts, verbal lectures and posters all over the workplace were other methods used to convey information on the health education. Weekly audio vision tapes on health and safety were provided to be watched by workers at the canteen over lunch break.

Part of health education on personal hygiene involved; training workers to do their job without being covered with lead dust, providing each worker with proper tools for clean up, teaching them how to wash up and take a shower. Keeping of facial hair was discouraged as this could give room for some lead particles to be inhaled. The

company provided hot and cold running water, skin cleaner; finger nails brushes, towels, a large sink and a mirror. Emphasis was placed on need to wash their arms, face and neck every time they leave the plant and especially every time before eating, drinking or smoking. After shower, they picked up their street clothes and personal items from the clean locker room before going home.

Blood lead reduction program through health education also involved use of Personal Protective Equipment ((PPE) including; gloves, respirators, work clothes and shoes. None of these items were allowed to be carried home by the worker and each worker had a minimum of two sets of washable clothing items. One set was to be worn each day while the other second set was in the laundry. The work uniform which was provided covered better part of the body and the only left exposed areas were hands, neck and face. Hats were provided to cover the head.

Each worker was provided with two lockers. The worker left all their street clothes and shoes in the clean locker and put on their clean work uniform. They then proceeded to the dirty side locker room where they picked up their work shoes. The shower rooms were located between the clean and dirty locker room. In addition to regular medical examination, estimation of blood lead level was carried out on all employees in contact with lead after every three months. Any employee whose blood lead levels exceeded  $70\mu\text{g}/\text{dl}$  for male worker and  $40\mu\text{g}/\text{dl}$  for female worker proceeded on one month leave and was transferred into a less exposed area for at least three months upon resuming duties. Before re-deployment, group meetings with

the company occupational health clinician and the environmental consultant were held to deliberate on preventive measures.

A thorough medical and physical examination was performed by the company occupational health physician after which they proceeded on a one month leave and subsequent re-deployed to less exposed sections. Stimulus by reward to those workers who managed to reduce their blood lead levels significantly was also introduced (Stimulus, in this case was cash money given to workers who managed to reduce their blood lead levels by at least  $9\mu\text{g}/\text{dl}$  per sampling quota). The company introduced vitamin C tablets to all workers working in the factory; this was provided at the dose of 500mg daily and was taken orally with ten o'clock tea (ABM, 2009).

The researcher being a member of the Safety, Health and environmental (SHE) committee at ABM had full responsibility for implementing these interventions. This committee had the full backing of the company top management, hence was able implement all aspects of health, safety and environmental issues. During the four year study period when the intervention measures were put in place, (January 2006-December 2009), there were no major changes in the work design or devices in engineering controls in the factory.

### 3.4 Study Variables

Blood lead levels was the depended variable. This was assessed against the interventions introduced based on health education and improved hygiene standards.

The independent variables in this case were:

- Health education and level of knowledge on lead and its effects on health.
- Usage of personal protective equipment.
- Intervention measures such as: use of presents as stimulus by reward to those whose blood lead levels reduce drastically and warning letters for those who registered high blood lead levels. (Stimulus in this case was monetary reward given to workers whose blood lead levels reduced by  $\geq 9\mu\text{g/dl}$ ).
- Health issues like: water intake (0.5-5lts per day), fruits intake and use of vitamin C. Alcohol consumption was also assessed against blood lead levels.
- Hygiene practices like; bathing after work, hand washing, cutting of hair, beards and finger nails.

### 3.5 Study Area

The study was conducted at Associated Battery Manufacturers (ABM) Company, which is located at Kampala road, off Enterprise road, within the industrial area of Nairobi (See map Appendix 2) and Chloride Metals Kenya (CMK) smelter plant in Athi-river in the outskirts of Nairobi off Mombasa road (See map Appendix 3). ABM is located in the industrial area some 18 kilometres east of Nairobi city. It falls under Makadara constituency, Viwandani ward, Nairobi East District. CMK is located some 60km South/ East of Nairobi off Mombasa road towards Namanga on

the Kenya/ Tanzania border. The core business of CMK is smelting of lead from old recycled batteries. Re-cycled batteries form 95% of the raw material lead used in the manufacture of locomotive battery, the remaining 5% is imported mostly from Asian countries. The smelter plant CMK is directly under the management of ABM.

### **3.6 Study Population**

The study population comprised of factory workers at various sections in the battery manufacturing plant at ABM Nairobi and smelter plant workers at CMK Athi river. ABM had a workforce of 151 permanent employees and about 40, who work on casual basis in the factory or on attachment from tertiary colleges. CMK at the time of this study was manned by 61 permanent employees and about 20 casual workers. Due to its nature of operation, ABM/ CMK is a male dominated company with only 23 women, most of whom works in the canteen department serving food and the accounts department. Only two (2) ladies work in the quality department and frequently visit the factory. The study population comprised a total of 272 factory workers, who work directly in the lead environment and are to benefit from the intervention measures put in place from this study.

#### **3.6.1 Inclusion Criteria**

Factory workers on permanent terms at Associated Battery Manufacturers (ABM) Nairobi and Chloride Metals Kenya (CMK) limited Athi river, who work directly in the lead exposed environment and willing to participate in the research were included in the study. The other inclusion criteria was that they ought to have worked

continuously in the same environment for the period between April 2003 and December 2009.

### **3.6.2 Exclusion Criteria**

Office workers who were not working direct in the lead exposed environment and all employees working on casual and contract terms. Nearly half of the workers at CMK were employed after 2006, hence not included in the study.

### **3.7 Sampling Technique and Sample Size**

Purposive sampling technique was applied in this study. Under this technique; all workers working directly and continuously in the lead environment (between April 2003 and December 2009) were included in the study. A total of ninety seven (97) workers participated, Seventy four (74) from Associated battery manufacturers (ABM) Nairobi and twenty three (23) from the smelter plant; Chloride Metals Kenya (CMK) Athi river.

### **3.8 Data Collection Technique**

The management of the company gave permission to have the study conducted and provided release time for the workers in order for them to participate in the study.

The researcher through the human resources manager issued a memorandum to all workers, informing them of the study and soliciting for their participation in the study. The dates for the study were also included in this memorandum. This made it easier for the interviewer because the respondents were prepared for the exercise.

The quarterly blood for lead analysis was collected by the researcher for the entire period of the study. At the end of the study period in December 2009, questionnaires were presented to all workers working in the factory and had been in continuous full time employment with the company since April 2003 at both ABM and CMK. The questionnaire focused on demographic and social characteristics, medical history including past history of blood lead levels and personal hygiene.

Quarterly blood lead levels and medical history records were retrieved from the company's medical staff clinic records. Interviews with key informant individuals like the human resources manager, members of health and safety committee and the clinic staffs was conducted to collect additional data. Direct observation method was used to assess standards of hygiene pre and post interventions. Response rate was ninety seven per cent (97%), three respondents failed to participate as they were either on leave or on sick off.

### **3.9 Research Instruments**

In order to compare data obtained by using different research methods, this study used four different instruments; Blood lead levels, questionnaire, Interview schedule and direct observation.

### **3.9.1 Blood lead levels**

A sample of blood was drawn from a worker's vein, the sample tube was sealed, stabilised and sent overseas for determination of lead. Blood specimens were collected after thorough cleaning of the skin with surgical spirit. Sterile lead free 4mls vacutainers were used to collect blood. All sample bottles were tightly covered and well labelled for proper identification, prior to storage in refrigerators and subsequent transport through air to United Kingdom. Medical wastes in form of swabs, needles, syringes, gloves used during the procedure, were placed in labelled disposable plastic containers and taken to CMK Athi river smelter plant for incineration.

### **3.9.2 Questionnaire**

The questionnaire developed for this study was designed by the researcher and was divided into four sections: Socio- economic and demographic characteristics, Hygiene, health education and Blood lead level profile (Appendix 1) Qualitative data in form of field survey consisted of structured and unstructured questionnaires which were designed and adapted for the study population. After taking consent, each subject was interviewed by the author on one to one basis.

### **3.9.3 Interview Schedule**

Interview schedule was administered to the personnel manning the clinic and the human resources manager and members of the health and safety committee. The main issues of concern during the interview was to verify the company's adherence

to the Occupational Safety and Health Act supplement Number 22 of 1<sup>st</sup> April 2005, which was one of the objectives of the study. Another concern was to verify the existence of health and safety committee and to establish previous records on blood lead levels.

### **3.10 Quality of Data Assurance**

Before administration of questionnaires, a pre-test was performed on 10 workers who form 10% of the sample size. Relevance of questions was checked during pre-testing of questionnaire to see whether the required information would be generated. The researcher administered the questionnaires personally to the target group after explaining to them all the details required. The language used for data collection throughout the entire research was English and where it was not possible, or for the purpose of clarity; Kiswahili language was used to supplement it.

The blood sample specimens for lead analysis were collected by the researcher during the entire period of the study. To avoid contamination, the blood sample was taken from the worker who had come direct from home and had not put on his/her uniform before commencing work. Random duplicate sample for blood lead sample analysis was taken to South Africa through path laboratory in Nairobi. The sample collecting room was kept extremely clean. Lead in blood sampling period took one week and any worker who was not at the work station during the period had his/ her blood lead level not taken for that particular quarter.

