SOURCES OF LEAD CONTAMINATION AND AWARENESS AMONG BANGLADESHI WOMEN OF CHILD BEARING AGE.

Submitted by,

Raksa Andalib Hia

ID: 11146010.

Submitted to BRAC University in accordance with the requirements for the
Degree of Bachelor of Pharmacy.
Session: Spring'11

DEPARTMENT OF PHARMACY
BRAC UNIVERSITY

Dedicated To:

My parents and my brother;who are my driving forces in life.

Their presence makes me breathe; their inspiration brings me hope;

And their support keeps me invulnerable.

March, 2015.

The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

This copy has been supplied on the understanding that it is copyright material and that no quotation from the thesis may be published without proper acknowledgement.

ACKNOWLEDGEMENTS

ABSTRACT

Lead is one of the oldest toxins existing in the environment because of its nature and extensive use from the ancient times. Lead is commonly known as a silent killer because, at any concentration, without any noticeable symptom it can affect almost all organs in the body.Unsafe blood lead levels may cause lower IQ level, autism, abnormal delivery and may increase the involvement in crime. Generally, pregnant women, fetus and children are the most vulnerable groups to lead poisoning because of rapid bone mobilization and neurodevelopment. Therefore, the aim of this study was to evaluate the awareness about lead among Bangladeshi women of child bearing age. To evaluate the knowledge on exposure to lead, a questionnaire survey was conducted and completed by all participants (Less-educated women, n=62; Educated women, n=52). Data were analyzed by using SPSS (Version20). Appropriate statistical tools were utilized to draw the results. The study findings showed that there is a highly significant difference in economic condition ($p<0.0001$), home location ($p<0.0001$), cosmetics use ($p<0.0001$), even in food habit ($p<0.0001$) between the groups. Moreover, significant difference has also been found in awareness about lead toxicity among educated and less-educated women ($p<0.0001$). However, interestingly, no significant difference was found in the knowledge about the (hidden) sources of lead in everyday life between the groups ($p<0.109$), frequency of lipstick use ($p<0.201$) and in the use of coloring agents in food ($p<0.724$). Since lead exposure reduces the IQ level at any concentration, therefore, scientists have found an economic impact of lead on the society. The importance of this study lies in the fact that, if the women are aware about the sources of lead and consequences of lead toxicity, the body lead burden could be reduced in the next generation as lead can directly affect the fetus from mothers' exposure.

TABLE OF CONTENTS

CHAPTER 5: GENERAL DISCUSSION

CHAPTER 6: CONCLUSION

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

1. ADHS: Arizona Department of Health Sciences

2. ALA: Amino Levulinic Acid

3. ALAD: Amino Levulinic Acid Dehydratase

4. ATSDR: Agency for Toxic Substances and Disease Registry

5. BLL: Blood Lead Level

6. CDC: Centers for Disease Control and Prevention

7. CNS: Central Nervous System

8. EPA: US Environmental Protection Agency

9. ESDO: Environment and Social Development Organization

10. GABA: Gamma amino Butyric Acid

11. GAELP: Global Alliance to Eliminate Lead Paint

12. IARC: International Agency for Research on Cancer

13. IPCS: International program on chemical safety

14. IPEN: International Pops Elimination Network

15. PVC: Polyvinyl Chloride

16. SPSS: Statistical Package for the Social Sciences

17. UNEP: United Nations Environment Program

18. WHO: World Health Organization

19. ZPP: zinc protoporphyrin

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Lead is one of the first metals known to and used by humansbecause of its Physico-chemical properties, low cost and ease of use (D'souza, 2011, Lessler, 1988).Lead is found at low concentration as lead sulfide (commonly known as galena) in the earth's crust, but widespread occurrence of lead in the environment has been detected. This has happeneddue to the anthropogenic activity involving lead which allows it to enter the environment at any stage from its mining to final use. Once lead enters into the environment, it persists for decades after decades and becomes a source of human exposure (WHO, 2006).There are varieties of pathways through which human may become exposed to lead, including water, soil, air, dust etc. (Juberg, 2000). This heavy metal has the ability to bio accumulate through ingestion, inhalation and also through skin contact. Due to its chemical nature, accumulated lead cannot be removed by the body system until the metal is flushed out from the body by using some interventions (Abdullahi, 2013).

Typically, lead is a highly toxic substance that exerts acute and potentially fatal effects even at very low dose (less than 2μg/dl; Gilbert and Weiss, 2006). The term lead poisoning can be used to describe the condition, in which the blood lead level in adults exceeds 5 micrograms per deciliter (μg/dl) though there is no harmless blood lead level has been identified for children (CDC, 2014). Because of the toxicity, lead is the most researched and studied topics (Juberg, 2000).According to the Centre for Disease Control and Prevention, CDC (2004) lead may affect almost every organ of the human body.

The toxic effects of lead, include neurotoxicity, carcinogenicity, reproductive toxicity and neurobehavioral effects (Juberg, 2000). If exposure to lead occurs at higher levels, almost all organs and organ systems may become damaged including central nervous system and kidneys (Tong *et al*, 2000).There are also few reports indicating that lead may affect the cardiovascular system directly resulting in hypertension with renal impairment (Krishnaswamy, 1998).Even at lower levels of exposure lead has been associated with cognitive deficits, including loss of IQ, impairment of communication or deficiency in language skills, memory problems, inattention, lack of concentration, poor fine-motor skills and difficulty with planning and organization.(Vigeh*et al,* 2010; Chandramouli*et al*, 2009; Min *et al*, 2009; Bellinger, 2008; Jusko*et al*, 2008; Surkan*et al*, 2007; Tellez-Rojo*et al*, 2006; Gilbert and Weiss, 2006). Children and pregnant women are the most vulnerable to lead poisoning (WHO, 2010). Lead may become transferred to fetus from mother through placenta (Juberg, 2000). Childhood lead

poisoning may cause psychological deficits resulting in the development of aggressive and antisocial behavior in children (Reyes, 2007).Moreover, it has also been reported that fetal exposure to lead is more dangerous than later exposure because it occurs at a time when there is rapid development of the central nervous system (Ernhart, 1992).

There are many sources of lead through which certain individuals as well as communities may become affected (CDC, 2004). Inorganic lead is commonly found in old paints, soil, dust and various consumer products. Organic lead is used in leaded petrol which is extremely dangerous as combustion of organic lead releases lead into the environment and may get absorbed through the skin resulting in toxicity to the central nervous system and brain (WHO, 2010). Although the ban on lead in petrol markedly reduced the environmental risk, still there remain other sources of air-borne lead, which may be inhaled or settle on soil, and on surfaces in the home or work-place (Berwick, 1987). In the home, lead-based paints remain a problem. Water service lines made up of lead are a great source of lead as lead becomes dissolved from the pipelines into the water (Tripathi, 2008). There are many reports on heavy pollution of lead from lead smelters (Hernberg, 2000). Cosmetics including kajal, lipsticks as well as some dietary supplements containing small amount of lead have also been detected (Juberg, 2000). In many countries Ayurvedic medicine is used to treat ailment and several cases of patients with high blood lead level have been reported who were under ayurvedic treatment (Strout*et al,* 2011).