### 3.11 Data Analysis

The data collected was edited, coded, organised and presented by use of frequency tables and bar graphs. It was analyzed using Statistical Package for Social Sciences (SPSS) software. Descriptive statistics was used to describe data (frequencies, percentage, means, standard deviation and range). T-test of significance for the difference in the Mean was done for the various variables to test the null hypothesis that; there is no significant difference between the mean values of the blood lead levels of the workers for the period before and after the intervention measures.

Where the calculated t-value was greater than the table t-value, then it was concluded that the variable tested brought significant difference towards reducing the mean blood lead level value among the workers. The p-value indicated the probability of a particular result occurring by chance or not. When  $P > 0.05$ , then the relationship was insignificant, while when  $P < 0.01$  then the relationship was termed significant.

The following variables were tested and analyzed results presented in chapter four: Blood lead levels for the period before and that after the interventions measures were put in place, use of personal protective equipment, health education and the knowledge of effects of lead on health, use of presents as stimulus for reducing blood lead, warning or caution letters and transfers to different departments upon scoring high blood lead levels. Other variables on personal hygiene and habits tested were; bathing after work, hand washing, cutting of nails, beards and hair, quantity of water intake, fruits intake and consumption of vitamin C tablets. The Influence of alcohol

on blood lead levels was also tested after establishing that (65%) of workers consumed it.

### **3.12 Ethical Considerations**

Research activities commenced upon approval from the department of Public Health, School of health sciences (Kenya University). Graduate school, (Kenya University) ref: I57/OL/3769/04. National council for research and Technology ref: NCST/RR1/12/MAS/143/3 (Appendix 5). The management consent from the company was obtained from the managing director, Associated Battery Manufacturers Company through the human resources manager. Consent was obtained from research subjects before research commenced. All data collected as part of this study will be handled with utmost confidentiality. Research findings will be used for academic purposes, and to benefit the study population. Research findings are to be given out to individual workers involved in the study and to the management of the company.

## CHAPTER FOUR

### RESULTS AND DISCUSSION

#### 4.1 Introduction

This chapter presents the analysis and interpretation of data collected from the field and laboratory mean blood lead levels. The results are presented in descriptive form using, tables, bar charts, figures and percentages. Statistical tests of association and significance are given where applicable.

#### 4.2 Socio- Demographic Characteristics of Study Population

A total of 97 respondents from the two sites participated in this study (these were the number of workers who had been in employment consistently for the entire period of the study and were directly exposed to lead environment). Majority 74 (76%) of the workers were from Associated Battery Manufacturers Company (ABM) Nairobi, while 23 (24%) were from Chloride Metals Kenya (CMK) Athi-river (table 4.1). Male were the majority at 92% while female were only 8%. This is a male dominated company as dictated by the nature of work. Majority of respondents (97%) were married while (3%) were single. Age statistics show that the highest Age among the respondents was 56 years while the minimum age was 30 years with a mean age of 43.6 years. Of the workers who participated in the study, fifty two or (54%) had over 15 years work experience with the company.

Regarding educational background, majority of the respondents (67%) had secondary level as the highest level of education achieved. Twenty (20%) had polytechnic or university education as the highest achieved academic qualification, while (13%) had primary education. Majority (95%) of respondents with university education had majored in chemistry and were working in the quality assurance department.

**Table 4.1: Socio-Demographic Characteristics of the Study Population.**

Category	Type	Frequency	Percentage %
Section	ABM	74	76
	CMK	23	24
Sex distribution	Male	89	92
	Female	8	8
Duration of Work	6 - 15 years	45	46
	Over 15 years	52	54
Education Level	Primary	13	13
	Secondary	65	67
	University/poly	19	20

**Sample size = 97**

### **4.3 Coverage of Health Education and Hygiene Standards Interventions**

Beginning January 2005; Safety, Health and Environmental (SHE) committee came in to place at ABM and CMK. This was a committee of twenty people, composed of ten from shop floor workers and ten from management. The main purpose for this committee was to look into all the safety, health and environmental issues affecting the organization, emphasis was placed on ways of reducing blood lead levels. Under SHE, the following measures were undertaken; Health education on general awareness of lead and its effects on human health. Health education consisted of health personnel, environmental consultant and members of SHE committee, educating workers through quality work groups on lead; its effects on human health, how it gets into human body, signs and symptoms of lead poisoning and long term effects of lead on human health. The role of putting on the correct personal protective equipments (PPE) had also been emphasised after the correct PPE were provided.

Other aspects of health education included, explaining to workers the control measures as a way of reducing the lead exposure and improved hygienic measures like general cleanliness, effects of smoking and eating at the workplace, importance of keeping the nails trimmed and clean. Stimulus by reward to those workers who reduced their blood lead levels significantly was also introduced at the same time to encourage workers to comply with these measures. (Stimulus, in this case was cash money given to workers whose blood lead levels reduced by at least  $9\mu\text{g}/\text{dl}$  per blood lead sample intake). A total of 53 workers or (56%) got the present during the study period.

Hygienic measures already undertaken by the company included: adequate facilities for washing. ABM which had a workforce of 151 permanent staff, provided 12 bathrooms for all its factory workers who took bath in shifts after work. CMK which has a workforce of 61 permanent staff provides 6 bathrooms for its entire workforce; these are considered adequate as per labour laws. The same respective number of toilets was provided for at ABM and CMK. There were no bathroom facilities provided for the ladies working at both ABM and CMK sites. As regards changing and storage of clothing, each and every worker was provided with two lockers in separate rooms, one for home cloths while the other was used for the personal protective clothing which were worn while at work.

Laundry services were provided for; with the used working cloths both at ABM and CMK washed and ironed at the central place in ABM. The company had provided personal protective equipment which included; face masks, boots, dustcoats, overalls, head caps, helmets and hand gloves. This was enough for all work specifications provided as per sections of work. Wet cleaning, as opposed to dry cleaning of surfaces was the method applied for cleaning to reduce dust inhalation.

The company introduced vitamin C tablets to all workers working in the factory; this was taken voluntarily at the dose of 500mg taken orally during the ten o'clock tea. Workers were also advised on the importance of water and fluids intake as a possible way of increasing excretion thereby reducing blood lead levels. In addition, regular

medical examination and estimation of blood lead levels were carried out on all employees in contact with lead after every three months. Any employee whose blood lead levels exceeded  $70\mu\text{g}/\text{dl}$  proceeded on one month leave and was transferred into a less lead exposed area for at least three months upon resuming duties. Ten workers constituting (10%) were transferred to less exposed areas due to high blood lead levels during the study period (ABM, 2009).

#### **4.4 Level of Compliance to Occupational Health and Safety Act**

The company formed the health and safety committee in January 2005. This was prompted by the ministry of labour Regulations on Occupational Safety and Health committee rules of August 2004. In 1st April 2005 the government of Kenya under the ministry of labour published in the Kenya gazette regulations controlling aspects of dangerous substances control and regulations in the workplace. It was established during the study that the company fully comply with the regulations specified in the Act in the occupational health and safety Act. This was established through confirmation of the following activities within the company:

- 1) Medical examination was done annually to all workers exposed to the occupational hazards as required by law by a designated medical practitioner. This is in compliance to the Act which directs that all occupations outlined in the eighth schedule, which includes lead; undergoes both pre-employment and periodic medical examinations by designated health practitioner as outlined in the first schedule (see Appendix 1 attached).

- 2) Pre employment and periodic medical examination was done.
- 3) The results of examinations of each individual were entered into each individual's medical record. Summary of the above medical examination were sent to the director of occupational health within 21 days as required by law.
- 4) Blood Lead levels were taken after every three months for all workers exposed to lead.
- 5) It was confirmed that employees whose blood lead levels exceeded  $70\mu\text{g}/\text{dl}$  for men and  $50\mu\text{g}/\text{dl}$  for ladies were given one month leave and redeployed to less exposed areas upon resuming work. A total of 10 workers; all men, were transferred during the study period. Certificates of redeployment as outlined in the third schedule were filled by the company medical officer and circulated as required by law.
- 6) The above mentioned highlights together with the formation of health and safety committee on both sites (ABM and CMK) helped much in the implementation and monitoring of the health education and hygiene interventions in reducing blood lead levels as confirmed by the statistical results from this study.

#### **4.5 Impact of Health Education and Hygiene Interventions.**

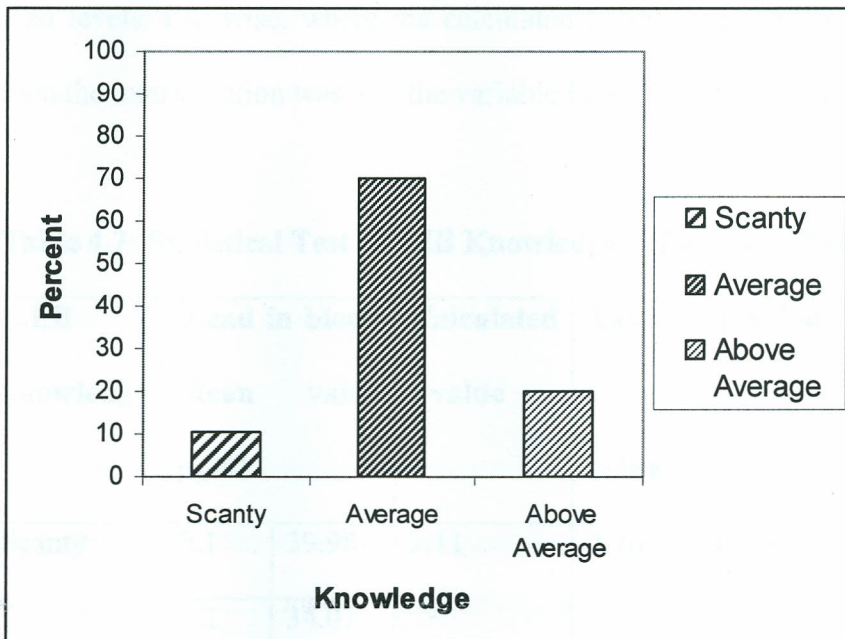
From the study results (99%) of respondents confirmed that education on health and safety issues took place at their work stations. Different sections had different quality work groups which met monthly for about one and a half hours per session.