Exposure to lead is responsible for about 0.6% of the global burden of disease including new cases of childhood intellectual disabilities every year (WHO, 2014).Lead in the environment is a threat to public health and has become a matter of concern (Gordon *et al*, 2002). Most of the developing countries and almost all the underdeveloped countries do not conduct any awareness program regarding lead and the adverse effects of lead.In recent years, WHO and UNEP jointly led International Lead Awareness weeks in order to raise awareness among mass population about the widespread use of lead paint. Awareness is the key to prevent lead poisoning, developed at any concentration.

In order to achieve a lead free environment for the future generation, awareness among mass people must be raised. There are various known and hidden sources of lead in the environment. In everyday life people of developing country like Bangladesh is exposed to those sources. Therefore, it is now a crying need to aware the people about all possible sources of lead to prevent the lead burden in future generation.

1.2 AIM

The aim of this study is to find out the sources of lead and its awareness level in Bangladeshi women of child bearing age.

1.3 OBJECTIVES

1. What are the hidden sources of lead in everyday life?

2. Is there any difference on the awareness of lead exposure between the educated women and less-educated women?

3. Is there any difference in lifestyle (food habit, cosmetic use, herbal medicine use etc.) between the educated women and less-educated women?

The need for a comparison group

Women who did not get any education or educated only upto secondary level were the study group of this survey research (group 1). Women who were educated above the secondary level were treated as the comparison group (group 2). Women who participated in this study have been divided intothese two groups in order to evaluate their depth of knowledge about the sources of lead they are exposed to in their daily life.

Justification of research question 1

The first question of this research study will guide us to find out the hidden sources of lead in our everyday life. This will help us to find out who are at high risk of lead exposure leading to lead poisoning.

Justification of research question 2

The purpose of incorporating the second question in this research study is to find out the difference in knowledge about lead and lead toxicity between the two educational groups. In Bangladesh, research reveals a trend of girls' dropout from school starting at a slower pace of about 9-10 percent at Class VI, rising slowly to Class IX and ending with a 'bang' of around 60 to 70 percent at Class X (Ahmed *et al*, 2010). Therefore, this question will justify the level of awareness in both the educated and less-educated womenwith a possibility of comparing the awareness level between the educational groups.

Justification of research question 3

The third question of this research study will help us to perceive the rate of differences in lead exposure between the educational groups considering their lifestyles and food habits, whicharethe major factors directly related to non-occupational lead exposure.

1.4 ORGANIZATION OF THE THESIS

➤ This thesis is organized into five chapters. This **first chapter** focuses on the background of the study, sets the project within context, and highlights the aim and objectives of this study with justification.

➤ **The second chapter** describes the history of lead, uses of lead from ancient to modern times, discovery of lead poisoning and properties of lead. This chapter also focuses on the toxicological effects of leadboth in adults and children, routes of lead exposure as well as primary and hidden sources of lead. The chapter ends with a discussion about lead poisoning in global aspect, status of lead poisoning in Bangladesh and awareness about lead and its poisonous effects.

➤ **The third chapter** explains the research design including the determination of sample size and ethical issues considering this survey research. This chapter also highlights the development of questionnaire, pre-testing and validity testing of the questionnaire and the specific software used for data analysis.

➤ **The fourth chapter** incorporates the analysis of survey data, the result of the analysis and the comparison between educated and less-educated group regarding the factors related to lead and lead poisoning.

➤ **The fifth chapter**outlines a general discussion including the overview of the study, methodological consideration and empirical outcomes of the data. This chapter also focuses on the limitations of this study.

➤ **Sixth and last chapter**narrates the contribution of this study and also comprises an overview of major findings. At the end of this chapter possible recommendations have been discussed thoroughly with an aim of bringing this silent killer to light as well as assisting in policy making regarding the prevention of lead poisoning by raising awareness

CHAPTER 2

THEORETICAL BACKGROUND

2.1 HISTORY OF LEAD

Lead is one of the naturally occurring heavy metals found on the earth's crust (Rusyniak *et al,* 2006) with trace amounts in soil, plants and water (Needleman, 1999). It is considered as one of the seven metals of antiquity that has been playing an important role for the progress of mankind (Casas and Sordo, 2006), though the history of lead discovery is unknown. Lead is extracted from its ore, commonly known as galena containing about 86.6% of lead along with other metals including silver, arsenic, tin and antimony. During ancient times, silver was extracted from the ore of galena as the mining and exploitation of galena was easier and cost effective and lead was extracted as a by-product during the extraction of silver (Wexler, 2014). The oldest lead object, a string of beads worn, was found in the city of Anatolia approximately about 8000 years ago by the archaeologists (Wexler, 2014). The mining of Lead alone had started as early as 6500 BC. The first evidence of lead mining from its ore has been found in Turkey before the Bronze or Iron ages (Needleman, 1999). Among many ancient cultures, the Egyptians, Hebrews, Phoenicians, Greeks and Romans have mined lead (Rusyniak *et al,* 2006). The ancient Greeks started producing lead on a large scale. During the development of Greek civilization, lead production became 300 times higher than that of silver due to increasing use of lead (Wexler, 2014). Lead had become the metal of high economic value and its production and transformation employed a large number of people. During The golden age of the Roman Empire, lead was the most popular metal and widely used due to its easy workability, low melting point, ability to form carbon metal compounds, recyclability, a high degree of corrosion resistance and low cost (Needleman, 1999). During Roman times, the most important lead mines were situated in the Iberian Peninsula, The Balkans, in the territory of ancient Greece and in Asia Minor (Wexler, 2014). The Romans called this metal 'plumbum' and the chemical symbol of this element came from this name which is denoted by 'Pb' (chemical element forum, 2014).