Agenda number one in all quality workgroups was discussion on health safety and environmental issues. It was mainly through such forum that lead issues were discussed. To spearhead the discussion was an environmental consultant who worked full time with the company and attended all quality workgroup meetings. Health personnel at the site clinic also played significant role in educating workers on lead, its effects on health and environmental issues. This was normally done on a one to one basis with the worker and follow-ups made.

#### **4.5.1 Health Education and General Knowledge on Lead**

The general knowledge on lead and its ill effects was tested on a 1 to 10 scale. This was based on general questions on lead, its ill effects on body, preventive measures both known and practised. Scores of 1 to 3 was classified as scanty knowledge, 4 to 7 as average knowledge while 8 to 10 as above average knowledge .While (10 %) of the respondents had scanty knowledge on lead and its ill effects (figure 4.1), Majority (67%) had average knowledge on lead and its effects on health and (20 %) of respondents had an above average knowledge of lead and its ill effects on the body.

**Figure 4.1: Knowledge on Lead and its Effects on Health**



#### **Test for Statistical significance on Levels of knowledge about effect of Lead**

A two tailed t-test at 95% confidence interval was done. The main reason for statistical application of the t-test emanated from the fact that; means of two variables was tested at the same time (mean of LIB levels against the tested independent variables), and from the fact that some variables tested had very few respondents, some as low as ten. As a rule, the methods and the theory of small samples are applicable to large samples, though the reverse is not true. While dealing with small samples, the main interest is not to estimate the population value as it is with large samples; rather the main interest lies in testing a given hypothesis (Gupta,

1999). Where the calculated t-value was more than the table t-value, then the interpretation was that the variable tested was significant towards reducing blood lead levels. Likewise, where the calculated t-value was less than the table t-value, then the interpretation was that the variable being tested was not significant.

**Table 4.2: Statistical Test on LIB Knowledge before and after interventions**

L.I.B knowledge	Lead in blood		Calculated t-value	Table t-value	p-value	Significance
	Mean value $\mu\text{g/dl}$	value				
Scanty	B.I	39.98	2.11	2.26	0.064	Not significant
	A.I	34.07				
Average	B.I	38.2	2.05	1.96	0.044	Significant
	A.I	36.1				
Above average	B.I	35.2	0.45	2.10	0.657	Not significant
	A.I	36.3				

B.I=Before Intervention. Period April 2003 to December 2006.

A.I= After Intervention. Period April 2005 to December 2009.

Study results showed that for among the workers interviewed, ten (10) respondents were found to have scanty knowledge on lead and its ill health effects. While there was real difference in the mean values of the blood lead level realized after intervention measures (A.I) as compared to before interventions (B.I) (table 4.2), the

difference was not statistically significant. The calculated t-value (2.11) was less than the table value (2.26) with a p value of 0.064. This implies that for those with scanty information about the effect of lead, the intervention measures did not realize significant change towards reducing blood lead levels.

As regards average knowledge, 67 respondents had average knowledge of lead and its ill health effects. It was noted that the calculated t-value (2.05) was greater than the table t-value (1.96) with a p value of 0.044 (table 4.2) implying that; statistically, there was significant difference between the mean blood lead levels for the workers with average knowledge on lead and its ill effects after the intervention measure were put in place. As regards respondents with above average knowledge on lead and its ill effects on health, there were 19 respondents. The calculated t- value of 0.45 was lower than the table value of 2.10 with p value of 0.657 hence not significant. This was despite the increase in the mean value of blood lead levels to 36.1 $\mu$ g/dl after the interventions from 35.2 $\mu$ g/dl before the intervention measure was put in place.

#### **4.5.2 Personal Hygiene and Health Practices**

Majority of the respondents (69%) wash their hands every time (7-10 times in a day), for instance after visiting the toilets, when taking any break and before smoking for those who smoke cigarettes (table 4.3). Thirty respondents or (31%) wash their hands only when necessary, like before taking meals. Majority (74%) cut their beards every 1-2 weeks while (26%) shave their beards once in a month. Majority (60%) of the respondents cut their hair every 1-2 weeks and (29%) did it once in a month. The

remaining (11%) cut their hair after every 3 months. In terms of hands nail maintenance, majority of the respondents (83%) cut their nails weekly while the remaining (15%) cut their finger nails after every two weeks. Majority of the respondents (91%) took bath daily after work at the factory. Most of those who did not take bath at work were female workers who stated that the company did not provide bathroom facilities meant for them.

**Table 4.3: Personal Hygiene and Health Practices**

Category	Type	Frequency	Percentage %
Washing of hands In a day	Before eating	30	31
	Always(7-10 times per day)	66	68
Hair cut	1-2 weeks	51	60
	Monthly	25	30
	Quarterly	9	11
Beards shave	1-2 weeks	66	74
	Monthly	23	26
Nails cut	Weekly	76	83
	Fortnightly	15	16
Bathing daily After work	Yes	87	91
	No	9	9

**Table 4.4 Statistical test on specific personal hygiene standards tested (before and after interventions)**

Hygiene step	Mean value of Blood Lead Level		Calculated t- value	
	April 03 – Dec 05 (B.I)	April 06 - Dec 09 (A.I)		
Bathing	40.6	38.4	2.36	Significantly different
Hand washing Weekly	38.1	36.1	1.72	Not significant
Cutting hair/beards weekly	40.6	40.4	0.13	Not significant

#### **Statistical significance on the personal hygiene standards tested**

The t-test shows that other than bath taking, there was no statistical evidence that, individually, the other hygiene factors considered in this case brought significant difference in the mean values of the blood lead levels (table 4.4). For those taking daily bath at the workplace, the calculated t-value was 2.36 against the table value of 1.96 which was statistically significant.

### 4.5.3 Behavioural Habits

Majority of the respondents; sixty three in number or (67%) indicated that they were consumers of alcohol (table 4.5). Of those who consume alcohol, Majority 43 or (70%) consumed it occasionally and consumption was mainly dictated by the financial position of the consumer. Very few, (2%) of those who took alcohol consumed it daily. The remaining (13%) took alcohol on weekends only. Thirty three percent (33%) of respondents were not consumers of alcohol. On the quantity of water intake per day, fifty respondents or (51%) took more than 1 litre of water per day, while the remaining (48%) took between 0.5 to 1 litres of water in a day.

It was a bit difficult to establish the correct picture of factory workers who smoke as most of them do not smoke openly as the company discourages smoking at the workplace. Majority of the respondents (76%) indicated that they were not smokers of cigarettes; none of the females smoked cigarettes (table 4.5). Of those who indicated that they smoke, statistics show that (45%) smoke less than 5 sticks per day while (54%) smoke more than 5 sticks in a day.

**Table 4.5: Behavioural Habits tested**

Category	Type	Frequency	Percentage %
Drinking Alcohol	Yes (consumed)	63	67
	No (did not consume)	31	33
Daily water Intake. litres/day	0.5-1	47	48
	>1	50	51
Smoking of Cigarettes	Yes (smoked)	23	24
	No (did not smoke)	74	76

#### 4.5.4 Eating Habits

Table 4.6 gives a summary of respondents eating habits. Nearly half (55%) of the respondents took three meals a day, mainly lunch, supper and breakfast. Majority (78%) of respondents took fruits daily; the remaining (22%) took fruits rarely, at times or were not taking fruits at all. Majority (66%) of respondents indicated that they took vitamin C tablet which was provided at the workplace during the ten o'clock tea. Of those who took vitamin C, (79%) took it daily. Very few (7%) of respondents took vitamin C tablets occasionally, while (15%) took it once after every 2 weeks.

The irregularity to vitamin C intake emanated from the fact that the tablet was only provided at 10.00 am during tea break. Some workers indicated that they were not taking the vitamin due to the sour taste from the tablet. ABM/ CMK operates in three shifts, therefore workers working in odd shifts were not able to take the vitamin C tablet. As regards domestic water source, majority (89.4%) used tap water (This is water provided by Nairobi Water Company for Nairobi residents and Athi water services for those residing in Athi-river). Of those who use tap water, (57.7%) treated their water by either boiling by use of chemicals. Quite a number (42%) of respondents did not treat the water they consumed.

**Table 4.6: Eating Habits**

Category	Type	Frequency	Percentage %
Number of daily Meals	2	44	45
	3	53	55
Fruits intake	Daily	75	78
	Sometimes	12	12
	Rarely	8	8
	Not at all	1	1
Vitamin C tablets Intake	Yes	64	66
	No	33	34
Domestic water Source	Tap	84	89
	Borehole/tap	9	10
	River	1	1

**Table 4.7: Test for statistical significant on behavioural and eating habits**

Variable tested	LIB mean value $\mu\text{g/dl}$ (before and after interventions)			Calculated t-value	Table t-value	p-value	Significance
Alcohol	Consumed	BI	40.7	2.04	1.96	0.045	Significant
		A.I	38.8				
	Did not consumed	B.I	31.4	0.29	1.96	0.772	Not significant
		A.I	30.9				
Water intake/day	0.5- 1	B.I	37.9	2.02	1.96	0.049	Significant
		A.I	35.2				
	1-5ltrs	B.I	37.6	0.82	1.96	0.415	Not significant
		A.I	36.6				
Fruits (intake)	Always	B.I	37.6	1.72	1.96	0.09	Not significant
		A.I	36.6				
Vitamin C(intake)	Always	B.I	40.7	1.31	1.96	0.194	Not significant
		A.I	39.2				

There were 63 or (70%) respondents among those who consume alcohol. Out of these (70%) of respondents indicated that they took it occasionally (2%) of whom consumed it on a daily basis. The calculated t value for those who consumed alcohol was 2.04 against table value of 1.96 with a p value of 0.045, which was significant

(table 4.7). There were 31 respondents who were not taking alcohol. A 2 tail test of significance gave a calculated t-value of 0.29 against the table value of 1.96 with a p value of 0.772 which was not significant. The results seem to provide statistical evidence that alcohol consumers could have benefited more from the interventions especially with regard to hygiene practices hence significant improvement towards reduction of the mean blood lead levels.

As regards water intake; Forty seven respondents indicated that they took between 0.5 to 1 litres of water on a daily basis. A 2-tailed t test and at 95% confidence interval showed that the calculated t-value of 2.02 was greater than the table value of 1.96 hence significant with a p- value of 0.049. It was therefore concluded that there was statistical evidence that intake of water up to 1.0 litre a day could bring significant difference in the mean value of the blood lead level among the workers. Fifty respondents indicated that they took between 1.5 – 5 litres of water per day. While there was real difference in the mean values of blood lead level, from 37.6 $\mu\text{g}/\text{dl}$  before intervention to 36.6 $\mu\text{g}/\text{dl}$  after the interventions, excess water intake failed to produce statistical evidence that it could bring significant difference in the mean value of the blood lead level among the factory workers. The calculated t-value of 0.82 was less than the table value of 1.96 (table 4.7).

As regards fruits intake; seventy five respondents indicated that they took fruits on a daily basis. While there was a real difference in the mean values of the blood lead level of the workers who always took fruits, 37.0 $\mu\text{g}/\text{dl}$  before interventions and

35.4 $\mu$ g/dl after the interventions (table 4.7), the calculated t-value of 1.72 was less than the table value of 1.96 with a p value of 0.09; hence not statistically significant. Thus, fruits may bring change but it is not a sure way in itself for reducing lead in blood. As regards the use of vitamin C tablets; sixty four (64) respondents indicated that they consumed vitamin C tablets regularly. The calculated t-value of 1.31 was less than the table value of 1.96 with p value of 0.194 (table 4.7), thus there was no statistical evidence that vitamin C intake could significantly change the mean value of the blood lead levels.

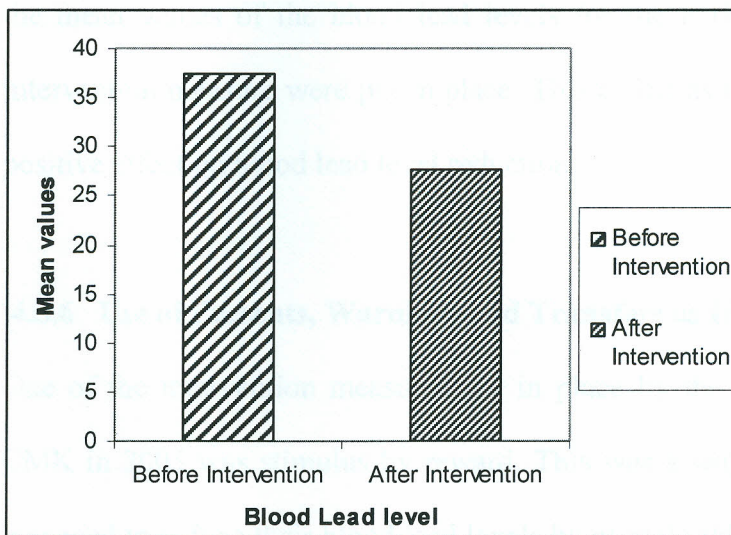
#### **4.5.5 Use of the Personal Protective Equipment**

Majority of the respondents (93%) indicated that their areas of work required that they use personal protective equipment (PPE). Study results (table 4.8) showed that majority of the respondents indicated that they always use personal protective equipment. This again depends on the section one was working from and the type of PPE's which were designed differently for different sections. Sections of work in ABM were mainly, formation, M40, pasting, casting, plate cutting and preparation, brushing, enveloping, assembly line and quality assurance. CMK has furnace, pot and battery breaking with another quality assurance section. Each section had its own unique set of PPE depending on the hazards they were exposed to.

**Table 4.8: Usage of the personal Protective Equipment**

Use of Protective Equipment	Always (%)	Sometimes (%)	Not at all (%)
Dust Mask	87	11	1
Cartridge Mask	6	4	90
Dust coat/overall	87	6	7
Hand gloves	66	20	14
Boots/gumboots	96	3	1
Head caps	62	20	17

**Figure 4.2: Use of Personal Protective Equipment (PPE)  
(Before and after interventions)**



Study results from figure (4.2) showed that the mean value of blood lead levels dropped from 37.4 $\mu\text{g}/\text{dl}$  before interventions to 27.7 $\mu\text{g}/\text{dl}$  after the intervention measures when usage of personal protective equipment (PPE) was put in place.

**Table 4.9: Statistical test on Use of Personal Protective Equipment (PPE)**

Variable	LIB mean value		Calculated t-value	Table t-value	p-value	significance
PPE usage	B.I	37.4	4.66	2.262	0.001	Significant
	A.I	27.7				

Study results (table 4.9) showed that on the use of personal protective equipment, the calculated t- value was 4.66 against the table value of 2.262 with a p value of 0.001 indicating statistical significance that the use of PPE lead to significant difference in the mean values of the blood lead levels for the period before and that after the intervention measure were put in place. This confirms that proper usage of PPE had positive effect on blood lead level reduction.

#### **4.5.6 Use of Presents, Warnings and Transfers as Intervention Measures.**

One of the intervention measures put in place by the company both at ABM and CMK in 2005 was stimulus by reward. This was a way of rewarding workers who managed to reduce their blood lead levels by over 9 $\mu\text{g}/\text{dl}$  per quorta. The reward was

usually in form of cash money. Caution or warning letters were issued to workers whose blood lead levels went up by over  $10\mu\text{g}/\text{dl}$  and the management felt that they were not doing enough towards reducing their blood lead levels. Regulations on occupational health under the legal notice supplement number 22 of 1<sup>st</sup> April 2005, stipulates that workers whose blood lead levels exceed  $70\mu\text{g}/\text{dl}$  and  $50\mu\text{g}/\text{dl}$  for men and women respectively should be redeployed. As a company regulation, such workers normally proceeded on one month leave before being redeployed to less exposed sections.

**Table 4.10: Use of Presents, warnings and transfer as interventions**

Category	Type	Frequency	Percentage %
Given present (Stimulus reward)	Yes	53	56
	No	42	44
Cautioned (Warning)	Yes	26	27
	No	70	73
Transferred (Redeployed)	Yes	10	10
	No	86	90

Study results from (table 4.10) established that most of the respondents fifty three or (56%) indicated that they had at least been given present(s) for reducing their blood lead levels. Only (27%) of the respondents had been given caution or warning letters due to increased blood lead levels. As regards redeployment, only ten respondents or

(10%) indicated that they had been transferred to less exposed sections due to increased blood lead levels.

**Table 4.11: Test of significance on the use of presents, warnings and transfers  
(Before and after interventions)**

Category	LIB mean $\mu\text{g/dl}$			Calculated t-value	Table t- value	p- value	Significance
Presents	Given	B.I	42.36	1.09	1.96	0.283	Not significant
		A.I	40.94				
	Not given	B.I	31.6	1.62	1.96	0.113	Not significant
		A.I	29.7				
Cautioned (warned)	YES	B.I	46.66	0.53	2.06	0.600	Not significant
		A.I	45.59				
	NO	B.I	34.5	2.12	1.96	0.037	Significant
		A.I	32.4				

As regards the use of Presents (stimulus by reward): The calculated t-value for workers rewarded for blood lead level reduction was 1.09 which was less than the table t value of 1.96 with p value of 0.283 (table 4.11) hence not significant. For the group not given presents, the calculated t-value was 1.62 against the table value of 1.96; thus there was no significant difference on the blood lead levels whether presents are given or not.