In the ancient world, lead was found to have a variety of applications (Casas and Sordo, 2006) long before knowing the poisonous effects of lead. Romans used lead for making water pipes, aqueducts, tank linings and cooking pots as lead has the property of both malleability and resistance to corrosion (Wexler, 2014). Very old leaded water pipes have been found in Mesopotamia, Cyprus, Persia, Egypt, Greece, Rome and the provinces of Roman Empire (Casas and Sordo, 2006). Uses of lead in ancient architectural practices included ship building (Wexler, 2014), joining masonry, cesspool coverings, roofing, damp-proofing of foundations, parapet walls and buildings. The Greeks used copper-lead-tin alloys during the Archaic, Classical and Hellenistic periods. Lead weights, coins, lead statues were also found from many

5

ancient cultures. During Roman Empire, lead vessels and kitchen wires were widely used (Casas and Sordo, 2006). Colored lead compounds were used in early cosmetics including face powders, lipsticks and mask paints (Wexler, 2014) as well as in glass, glazes, paints and pigments as coloring agents by the ancient scientists (International lead association, 2014). Lead was also used for food preservation. One of the examples of food preservation is the addition of lead to wine to avoid its fermentation (Wexler, 2014). During the fall of The Roman Empire, the production of lead went downward. After the opening of lead and silver mines in central Europe, the production of lead started to increase again. Lead had some important medicinal uses in the Ayurvedic medicine system such as parasitic infections, itching, chronic skin diseases, piles, alopecia, leprosy, mouth and throat diseases, disease of the gum, drowsiness etc. (Needleman, 1991). In recent years lead has been used in various industrial purposes but it has no physiologic use (Rusyniak *et al,* 2006).

2.2 DISCOVERY OF LEAD POISONING

Generally, lead poisoning is termed as 'plumbism' or 'saturism' (Krishnaswamy and kumar, 1998). The earliest written documents about lead poisoning have been found in Egypt (Hernberg, 2006). Lead poisoning was first recognized by The Great Greek physician Hippocrates around 500 BC (Wedeen, 2011). Hippocrates described the condition of a lead miner attacked with severe colic (Emsley, 2005) without knowing the etiology (Hernberg, 2006). The Ancient Greek poet and physician Nikander of Colophon is attributed for giving the first description of lead poisoning as a disease with a modern understanding in around 200 BC. Nikander mentioned lead colic (abdominal pain), peripheral neuropathy (wrist drop), encephalitis (mental confusion) and anemia (pallor) as the major symptoms of lead poisoning in his poem (Wedeen, 2011). Nikander also categorized hallucinations and paralysis as the symptoms of lead poisoning and recommended strong laxative treatments to cure the disease (Emsley, 2005). At that time, the main victims of lead poisoning were the lead workers and wine drinkers. The Romans also suffered from lead poisoning causing infertility and psychosis among the Roman aristocracy. The upper class Romans used to have lead-sweetened wine as a part of their higher standard of living (Needleman, 2003). In 1767, Sir George Baker discovered the etiology of lead poisoning with the help of Benjamin Franklin who reported to Baker that, people from England suffering from abdominal pain without diarrhea had West Indian rum contaminated with lead (Wedeen, 2011). The modern clinical description of lead poisoning was given by the French physician Louis Tanquerel des Planches in his famous 'Traite Â des maladies de

Plombou' based on 1200 cases on occupational lead poisoning in 1839 (Hernberg, 2000; Emsley, 2005).

2.3 PROPERTIES OF LEAD

In terms of chemistry, Lead is a low melting, bluish-white metal which turns into a dull grayish colored metal when it becomes exposed to air. Metallic lead is the heaviest member of the carbon group though lead looks and behaves very differently from carbon (chemical element forum, 2014). Lead has a valence of +2 and +4 with an atomic number of 82 and an atomic mass of 207.2. Lead is very soft, highly malleable and ductile in nature. Lead is resistant to corrosion and a poor conductor of electricity. Metallic lead is hard to dissolve in water but easily dissolve in nitric acid and concentrated sulfuric acid (Nordberg, 2005). Lead has a density of 11.34 g/cm^3 and a low melting point of 327.46°C or 621.43°F (WHO, 2010).

The natural abundance of this metal in the Earth's crust has estimated between 13 ppm and 20 ppm(NIEHS, 2014).The four stable isotopes of naturally occurring lead includes: ^{204}Pb (1.4%), ^{206}Pb (25.2%), ^{207}Pb (21.7%) and ^{208}Pb (51.7%). The ratio of natural abundance of these isotopes of lead varies with the geological sources of lead. Among the four isotopes of lead only one isotope, ^{204}Pb is non-radiogenic and the rest three isotopes are radiogenic (Nordberg, 2005). These radiogenic isotopes are the end-products of each of the three series of radioactive decay of naturally occurring radioactive elements: end product of the uranium series is ^{206}Pb, end product of the actinium series is ^{207}Pb and the end product of the thorium series is ^{208}Pb (Lide, 2003., Nordberg, 2005). Lead comprises approximately 0.002% of the earth's crust (Rusyniak *et al*, 2006).

2.4 PHARMACOKINETICS OF LEAD

2.4.1 Absorption

Approximately about 10% of the ingested lead gets absorbed in adults however the absorption rate of ingested lead is higher in children. After inhalation, lead gets deposited into the upper and lower part of the respiratory tract. After deposition a certain amount of lead gets transferred through the walls of lungs into the systemic circulation (Nordberg *et al,* 2007). Organic lead can easily be absorbed through skin than inorganic lead because of their lipophilic property (Fenton, 2001). Absorption of lead from the gastrointestinal tract is greatly influenced by nutritional

factors such as intake of calcium. According to a study, calcium and lead both compete for similar binding sites on intestinal mucosal proteins. It has been found out that, low level of calcium intake increases the absorption of lead in rats (Mahaffey *et al*, 1973). According to another study, administration of vitamin D increases lead absorption. Some dietary constituents such as ascorbic acid, sulfhydryl group amino acid etc. may also increase the absorption of lead (Mcgrath, 2014).

2.4.2 Accumulation

After entering into the bloodstream, about 95% of lead binds to erythrocyte membrane and hemoglobin and remaining 5 % remains in the plasma (Gordon *et al.*, 2002). Lead has a biological half-life of about 25-35 days in the blood (Mcgrath, 2014; Gordon *et al*, 2002). There are three compartments for accumulating lead in the body: circulating blood, relatively labile soft tissue and the hard tissue (Mcgrath, 2014). After being absorbed lead gets transferred into the soft tissues of lungs, liver and kidneys and then gets stored into the hard tissues of teeth, bone and hair. Generally, lead is stored in the form of lead triphosphate. Bone is the main storage site for lead triphosphate (Fenton, 2001). About 90-95% of the absorbed lead becomes stored in the skeleton and dentine with a biological half-life of 20-30 years (Gordon *et al*, 2002). Rest of the lead is stored in the soft tissue and has a biological half-life of 100-200 days (Krishnoswamy and Kumar, 1998).

2.4.3 Excretion

The major route of ingested lead elimination is fecal excretion (Mcgrath, 2014). About 90% of the ingested lead gets excreted in the stool. Most of the inhaled lead follows the pathway of renal excretion (Krishnoswamy and kumar, 1998). Excretion of lead through kidney occurs in two ways: glomerular filtration and transtubular flow (Goyer and Mahaffey, 1972). Elimination of lead from the body may also occur through sweat and breast milk (Krishnoswamy and kumar, 1998). It is evident that, a small amount of lead is also excreted in the bile (klaassen and shoeman, 1974).
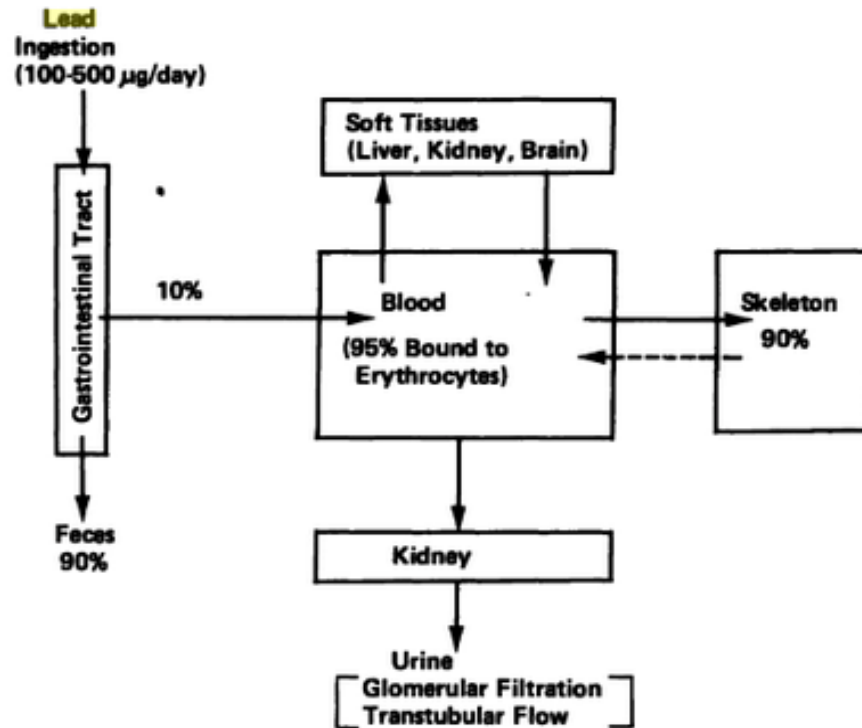
Fig 2.1: Absorption, Distribution and Excretion of Lead (Mcgrath, 2014)

2.5 TOXICOLOGY OF LEAD

2.5.1 Effects of lead poisoning

a) Effects on Hematopoietic system:

Inhibition of heme biosynthesis is considered as an important toxicological effect of lead. Many stages of the pathway of heam synthesis can be affected by lead. The whole mechanism of the inhibition of heam biosynthesis is associated with an enzyme called ALAD (d-Amino Levulinic Acid Dehydratase). This enzyme is responsible for the catalysis of prophobilinogen formation, (a stage of haemoglobin biosynthesis) from two molecules, 5-amino-laevulinic acid (ALA) and ferrochelatase. Inhibition of ALAD enzyme inhibits the formation of prophobilinogen and so, further synthesis of heamoglobin is also inhibited. Inhibition of ALAD may also increase the amount of circulating amino levulinic acid. Amino levulinic acid (ALA) is a weak gamma-amino butyric acid (GABA) agonist. Increased amount of circulating ALA may cause some behavioral disorders. Additionally, ferrochelatese is responsible for catalyzing the ferrous iron incorporation into the portoporphyrin IX. When this enzyme is inhibited by lead, zinc is substituted for iron and

zinc protoporphyrin (ZPP) is produced and remains in the erythrocytes for life-time resulting in reduced heaoglobin production and inhibition of cytochrome P450 dependent phase-I metabolism (Flora, 2009; Gordon *et al*, 2002; Juberg, 2000).

glycine + succinyl coenzyme A

5-aminolaevulinic acid synthase

5-aminolaevulinic acid *(ALA)*

<u>*ALA dehydratase (ALAD)*</u>

porphobilinogen

porphobilinogen deaminase
(defect of acute intermittent porphyria)

uroporphyrinogen

uroporphyrinogen decarboxylase

coproporphyrinogen

<u>*coproporphyrinogen oxidase*</u>

protoporphyrinogen

protoporphyrin oxidase

protoporphyrin IX + iron*

<u>*ferrochelatase*</u>

haem

negative feedback

enzymes depressed by lead are underlined
*in lead poisoning free protoporphyrin IX chelates with zinc to form zinc protoporphyrin

Fig 2.2: Effect of Lead Poisoning on Hematopoietic System (Gordon *et al,* 2002).

It has also been reported that lead may cause bone marrow depression as well as shortening the life span of erythrocytes resulting in anemia (Hernberg, 2000). Hypochromic and microcytic anemia may occur as a result of the inhibition of enzyme pyrimidine 5′-nucleotidase (krishnoswamy and kumar, 1998; Hernberg, 2000).

b) Effects on renal system:

Chronic and acute lead poisoning is associated with several adverse effects on the renal system which may end up with nephropathy (Weeden, 1982) characterized by disturbed functions of the tubular structures (Juberg, 2000). Kidney damage due to high lead level was common in industrial workers (Gordon *et al*, 2002; Radošević*etal*, 1961). Fanconi syndrome (Proximal renal tubule dysfunction) in the presence of hyperphosphataemia and rickets was first identified in acute lead poisoning. It was manifested by glycosuria, aminoaciduria and hyperphosphturia (Flora, 2009). Interstitial nephritis, vascular changes and chronic renal failure have been seen in chronic lead poisoning (Gordon *et al,* 2002). Long term lead exposure and repeated lead intoxication may result in renal lesions (Radošević*etal*, 1961). Lead nephropathy makes the excretion of uric acid slow resulting in high occurrence of gout (Needleman, 2004). Alterations in cell adhesion molecules in renal proximal tubules can be the possible mechanism for lead nephrotoxicity (Acien*et al,* 2009).

c) Effects on the nervous system:

Neurotoxicity resulting from lead exposure in adults is known from the Roman times (Grandjean and Landrigan, 2006). It has been reported that, workers exposed to low to moderate level of lead suffered from slower motor nerve conduction along with difficulties in remembering incidental information. Wrist drop (weakness of wrist and fingers) due to paralysis of distal, upper extensor muscles (Flora, 2009) may occur at BLL 60 µg/dL or greater (Juberg, 2000; Goyer, 1996). Intracellular action of calcium in secondary messenger signaling may become impaired by lead resulting in the loss of integrity of the junctions between the endothelial cells of the brain. This may allow subsequent passage of plasma into the brain leading to cerebral oedema. Lead also acts as a direct toxicant on the process of neurotransmission by interfering in the function of calcium (Gordon *et al,* 2002). Recent studies show that, exposure to lead might be a risk factor for neurodegenerative disease in adulthood (Bellinger, 2011).In case of young children, low level exposure to lead is associated with impaired function of the central nervous system though the common presentation in children is severe encephalopathy (Gordon *et al,* 2002) manifested by ataxia, memory loss along with coma and death at highest levels. Usually, encephalopathy occurs in children when the blood lead level is greater than 80µg/dL. Children with slightly elevated BLL (i.e. > 10-15 µg/dL may develop neurological or behavioral impairments (Juberg, 2000).