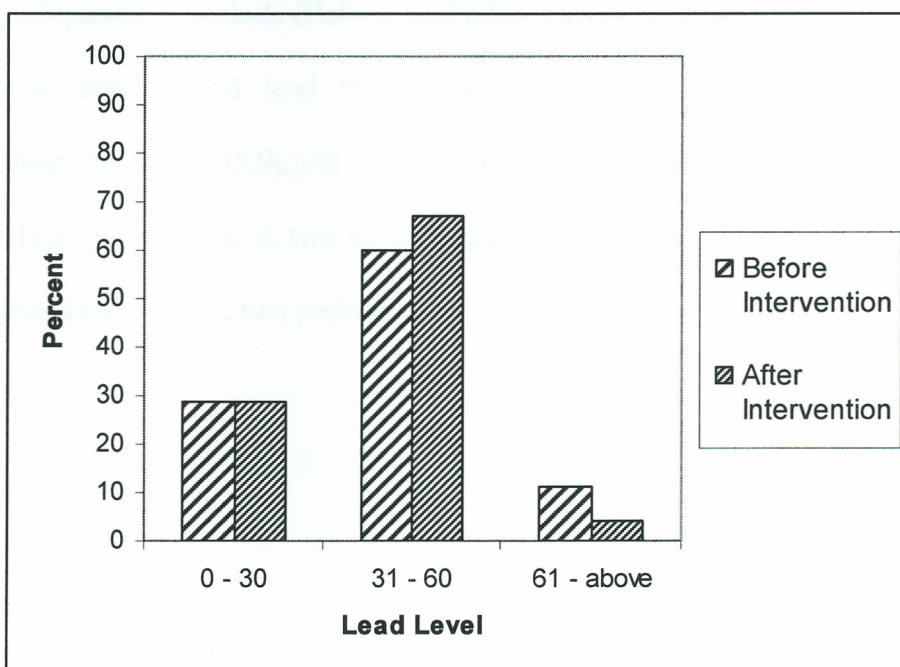
On the use of Warning or caution letters as a form of Intervention; the results did not seem to produce statistical evidence that the intervention could bring significant change in the mean values of the blood lead level. For the workers who got caution letters for high blood lead levels, the calculated t-value of 0.53 was less than the table value of 2.06 with a p value of 0.600 hence not significant towards reducing mean blood lead levels. For the group not given warning letters, there was significant difference in the mean values of the blood lead levels for the different periods before and after interventions. The calculated t-value was 2.12 while the table t-value was 1.96 with a p- value of 0.037 hence significant. The results suggest that warning as a form of intervention did not work to bring meaningful change in the blood lead levels; however those workers who were not issued with warning letters showed some significant change towards lowering of their mean blood lead levels.

#### **4.6: Analysis of Blood Lead Levels among Workers at ABM/CMK**

Study results (table 4.12 and figure 4. 3) indicated that; While there was no change in the percentage of the number of workers whose blood lead level was in the range of (0 – 30 $\mu$ g/dl), twenty nine percent (29%) for the two periods before and after intervention measures, there was a drop in the percentage of those whose blood lead level was in the range above 61 $\mu$ g/dl from 11% to 4%. This suggests that only those who had highest level of blood lead levels (above 61 $\mu$ g/dl) were the ones who worked hard towards lowering their blood lead levels to the range of (31 -60 $\mu$ g/dl).

**Table 4.12: Distribution Range of Blood Lead levels among workers****(Before and after interventions)**

Blood Lead levels $\mu\text{g/dl}$	April- 03 - Dec- 05 Period (B.I) Before Interventions		April-06 – Dec-09 Period (A.I) After Interventions	
	Frequency	%	Frequency	%
0 – 30	28	29	28	29
31 – 60	58	60	65	67
61 – above	11	11	4	4
Total	97		97	

**Figure 4.3: Combined ABM and CMK blood lead levels****(Before and after intervention)**

This may suggest that intervention emphasis may not have been put on those with blood lead levels in the lower categories. The intervention measures may have focused much on those with higher levels of  $61\mu\text{g}/\text{dl}$  and above, thereby ignoring other groups. That may have been the undoing or the workers in the lower categories may have taken the intervention measures for granted, thereby ignoring serious interventions towards reducing their blood lead levels. But it is also interesting that from the statistics about their participation in the health education and positive hygiene practices, all workers appear to have participated equally in the practices, which should have resulted to reduction in the blood lead levels of the entire group to shift percentage towards lowest blood lead level.

#### **4.6.1 Test of the significance of the difference in the Mean values for the two independent periods (Before and After Interventions)**

The mean blood lead levels dropped from  $37.8\mu\text{g}/\text{dl}$  for the period before interventions to  $35.9\mu\text{g}/\text{dl}$  for the period after the intervention measures were put in place (table 4.13). A two tailed t-test of significance was done for the mean blood lead levels for the two periods.

**Table 4.13: Statistical test on Mean values of the Blood Lead levels for the two Independent Periods (B.I and A.I)**

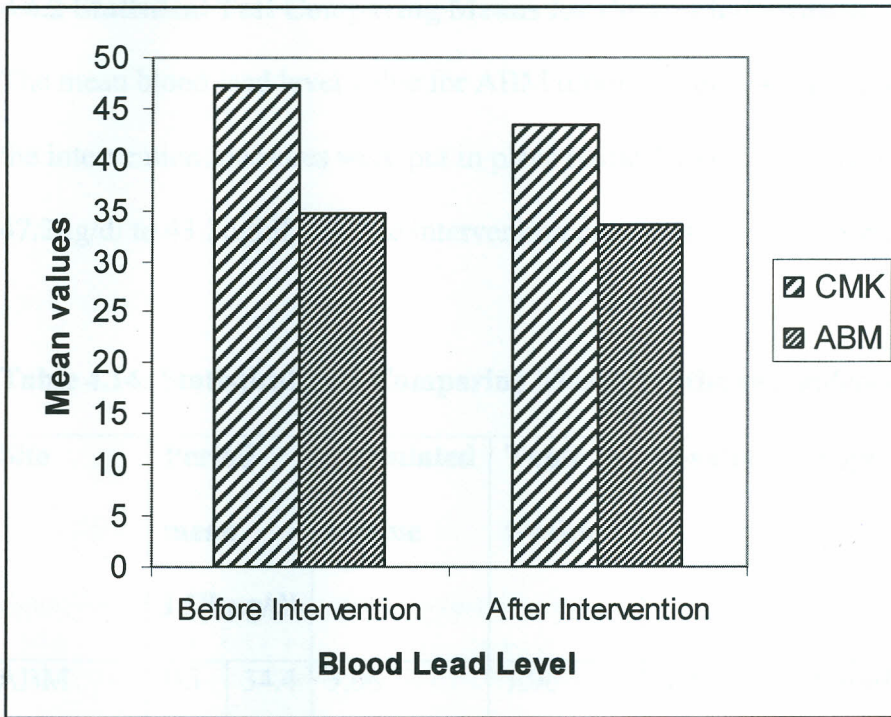
Period	Mean value of LIB $\mu\text{g/dl}$	Calculated t value	p-value	Table t-value	significance
B.I	37.8	2.03	0.045	1.96	significant
A.I	35.9				

Period before interventions (B.I) April-03 to Dec-05

Period after interventions (A.I) April 06 to Dec-09

-Ho = null hypothesis would be that there is no significant difference between the mean values of the blood lead levels for the period before intervention(B.I) and that after the interventions (A.I). Using the t-test (table 4.13), the calculated t-value was 2.03 against the table value of 1.960 at 95% confidence interval and a p value of 0.045. The null hypothesis was therefore rejected and it was concluded that there was significant difference between the mean blood lead level values after the intervention measures were put in place. That, therefore, confirms that the intervention measures put in place generally brought significant change towards lowering the mean blood lead levels.

**Figure 4.4: Comparing Means for the two independent groups**



Study results (figure 4.4) shows that there was real difference in the means of blood lead levels with CMK standing at 47.2  $\mu\text{g}/\text{dl}$  and ABM at 34.8 $\mu\text{g}/\text{dl}$  before interventions. After the intervention measures were put in place, the mean value of blood lead levels dropped to 43.3 $\mu\text{g}/\text{dl}$  for CMK and 33.6 $\mu\text{g}/\text{dl}$  for ABM respectively.

#### 4.6.2 Statistical Test Comparing Means for the two independent sites.

The mean blood lead level value for ABM dropped from 34.8 $\mu$ g/dl to 33.6 $\mu$ g/dl after the intervention measures were put in place (table 4.14). For CMK the drop was from 47.2 $\mu$ g/dl to 43.3 $\mu$ g/dl after the intervention measures were put in place.

**Table 4.14: Statistical Test Comparing Means for the two independent sites.**

Site	Period		Calculated t-value	Table t-value	p-value	Significance
	mean LIB $\mu$ g/dl					
ABM	B.I	34.4	3.06	1.96	0.002	Significant
	A.I	33.6				
CMK	B.I	47.2	2.90	1.96	0.006	Significant
	A.I	43.3				

Period before interventions (B.I) April-03 to Dec-05

Period after interventions (A.I) April 06 to Dec-09

For ABM, the calculated t-value of 3.06 (table 4.14) was higher than the table value of 1.96 with a p value of 0.002; hence significant difference between the means for the two periods before and after the intervention measures were put in place. For CMK, the calculated t-value of 2.90 was higher than the table value of 1.96 with a p

value of 0.006 hence; there was significant difference between the means for the periods before and after the intervention measures were put in place. The results suggests that the Mean values of the blood lead levels for the workers at the two sites would always be significantly different before or even after intervention measures were put in place. This indicates the peculiarity of each site.