d) Effects on reproductive system:

It has been reported that exposure to lead can affect the reproductive system in both adult males and females. Occupational exposure to lead may have adverse effect on semen quality (Hu *et al,* 1992) and sperm production in men. On the other hand, severe lead toxicity in women reported to cause sterility, miscarriage, stillbirth, neonatal morbidity and mortality (Juberg, 2000).

e) Effects on hard tissues

Once lead enters into the body, it is accumulated over lifetime and the body releases it very slowly. Most of the lead retained in the human body is ultimately deposited in bones and teeth of human resulting in approximately 94% of total lead body burden in adults and approximately 73% in children. Lead accumulation in teeth is associated with dental health factors including the prevalence of caries, dental plaque, pH of saliva, levels of Salivalis lactobacilli (SL) and Mutans streptococci (MS), degree of dental abrasion and tooth color (F. Gil *et al,* 1996). Increased odds of tooth loss have been reported on long-term cumulative lead exposure in adults (Arora, 2009). In children, lead exposure has been reported to cause dental carries (Bellinger, 2011).

f) Other effects:

Several studies have concluded that blood lead level is positively related to blood pressure (Bellinger, 2011). Acute lead poisoning may cause hypertension along with renal failure. Impairment of renal function and development of hypertension due to lead exposure have been reported both experimentally and epidemiologically (Needleman, 2004). According to International Agency for Research on Cancer (IARC), lead and inorganic lead compounds may have carcinogenic effect on human (Juberg, 2000) though there has been no adequate data on the carcinogenic effect of lead. In some recent studies it has been found out that the rate of cancer has been increased among lead trade workers such as smelters, painters, fender repairmen etc. (Needleman, 2004).

2.5.2 Childhood lead poisoning

The first description of epidemic lead poisoning in children was reported in Australia about 100 years ago (Grandjean and Landrigan, 2006). It has been traced that the cause of the epidemic lead poisoning was ingestion of lead-based paint by children. Further many reports have been counted on childhood lead poisoning in USA and Europe. Childhood lead poisoning seemed to get its recognition as a common childhood disease in the mid of 1920s (Rabin, 1989). At that

time, lead poisoning was considered as an severe illness from which a child may recover or die. Many cases of lead poisoning in children remained undiagnosed by the doctors as the signs and symptoms of this disease were not properly identified at very lower levels of lead. Even after the identification of specific signs and symptoms of lead poisoning it was difficult to diagnose the disease as some of the symptoms are common to childhood diseases such as vomiting, abdominal pain and constipation. There was also the lack of proper diagnostic tools for the diagnosis of lead poisoning. For this reason, Blood lead level testing did not become available worldwide before 1940. Long term effects of acute childhood lead poisoning were first noticed in 1940 when some survivors of acute lead poisoning suffered from severe learning and behavioral problems. During 1970, lead poisoning spread out worldwide and children were reported with high blood lead level along with subclinical neurotoxicity, behavioral deficits and mental retardation (Burnham, 1999).

Children are more vulnerable to lead poisoning than adults for the following reasons: a) Children possess hand-to-mouth activity commonly known as pica. Because of this activity they try to keep into their mouth whatever they find nearby. This may result in increased risk of lead poisoning through the pathway of ingestion; b) the rate of intestinal lead absorption and retention is higher in children than adults; c) Lead affects the developing CNS of children more severely than the mature CNS of adults (Flora, 2009; Needleman, 2004). Lead intake is higher per unit body weight in children (WHO, 2010). No safe blood lead level has been detected for children (CDC, 2015). Lead retards synaptogenesis and reduces cortical connectivity. These may result in behavioral changes in children. Lead also causes growth retardation in children. Several cases of lead exposure associated with cognitive deficit in children have been reported from 1940 to 1970. Psychological deficits related to childhood lead exposure are strongly associated with aggressive and criminal behavior. The likelihood of violent behavior of children may increase the rate of childhood crimes and may significantly affect national crime trends (Reyes, 2007). Lead is also known to reduce IQ level resulting in learning disabilities, reduced attention, hyperactivity and behavioral problem. According to recent data, neurotoxic effects of lead may occur at lower levels of lead exposure than previously predicted (Jarup, 2003). Several experiments have been conducted on animals and the reports indicate that lead inhibits astrocyte specific protein which is important for the development of the brain (Krishnoswamy and Kumar, 1998). Elevated blood lead level has also been reported to have a positive relationship with childhood anemia (Jain, 2005).

2.5.3 Lead poisoning in pregnant women

Lead has been one of the most important environmental toxicant which is capable of altering the human reproduction (Jarrell, 2006). Vulnerability of pregnant women to the adverse effects lead is very high. As earlier mentioned, lead poisoning in pregnant women may cause miscarriage, stillbirth, premature birth, low birth weight and some minor malformations (WHO, 2010). During pregnancy, stored lead mobilizes from the bone and enters into the systemic circulation resulting in an elevated blood lead level. After the deposition of lead in placenta, a large portion of the mobilized lead crosses the blood placental barrier and enters into the fetus. Developing fetuses are more susceptible to lead as absorption of lead occurs more freely in fetuses compared to adults. Developmental toxicity or uncontrolled fetal hormone environment may be affected due to the teratogenic effect of lead. Even low level prenatal exposure to lead has shown potential toxic effects in fetus (Jarrell, 2006) such as neurobehavioral disorders (ATSDR, 2010). Some effects of lead on fetus neurodevelopment may become permanent and remain unchanged all through the childhood (Flora, 2009). During lactation maternal bone lead level is an important factor. The major sources of lead into breast milk are the maternal bone and diet. When stored lead mobilizes from bone to blood, it is subsequently excreted into breast milk. The higher the maternal blood lead level, the greater the entry of lead into breast milk resulting in increased blood lead level in children (CDC, 2006). High blood lead level is associated with abortion. It has been reported that, approximately 10.35 µg/dL blood lead level increases the risk of spontaneous abortion. High blood lead level during pregnancy may also cause elevated blood pressure. An increased blood pressure is always a risk factor for both the mother and the fetus (Jarrell, 2006). Smoking and low level of calcium intake can also cause increased blood and bone lead level in women during pregnancy (Borja-Aburto, 1999). Increased bone resorption is associated with increased bone lead mobilization in pregnant women. Though both tibia and patella lead is positively related to blood lead level, patella lead has shown more stronger relationship with increased blood lead level (Téllez-Rojo, 2004). Occupationally exposed pregnant women have been reported with higher blood lead level than non-occupationally exposed pregnant women(Jarrell, 2006).

2.6 ROUTES OF HUMAN LEAD EXPOSURE

Lead is widely distributed in the environment (Mcgrath, 2014) with substantial amounts in air, water and surface soil. The burden of lead has greatly increased due to some human activities such as mining, smelting, manufacturing of lead, battery manufacturing and recovery, lead alloy production etc. (Flora, 2009). Human exposure to lead has consequently increased with the increasing burden of lead (Tong *et al,* 2000). The major three pathways of human lead exposure are ingestion, inhalation and dermal contact. The main portals for entry of lead into human body are the alimentary tract and respiratory tract (Krishnoswamy and Kumar, 1998).

2.6.1 Ingestion

Ingestion is the greatest pathway of lead exposure in general population (Mcgrath, 2014). Ingestion of lead via food and water contributes significantly to increase the blood lead level (Juberg, 2000). Atmospheric lead may become deposited into soil, water and thus enters into the food chain (Tong *et al,* 2000). It is estimated that an individual ingests approximately 150-200 µg of lead per day through the oral route and 5-10% from the ingested lead gets absorbed. Ingestion of lead is considered as one of the most important causes of childhood lead poisoning as most children eat things other than foods such as contaminated soil, dirt, paint chips etc. because of their hand-to-mouth activity (Abdullahi, 2013).

2.6.2 Inhalation

Respiratory tract is the main route of lead absorption in adults (Gordon *et al,* 2002) though the extent of lead exposure through inhalation is relatively low. Inhalation is the salient pathway to occupational lead exposure (Juberg, 2000). Workers who are involved in various works related to lead such as lead mining and smelting, battery manufacturing, motor vehicle assebl etc., remains in the closest contact with lead (Tong *et al,* 2000). Long before it was estimated that an individual inhales air containing 3 µg of lead per day assuming no occupational lead exposure (Oskarsson, 1989). According to more updated data, about 10-20 µg of lead is inhaled daily through the respiratory tract by an individual. About 35-50% lead gets absorbed from the inhaled lead and rest of the inhaled lead gets excreted into urine (Krishnoswamy and Kumar, 1998).

2.6.3 Skin

Lead exposure through skin occurs occasionally. Absorption of lead through skin may occur in many occupations including manufacturing industries, pharmaceutical industries or residential settings (Abdullahi, 2013). Some organic lead compounds such as tetraethyl lead can easily be absorbed through the skin (Krishnoswamy and Kumar, 1998) because of their lipophilic property (Mcgrath, 2014). Lead exposure through skin may also occur due to the use of lead containing cosmetics and hair dyes. These lead containing cosmetics or hair dyes may enter into the dermal microcirculation through epidermal cells and sweat glands or through hair follicles. Once lead reaches the dermal microcirculation, it enters into the bloodstream. Lead absorption through skin depends on the amount of skin surface, duration of contact and the characteristics of lead compound, whether it is hydrophilic or lipophilic (Castellino*etal*, 1994).

2.7 SOURCES OF LEAD

2.7.1 Primary sources

- ➢ Leaded gasoline or petrol:
  In the past, the use of lead in gasoline for road vehicles was the major source of lead exposure for most people. Tetraethyl lead was used in petrol as an antiknock additive in order to eliminate engine knock. When leaded petrol burns, the tetraethyl lead is converted into inorganic lead compounds and they are emitted from the vehicles and exhaust as dust particles. The heavier dust particles are settled nearby and the lighter dust particles are carried away on the air (Emsley, 2005). Most of the lead that had been deposited from the heavier dust particles still remain into the soil as lead cannot be destroyed and act as a source of lead exposure.

- ➢ Lead-based paint:
  Lead-based paint is one of the most hazardous sources of lead. Lead paint can be present in many places like doors, windows, stairs, walls or any other painted surfaces. Deterioration of this paint such as peeling, chipping, chalking, or cracking cause elevated levels of house dust contaminated with lead. Dust originated from lead-based paint may gather on surfaces and objects which can become an important source of lead when people touch the surfaces and objects or children put the contaminated objects

into their mouth (CDC, 2013). Lead-based paint is one of the most important sources of childhood lead exposure (WHO, 2010).

- ➤ Leaded water pipe:

  Lead is commonly used in household plumbing materials and water service lines and enters tap water through the corrosion of plumbing materials (EPA, 2014). Leaching of lead compounds from PVC pipes may result in high lead concentrations in drinking water (WHO, 201). High lead levels in tap water may result in adverse health effects if lead in the water enters into the bloodstream and the blood lead level becomes elevated (CDC, 2013). Lead may also enter into river water from industrial waste materials.

- ➤ Hobbies and occupational lead exposure:

  Many hobbies are related to indirect method of human lead exposure, such as gardening, pet handling, glass painting etc. Gardening is directly related to soil, pesticides and fertilizers which may contain lead (Hettiarachchi, 2014). Pet, such as cat, dog, rabbit, which are exposed outside may carry leaded dust. Therefore, handing pet might be a source of lead exposure. Occupational exposure is higher in those workers who come in closest contact with lead in their working places (Tong *et al*, 2000). Occupational lead exposure usually occurs due to the inhalation of lead containing dust and fumes during mining, smelting and refining operations or during battery manufacturing, soldering, motor vehicle assembly, home renovation etc (Juberg, 2000; Tong *et al*, 2000). Both acute and chronic occupational lead exposures have been reported to cause renal dysfunction and hypertension (Loghman-Adham, 1997).

2.7.2 Potential sources

- ➤ Dietary sources:

  Foods can be one of the most important sources of human lead exposure. Food plants may become poisoned with lead if grown in lead contaminated soil. Application of lead containing fertilizers and pesticides can also contaminate food plants with lead. In the canning process soldering is the source of lead contamination (Nasser, 2014). So, another dietary source of lead is lead-soldered can. Lead-soldered food and beverage cans considerably increase the lead content of food and beverages. Lead containing products that are used in the manufacturing, distribution or storage of acidic foods and drinks significantly increase the lead levels. Lead can also migrate from ceramic or

pottery dinnerware and contaminate foods (WHO, 2010). Tea has been found to be contaminated with lead as lead becomes accumulated into tea leaves taken up from the soil (Solidum, 2014; Zazouliet al, 2010). High lead levels have also been identified in some spices. Among the spices, the most commonly contaminated spice is turmeric (ADHS, 2012; FDA, 2013). Some coloring agents have also been reported to contain lead pigments (CDC, 2013).