#### **4.7 DISCUSSION**

This study sets out to establish the effectiveness of health education and hygiene interventions on blood lead levels among factory workers. In order to accomplish the aim of the study, several variables were examined to determine whether they had any effect on blood lead levels. A -2-tail t-test at 95% confidence Interval was done on various variables and the following results were obtained:

As regards the knowledge about lead and its ill effects on health; average knowledge was significant with the calculated t-value of 2.050 against the table t-value of 1.96. This showed that, when workers had average knowledge on the effects of lead, then the intervention measure could help realize improvement in the lowering of the blood lead levels, but not when the knowledge was scanty or above average (see table 4.2). Like in the case of those with scanty knowledge, those who believe that their knowledge about the effects of lead was above average also failed to produce statistical evidence that the mean values of their blood lead levels would be significantly different after the intervention measure were put in place. This may be a

case of attitude or self esteem which make many despise being instructed on, thinking that they know better. However level of knowledge is important in the effort towards lowering of the blood lead levels.

These findings are similar to those observed by Herman, (2007) who in his studies noted that the potential health hazard of lead poisoning still exist and are rising due to lack of education regarding the dangers of working with lead. He reported that workers in the lead based industries were ignorant of ill health effects of lead hence do not take proper precaution while handling lead leading to higher level of exposure. Last (2000), found out that education of the workers about the importance of cleanliness, washing of hands to get rid of lead dust and paste before eating, good housekeeping in the workplace to avoid building up of toxic concentration all play significant role towards reducing blood lead levels.

Lormphongs *et al.*, (2003) in another similar study established that training of health education is a fundamental tool in prevention of occupational diseases and should be a continuous process. Porru *et al.*, (1993) in a prospective study reported that health education programme led to decrease in blood lead levels among lead workers.

As regards the use of personal protective equipment (PPE); the calculated t- value of 4.66 against the table value of 2.26 showed statistical evidence that the use of PPE led to significant difference between the mean values of the blood lead level between the period before and that after the intervention. Proper use of PPE, though causes

discomfort to some workers, should be encouraged as it was confirmed that it had positive effect on LIB reduction.

This conforms to the regulations on OSHA and Kenyan Occupational Health Act (2007), which places emphasis on providence of correct and adequate PPE for all industrial workers. However more emphasis should be placed on control of emissions from the source through engineering control measures. Lormphongs, *et al.*, (2003), showed that respiratory protective equipment and protective clothing should be used to supplement the engineering measures and that work control measures such as eating, drinking and smoking in different workplaces where workers are exposed to lead should be discouraged.

As regards water intake, the study established that; while there was a real difference in the mean values of blood lead level before and after interventions (see table 4.7). Excess water intake failed to produce statistical evidence that it could bring significant difference in the mean value of blood lead levels of the workers. The calculated t-value was 0.82 against the table value of 1.96 (see table 4.7). This finding contradicts the commonly held belief among workers in lead industry that the more water one takes the more lead is excreted from the body. Jiang (2009) reported that a 26 year old Taiwanese woman, who took 7 litres of water per day for three months to detoxify her body, became blind. The doctor who treated her reported that too much water consumed causes hyponatraemia; a condition where there is insufficient sodium in the blood as a result excess water intake and excretion. The

amount of water she drank daily was more than three times the recommended daily consumption for sedentary adults. Medical workers recommend that a normal adult should consume at least eight glasses of water per day (AAR, 2010). Thus; just enough water but not in excess is enough.

As regards alcohol intake; the results seem to provide statistical evidence that there was significant difference between the mean values of blood lead levels before and after the interventions among the alcohol consuming respondents. The calculated t-value was 2.04 against the table value of 1.96 with a p-value of 0.045 (see table 4.7). This could suggest that alcohol consumers benefited more from the interventions especially with regard to hygiene practises hence significant improvements.

In a similar finding but in a different field, Boylers (2010) reported that; compared to teetotalers; alcohol drinkers were less likely to develop rheumatoid arthritis (a progressive and often disabling inflammatory disease that attacks the joints). The researcher found out that non-drinkers were roughly four times as likely to develop rheumatoid arthritis as people who took alcohol. One limitation of both studies however, was that the researchers did not know how much alcohol people actually took during the study period or the type of alcohol they took. This may need further research as alcohol may be having positive influence on a number of health issues.

Table 4.4 shows that other than taking daily bath after work with a calculated t value of 2.36 against the table t value of 9.6, there was no statistical evidence that the other

hygiene measures tested such as: frequent hand washing, frequent cutting of hair, beards and nails brought significant difference in the mean values of the blood lead levels.

Similar results were found by Chuang (1999), who established that although the other personal hygiene measures evaluated such as taking a shower after work, washing of hands and changing cloths before going home increased in frequency during the study; the goal of these habits was to avoid bringing lead contamination home and to protect workers families especially children and not to reduce the workers blood lead levels. He also established that a major reduction of lead exposure for some jobs like pasting and plate cutting in the battery manufacture industry is unlikely to occur despite hygiene measures undertaken without major engineering changes in these departments.

In a related study, Askin (1997) explained that poor personal hygiene at the work sites increases the level of exposure and absorption of lead into the human body. Far *et al.*, (1993) reported that hand to mouth movements and hand washing practises in particular significantly influence blood lead level concentrations.

Workers both at ABM and CMK were observed in the dining hall taking meals while on work clothes. It was interesting to note that the health and safety committee at both sites put a lot of emphasis on health and hygienic measures like maintaining the

hair short, trimming of the beards and finger nails. While hygiene contributes individually, each contributes very little to the general picture mean blood lead levels. Herman (2007) in a similar study observed that workers scored high blood lead levels due to poor personal hygiene during and after work; they were observed in the dining area wearing work cloths and observed working without wearing proper personal protective equipment.

Chung (1999) reported that, use of different work designs and engineering controls (such as general and local ventilation), rather than an ever greater emphasis on personal hygiene habits, would probably be the best way to lower workers blood lead levels. Unfortunately it is difficult to persuade employers to implement such measures because of the expense.

The use of rewards as a form of intervention failed to produce statistical evidence that it could lower the mean blood lead levels among factory workers (see table 4.11). The same applies to warning letters given to those who scored high blood lead levels. The program was effective when it was initiated, but lost its credibility with time. There is a possibility of workers being less vigilant or careless leading to them scoring high blood lead levels, only to be more vigilant in the subsequent lead in blood quota sampling in order to qualify for the reward which was in form of cash money.

Maples *et al.*, (1992) reported that an employee training and motivation programme with monthly follow up measurement of lead in blood for one year led to a decrease in blood lead levels. Hence motivation should be on health education rather than by monetary rewards. The issue of transferring workers to less exposed areas also seem to have had no effect on blood lead level reduction. This can be explained from the fact that the workers were usually returned back to their old areas of work once the lead results come back to normal. Good workers tend to be good at certain departments and the company management returns them back to their previous work sections as soon as possible.

While there was real difference in the mean values of the blood lead level of the workers who always took fruits, the calculated t-value of 1.72 against the table value of 1.96 did not produce statistical evidence that the taking of fruits would bring significant difference in the mean blood lead values (see table 4.7). Thus, fruits may bring change but it is not a sure way in itself for lowering blood lead levels among factory workers. Fruit intake should be encouraged as it has been proved to have positive effects on the general health of humans from previous studies (AAR, 2010).

As regards vitamin C intake; the calculated t-value of 1.31 was less than the table value of 1.96 (table 4.7), thus from this study, there was no statistical evidence that vitamin C could bring significant change on the mean value of blood lead levels. However In this study some of the respondents refused to take vitamin C tablet

regularly citing the sour test from the tablet as a reason. The daily dose of 500 mg was low compared to the other studies on the same.

This contradicts studies done by Saryan (1999), whose study trials found out that high level of ascorbic acid in blood serum were invariably associated with low blood lead levels. Dawson *et al.*, (1999) established that from among the adult male smokers working in the lead environment. and put on daily 1000 mg vitamin C tablet; all the subjects studied had low blood lead levels after as little as one week of supplementation. The group receiving 1000 mg of vitamin C daily showed an 81% decrease in mean blood lead levels.

The results further suggests that the Mean values of the blood lead level for the workers in the two sites would always be significantly different, before or even after intervention measures, with mean blood lead level value for CMK always higher than that for of ABM (see table 4.14). These findings could correspond to those of (Frumkin, 2005) who reported that emissions of lead from smelting operations in developing countries are an ongoing concern. He reported that; these smelters often employ outdated technology or are equipped with inefficient pollution control devices. Secondary smelters involved in the recycling of lead in car batteries are disproportionately sited in developing countries because they cannot meet pollution control regulations in the developed countries (Frumkin, 2005).

## CHAPTER FIVE

### SUMMARY, CONCLUSION AND RECOMMENDATIONS

#### 5.1 Summary

The study further established that of the 13 variables tested to establish their effects on blood lead levels, only five (5) factors had shown that they could bring significant difference in the mean values of the blood Lead level. These were:

1. Use of Personal Protective Equipment
2. Health education leading to knowledge on lead and its ill health effects: it was established that the respondents with average knowledge on lead and its effects on health had significant reduction on blood lead levels.
3. Daily intake of water: There was statistical evidence that intake of water up to 1 litre a day could bring significant difference in the mean value of LIB among workers. Excess water intake however failed to bring significant difference in the mean value of LIB in such areas.
4. Bathing daily: Among the hygiene interventions tested, taking daily bath after work showed a statistical significant on reducing LIB levels.
5. Alcohol consumers seem to have benefited more from the interventions especially with regard to hygiene practises hence significant improvements in lowering mean blood lead levels.

The following tested factors were found to have had insignificant effect on blood lead levels:

- Warnings or caution,
- Transfers or redeployment,
- Presents or stimulus by reward,
- Washing of hands every time,
- Frequent cutting of hair, beards and nails.

The company adheres fully to the recommendations set up under the Occupational Safety and Health Act supplement number 22 of 1<sup>st</sup> April 2005. This was established through the records seen at the site health clinic and interview to the health personnel, Safety, Health and Environment committee members and the human resources manager.

## 5.2 Conclusion

The conclusions that can be drawn from this study are that:

The mean level of blood lead levels reduced with the intervention measures put in place. The study also confirmed that the blood lead levels for the workers at CMK were higher than those of workers at ABM (both before and after the intervention measures were put in place), this suggests the peculiarity of each site.

Looking at the general blood lead levels for the period April 2003 to December 2005 (before interventions) and April 2006 to December 2009 (after interventions):

The null hypothesis would be that there is no significant difference between the mean values of the blood Lead levels of the workers for the period before and after the intervention measures were put in place. A 2-tail t-test at 95% Confidence Interval was done (see table 4.13). The calculated t-value (2.03) was greater than the table t-value (1.96), the null hypothesis was therefore rejected and it was concluded that there was significant difference between the mean values of blood lead levels. That, therefore, confirms that the intervention measures put in place brought significant change towards lowering of blood lead levels among the factory workers.

As regards adherence to the Occupational Safety and Health Act 2007 and its impacts on blood lead levels; the following points were noted from the study:

- Medical examination was done annually to all workers exposed to the occupational hazards as required by law by a designated medical practitioner.

- Pre employment and periodic medical examination was done. Blood lead levels were taken after every three months for all workers working in lead exposed areas.
- It was confirmed that employees scoring blood lead levels more than 70ug/dl for men and 50ug/dl were given one month leave and redeployed to less exposed area upon returning to work. Certificate of redeployment was filled by the company doctor and circulated as required by law.
- The above highlights on adherence to the occupational health and safety Act, together with for formation of health and safety committee as required by law at both sites, helped much in the implementation and monitoring of health education and hygiene interventions as confirmed from the above statistical data.

### **5.3: Recommendations**

The conclusions drawn from the findings of this study have prompted various recommendations:

- 1) Health education should be emphasised and allocated more time and the quality of education improved further among the factory workers.
- 2) Usage of proper personal protective equipment be enforced and emphasised.
- 3) Bathroom facilities which are provided for the male workers should be urgently extended to the female workers.

- 4) Water intake should be encouraged as it is known to have other positive effects on the body. Up to one litre per day is just enough.
- 5) The company should scrap the usage of caution letters and stimulus by reward as a way of reducing blood lead levels.
- 6) Factory workers should change to clean clothing during lunch break rather than going to the canteen with the contaminated work clothing.

#### **5.4 Suggestions for Further Research**

- 1) Experimental design kind of study with a big sample size. One group to act as experimental while the other as control group.
- 2) Role of vitamin C, fruits and alcohol in blood lead levels needs further research.
- 3) Follow up study on all those who have worked in the lead industry to establish their health status.
- 4) Same study to be done at ABM and CMK as separate entities.

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## APPENDIX 1

### QUESTIONNAIRE

Questionnaire No.....  
interview.....

Date.....of.....

Code:.....

For supervisor

Are all questions filled?.....

Are the respondents reasonable? .....

Is the questionnaire ready for keying? .....

#### **Background Information**

1) How long have you worked for ABM/CMK

- a) 5-10yrs b) 10-15yrs c) 15-20yrs d) Over 20yrs

2) How old are you? .....

3) Sex of respondent.....

- a) Male b) Female

4)What is your marital status?.....

- a) Single b) Married c) Widowed d) Divorced

5)What is your highest level of education.....

- a)Primary b)Secondary c) University d) Others(specify)

#### **Personal Information**

6)Do you smoke cigarettes?.....

- a) Yes b) No

If your answer in above is yes, please state approximately how long you have been smoking cigarettes.....

What is the average number of sticks you smoke in a day?.....

- a) <5      b) 5-10      c) >10 sticks      d) others (specify)

7) Do you take alcohol?.....

- a) Yes      b) No

If your answer in above is yes, please state how long you have been taking alcohol.....

How frequent do you take alcohol.....

- a) Daily      b) Alt days      c) weekly      d) Occasionally

What quantity of alcohol do you take on average per sitting.....?

8) What is your average water intake per day?.....

9) What is your occupation?.....

10) Which is your current department of work.....

11) How long have you worked in the present station.....

12) Do you need protective equipment while working in this section?.....

- a) Yes      b) No

13) Do you have one? If so how frequent do you use it?

14) How frequent do you wash your hands?.....

15) How often do you shave your head.....Beards.....

- a) daily      b) weekly      c) fortnightly      d) monthly      e) others (specify)

16) How often do you trim your nails.....

- a) daily      b) weekly      c) fortnightly      d) monthly      e) others (specify)

17) Have you ever had an injury/ accident while working?..... a)Yes b)No if yes to above, what was the reason for the injury.....

18) Have you been trained at work in any field?.....

a)Yes b)No

If yes, what was the subject.....?

When.....

By who.....

19) Have you ever been admitted to a hospital in the last 10years?.....

a) Yes b) No

If yes, for what problem(s).....

### **Health and Safety Information**

20) Are health and safety issues discussed in your quality work groups?.....a) Yes b) No .If yes, how frequent.....

21) What are your knowledge on lead and its effects on health?..... a) Scanty b)Average c) Above average d) None

22) Have you ever got a present after reducing your blood lead levels ?..... a)Yes b)No If so how many times.....

23) How frequent is your blood taken for lead analysis..... a) Quarterly b) twice a year c) yearly d) others (specify)

24) Have you ever been transferred from a department because of high blood lead? a) Yes b) No .If yes, how many times.....

25) What about getting a warning letter on high lead?..... a) Yes b) No If so how many times.....

26) Please give your lead in blood profile in the following box:

	2003	2004	2005	2006	2007	2008	2009
April							
August							
Dec							

27) How many meals do you take in a day?.....

28) How frequent do you take fruits?.....

29) Do you take vitamin C tablets? .....a) Yes b) No

If so how frequent.....

30) How many shifts do you work in a day?.....

if more than one, why?.....

31) How many days do you work in a week.....? If more than Five, why?.....

32) Do you separate the used home cloths from working cloths at work?.....a) yes b) no If not why?.....

33) Where do you live?.....

how long have you lived there?..... if less than one year, where did you used to live before?.....

34) Do you get enough water for drinking in while at work?.....

35) Do you get enough water for sanitary needs (bathing after work?).....

....

36) Do you take bath after work? a) yes b) no.....

If yes, how frequent.....

37) How moist is your workplace

a)Dry b)wet c)moist

38) What is your main source of water for domestic use?.....