➢ Cosmetics:

According to recent reports, the presence of lead in lipsticks has been recorded and suggested that potential amount of lead exposure under the conditions of ordinary use is harmful. Lipsticks can be contaminated with lead from lead solder or leaded paints in production or from lead contaminated dust (Hepp, 2009). A popular eye cosmetic kajal (also known as surma) has been found to contain potential amount of lead harmful for human body. Kajal is not only used as a cosmetic by women but also used in children to ward off evil (Goswami, 2012). Continuous application of lipsticks and kajal by women also affect the fetus or newborn child in future. Another potential source of lead is sindoor which is applied in the parting of the hair by the married Hindu and some Sikh women as a symbol of their marriage (CDC, 2013).

➢ Traditional medicine:

Many cases have been demonstrated that traditional medicines are associated with elevated blood lead level (Pierce et al, 2012; CDC, 2012). Lead gets its way into traditional medicines during grinding, coloring or from the packages (CDC, 2013). According to the estimation by WHO, about 70% to 80% population in developed countries and about 80% Asian population use some form of alternative medicine including Ayurvedic, homeopathic, naturopathic, traditional oriental and Native American Indian medicine. Continuous use of traditional medicines has a possibility to cause severe health problems related to lead poisoning in future.

➢ Tobacco (Cigarette and betel quid):

All forms of tobacco use (whether smoked or smokeless) imposes a large public health burden globally (Barkat, 2012). Among them cigarette smoking and betel leaf are the most common potential sources of lead. Cigarette smoking contributes to increase the burden of lead in both human and environment spontaneously. Approximately about 6%

lead from a cigarette enters into the lungs of the smoker though the percentage may vary depending on the depth of inhalation and smoking intensity (Taylor, 2010). Many studies have demonstrated that consumptions of tobacco smoking is related to elevated blood lead level in general population (Rhainds, 1997). The habit of chewing Betel quid (commonly known as 'paan' in Bangladesh) is one of the most common social habits in East and South Asian countries which has been reported to increase blood lead level. To improve the taste tobacco leaves (also called shadapata) or zarda (flavored tobacco) are often added to the betel quid (Al-Rmalli*et al*, 2011) which may result in elevated blood lead level.

2.8 GLOBAL SCENARIO OF LEAD POISONING IN RECENT YEARS

After the phasing out of leaded petrol and banning of lead based paints and pigments, significant amount of decline has been noticed in blood lead levels worldwide. However, lead smelting, mining and recycling operations and other human activities are still continuously contributing to the global lead burden which is thought to be accountable for about 0.6% disease occurring worldwide. Despite of knowing the toxic effects of lead poisoning, lead is still added to paints, pigments, traditional medicines, cosmetics and other consumer products (WHO, 2010). As earlier mentioned, childhood lead exposure has been reported to contribute to increase intellectual disabilities in children with about 600,000 new cases every year (WHO, 2015). International lead poisoning prevention week has been carried out worldwide with the support of EPA, CDC, WHO, UNEP and the International Pediatrics Association to raise awareness about lead poisoning and to strengthen actions to eliminate the use of lead (WHO, 2013). Still some countries have not yet implemented assessment and exposure prevention programs even though they have been facing health problems related to lead poisoning. Contribution of lead poisoning to the global burden of disease and its negative effects on the global economy are still being undervalued (WHO, 2010).

2.9 LEAD POISONING IN BANGLADESH

Several studies have been conducted on lead poisoning in Bangladesh. Almost all the results have shown that blood lead level is higher than CDC's recommended level (5µg/dl), especially, in children and pregnant women. Recently, in a study, conducted with the collaboration between icddr,b and Stanford University, USA, it has been revealed that, women with high blood lead

levels are more likely to have canned foods and to use herbicides and pesticides. This study also concludes that the food supply of Bangladesh is contaminated with lead. In recent years, Environment and Social Development Organization (ESDO) has taken initiative to arrange programs on International lead poisoning prevention week of action in Bangladesh in collaboration with WHO, GAELP, UNEP and IPEN. A complete list of research publications conducted in Bangladesh on levels, sources and harmful effects of lead is presented in the appendix.

CHAPTER 3

RESEARCH DESIGN, PARTICIPANT RECRUITMENT AND SURVEY DATA

3.1 RESEARCH DESIGN

This study was designed to develop a representative picture about the awareness of lead among the highly educated and lower-educated women through the questionnaire. The topic of this questionnaire survey research was selected by reviewing many research papers from renowned journals in various sites including Pubmed, Elsevier, JAMA Network, Oxford Journals, Cambridge Journals,Springer etc. The reason behind selecting this topic was to find out the level of awareness about lead in women at child bearing age and to establish a comparison between educated and less-educated people regarding their knowledge about lead, sources of lead and poisonous effects of lead. There have been thousands of research papers published on lead (heavy metal) toxicity, blood lead levels, sources of lead exposure, harmful effects of lead, childhood lead poisoning etc.; however,no work has been done on the awareness of people on lead and its poisonous effects in developing and even in developed countries.

The participants for this survey were selected randomly from Dhaka city (Mohammadpur, Mohakhali, Gulshan, Adabor slumareas). Initially, the researcher explained the purpose and the importance of the study to the participants. Then theparticipantswho gave consent willingly were recruited for the study. The participants were chosen between the ages from 18 to 35 years, generally the child bearing age for women. Altogether114 participants were recruited where, 52 participants were from educated background (educated above secondary level and onwards) and rest 62 participants were from less-educated background (educated upto secondary level or did not get any education at all). This has been done for the purpose of comparing the knowledge about lead among educated and less-educated participants.