a) Tap water b) borehole c) river, stream

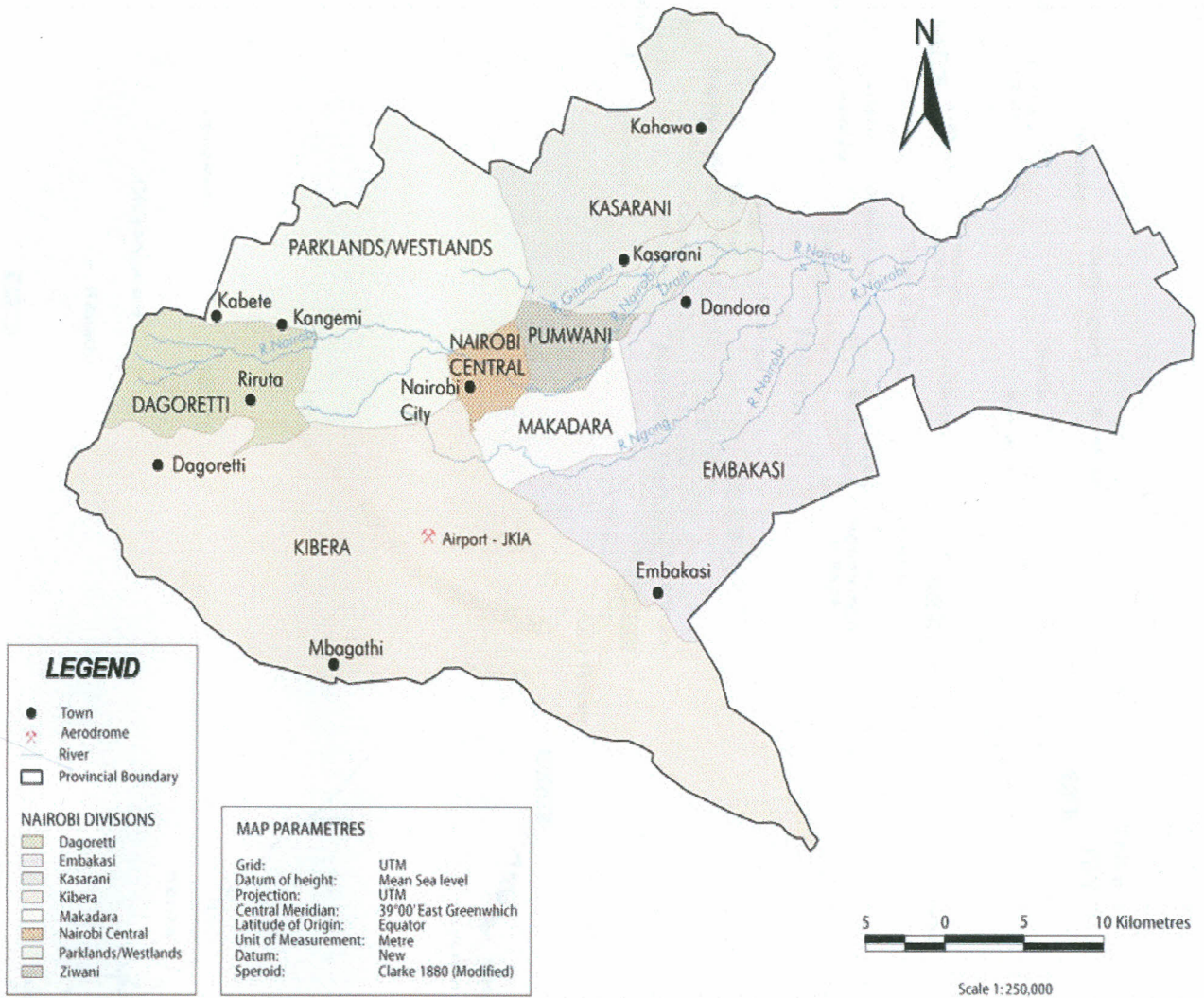
39) Do you treat your domestic water?..... a) yes b) no

If yes how?.....

a) boiling b) chemicals c) others (specify)

APPENDIX 2

STUDY AREA (MAKADARA-INDUSTRIAL AREA) NAIROBI





**APPENDIX 3**  
**STUDY AREA (ATHI RIVER) MACHAKOS DISTRICT**

(Legislative Supplement No. 13)

LEGAL NOTICE NO. 24

## THE FACTORIES AND OTHER PLACES OF WORK ACT

(Cap. 514)

IN EXERCISE of the powers conferred by section 45B of the Factories and other places of work Act, the Minister for Labour and Human Resource Development makes the following Rules:—

## THE FACTORIES AND OTHER PLACES OF WORK (MEDICAL EXAMINATION) RULES, 2005

1 These Rules may be cited as the Factories and Other Places of Work (Medical Examination) Rules, 2005.

Citation

2 In these Rules except where the context otherwise requires—

Interpretation

"medical examination" means examination of workers exposed to specified occupational hazards indicated in the First Schedule to these Rules for the purpose of prevention and control of occupational diseases;

"employer" includes owner and/or occupier;

"employee" means a person who has entered into or works under a contract of service or of apprenticeship or learnership, with an employer whether the contract is express or implied, oral or in writing and whether the remuneration is calculated by time or by work done or is in cash or in kind;

"designated health practitioner" means any medical practitioner whether a public officer or not who is authorized by the director, by certificate in writing, to carry out examination of workers in accordance with, and for the purposes of these Rules;

"director" means the directorate of occupational health and safety services;

"occupational diseases" means any departure from health occasioned by exposure to any factor or hazard in the workplace;

"workplace" includes any land, premises, location, vessel or thing at, in, upon or near where an employee is, in the course of employment.

3. These Rules shall apply to medical examination of all those employees in employment or have been in employment in every workplace, to which the provisions of the Act apply.

Application

Occupations  
requiring  
medical  
examination

4. (1) It shall be the duty of the employer to ensure that all persons employed in any of the occupations outlined in the Eighth Schedule to the Act undergo both pre-employment and periodic medical examinations by the designated health practitioner as outlined in the First Schedule.

(2) The fees to be charged by the designated health practitioner shall be as prescribed by the director.

(3) The Minister may, in the Gazette, publish any other work involving risk to the health of the employees.

(4) Any employer who does not comply with paragraph (1) shall commit an offence.

Duties of  
employer and  
employees as to  
medical  
examination

5. (1) The employer shall ensure that the examination takes place without any loss of earnings for the employees and if possible within normal working hours during their employment.

(2) The costs in connection with such examination shall be paid by the employer.

(3) The employees and former employees shall be under an obligation to undergo examination in accordance with these rules.

(4) Any person who contravenes this provision shall commit an offence.

Reports on  
examination

6. (1) Results of the examination shall be entered into each individual's medical record by the designated health practitioner and shall be updated with each examination whenever repeat tests are carried out.

(2) Summary report forms as outlined in the Second Schedule shall be completed after medical examination for each hazard and shall be submitted within twenty one days to the director and a copy sent to the employer.

(3) If there is more than one hazard in the same workplace, separate summary report forms shall be used for each hazard.

Certificate of  
redeployment

7. (1) If it is desirable that an employee be removed from further exposure to a particular hazard, the certificate of redeployment as outlined in the Third Schedule shall be filled and completed in triplicate by the designated health practitioner and a copy sent to the employer, employee and the director within seven days from the date of the examination.

(2) In these rules, unless where it is otherwise indicated, all abnormal examination results shall be repeated within two weeks to ensure consistency.

Certificate of  
fitness

8. (1) Examination results for persons entering employment or those returning from sick leave occasioned by occupational diseases shall be entered into the certificate of fitness as outlined in the Fourth Schedule, which shall be kept by the designated health practitioner, and a copy thereof given to the employee.

(2) If an employee is exposed to more than one of the specified hazards, a separate certificate of fitness shall be completed for each hazard.

9. (1) The provisions of section 45 regarding the notification of occupational diseases shall apply *mutatis mutandis* for all abnormal results as if they were set out therein.

Notification

(2) Notification shall contain particulars as outlined in the notification form in the Fifth Schedule.

10. Any person who contravenes these rules shall commit an offence and the provisions of the Act on offences and penalties shall *mutatis mutandis* apply.

Offences and penalties.

	<i>Work involving risk to health</i>	<i>Medical examinations</i>	<i>Examination interval</i>	<i>Indication for re-deployment and notification to the Director</i>
		5. Radiographic examination for shoulder, hip and knee joints.	Pre-employment to be carried out within 4 weeks of starting employment in compressed air exceeding 1 bar. Thereafter not less than once in ever 12 months	
		6. Stress electrocardiogram.	Pre-employment and annual for workers aged more than 35 years.	
7.	Handling fossil oil.	Clinical examination.	Pre-employment and annual.	Any abnormal dermatological or respiratory sign
8.	Work where ionising and non-ionising radiations are emitted.	Clinical examination.	Pre-employment and annual.	Abnormal visual and/or clinical sign.
9.	Work involving exposure to Iron.	Clinical examination.	Pre-employment and annual.	Any abnormal respiratory sign.
10.	Work involving exposure to lead and its compounds.	1. Clinical examination.	(a) Pre-employment and annual	Cases of suspected lead poisoning.
		2. Blood lead levels	(b) Pre-employment, annual and a repeat depending on blood lead level.	Males and females with blood lead levels of 70 micrograms per 100ml and 50 micrograms per 100ml respectively.

REPUBLIC OF KENYA



# NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telegrams: "SCIENCETECH", Nairobi  
 Telephone: 254-020-241349, 2213102  
 254-020-310571, 2213123.  
 Fax: 254-020-2213215, 318245, 318249  
 When replying please quote

P.O. Box 30623-00100  
 NAIROBI-KENYA  
 Website: www.ncst.go.ke

Our Ref: **NCST/RRI/12/1/MAS/143/3**

Date: **30<sup>th</sup> June 2010**

**Mr. Jared Ochieng Ngara**  
**Kenyatta University**  
**P. O. Box 43844**  
**NAIROBI**

Dear Sir,

**RE: RESEARCH AUTHORIZATION**

Following your application for authority to carry out research on "*The effectiveness of health education and hygiene interventions on blood lead levels among workers at associated battery manufacturers company, Nairobi, Kenya*" I am pleased to inform you that you have been authorized to undertake research in industrial area in **Nairobi East District, Nairobi Province** for a period ending **30<sup>th</sup> June 2011**.

You are advised to report to **the Chief Executive Officers, Associated Batteries Limited, Nairobi and Athi River** before embarking on the research project.

On completion of the research, you are expected to submit two copies of the research report/thesis to our office.

A handwritten signature in black ink, appearing to read 'P. N. Nyakundi'.

**P. N. NYAKUNDI**  
**FOR: SECRETARY/CEO**

Copy to:  
 The Chief Executive Officers  
 Associated Batteries Limited  
 Nairobi & Athi River

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