Initially, we approached to those women who fulfilled the criteria of this study and all of them gave their consent to contribute to this research study. The survey of the educated participants was done by self-administeredquestionnaire. On the other hand, the survey of the participants with less-educated background was done with the help of the researcher by means of face to face interview.
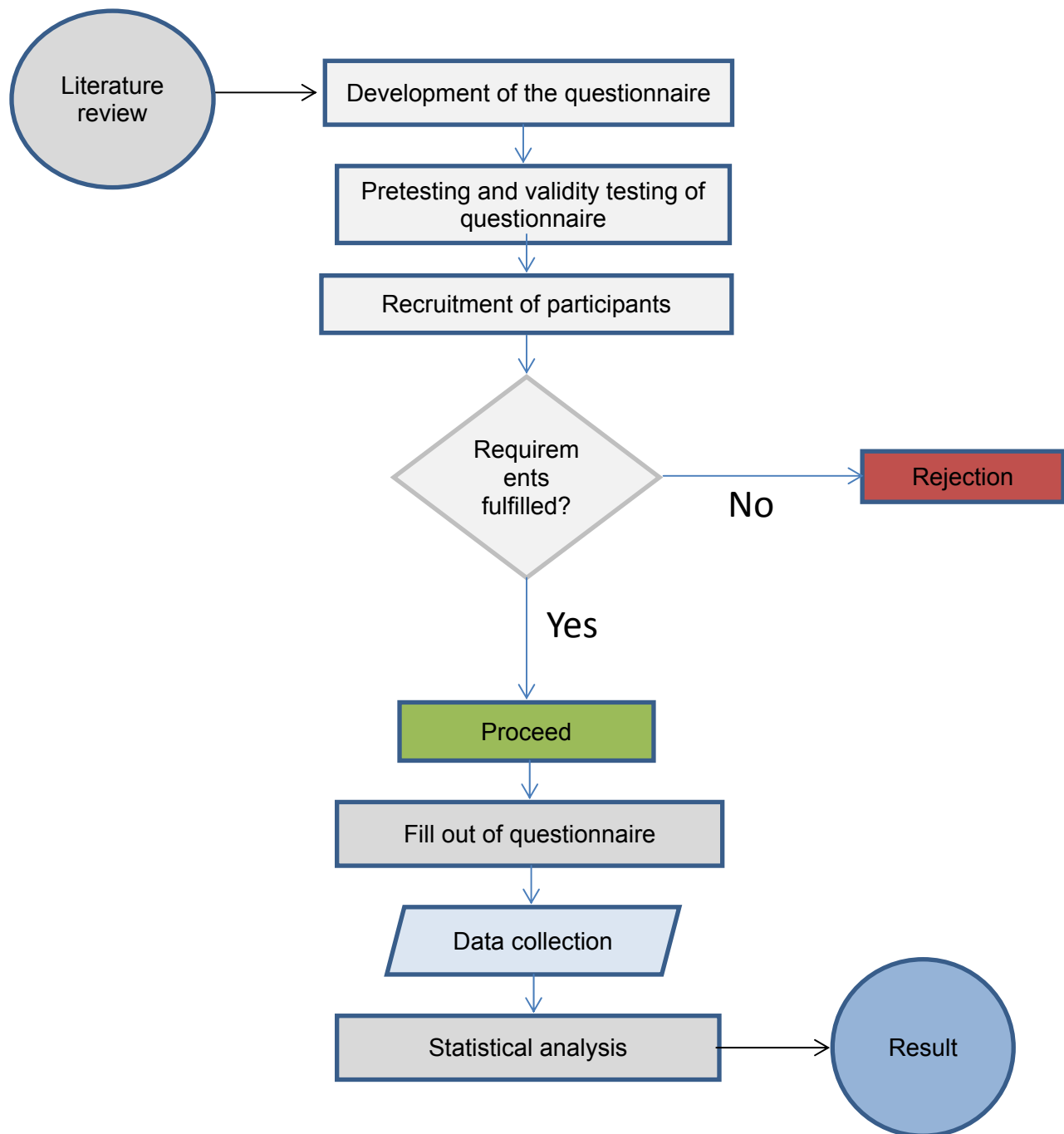
Figure 3.1: Flow Chart of Research Design

3.2 DETERMINATION OF SAMPLE SIZE

This research study was conducted with a sample size of one hundred and fourteen.It is evident that the appropriate sample size can reflect the true picture of the population. However, since there was no data for the sample size regarding the awareness study of lead, this study was considered as a pilot study. According to Johanson and Brooks (2010), Isaac and Michael (1995), Hill (1998), a pilot study participation of 10-30 subjects should be a reasonable number. They have suggested that "samples with N's between 10 and 30 have many practical advantages", including simplicity, easy calculation, and the ability to test hypotheses. In the medical field, Julious (2005) reiterated that "a minimum of 12 subjects per group be considered for pilot studies". Therefore, it can be said that, a total number of participants of 114 is satisfactory for this pilot study.

3.3 ETHICAL PERMISSION

This research study involves human participation and data collection. Therefore, in this study, ethical permission was a matter of concern to ensure the rights and safety of the participants as well as the researcher. Before starting the survey, an application for ethical approval considering the questionnaire and the interviews was sought from the Research and Ethics committee, Department of Pharmacy, BRAC University. After evaluating the material and the nature of the study, ethical approval was granted.

3.4 DEVELOPMENT OF THE QUESTIONNAIRE

The questionnaire was prepared in such a way that it would be effective enough to extract data from the participants regarding the sources of lead exposure as well as awareness of lead among the participants. The questionnaire would also provide information if the participants were alreadyfamiliar with lead and lead poisoning. The validity and compatibility of the questionnaire were ensured before starting the survey. Before starting the final survey, consultation was done with a statistician regarding the questionnaire. The questionnaire included questions about the participant's age, educational level, hobbies related to lead exposure, use of lead paint in the house, use of pesticides or herbicides,use of herbal medicine, use of cosmetics that may contain significant amount of lead, food habit of the participant, knowledge and consciousness about lead and its toxic effects. The questionnaire was easily understandable and the questions were simple and relevant to the topic. The questionnaire also

contained a suggestion box allowing the participants to suggest their ideas that may help to raise awareness and to prevent lead poisoning

3.4.1 Questionnaire: pre-testing, validity testing and finalizing

A reliable, understandable development of questionnaire, in a word, pre-testing of questionnaire is required in order to filling out the answer of the question easily. Moreover, to avoid analytical error validity testing of questionnaire is important. The simpler the questionnaire will be, the easier will be the questions for the participant to answer. In this study, pre-testing of the questionnaire was done by ten participants (Five from educated group and five from less-educated group). The questions found hard to understand to the participantswere marked and corrected properly according to the expert's comments.Validity testing of the questionnaire was also done to ensure that the contents of the questionnaire are comprehensive enough to collect all information and relevant enough to achieve the goals of the study.Before starting the survey, consultation wasdone with a statistician and the questionnaire was finalized accordingly.

3.4.2 Data collection and completion of the survey

Data were collected only from the participants those who fulfilled the requirements of this study, such as gender, age and education.Participants from the educated group filled out the questionnaire individually; in case of collecting data from the less-educated group, a face to face interview was conducted by the researcher.The survey was completed with randomly selected one hundred and fourteen participants.

3.5 SPECIFIC STATISTICAL METHODS USED FOR DATA ANALYSIS

Thestatistical analysis of the survey data was done by software called SPSS (Statistical Package for Social Sciences). SPSS version 20.0 was used in this study for analyzing the data. At first, all data were entered into the SPSS data sheet and then data cleaning was performed. The voids in the questionnaire were filled with the mean value of the answers.

The statistical package was used to calculate descriptive statistics. For continuous metric variables, mean and standard deviation were used as descriptive measures, while the independent t-test was used for comparisons when the data could be shown to be normally

distributed (e.g. participant age). The Pearson's Chi-square (χ^2) test and likelihood Ratio Chi-square test was used with nominal data (e.g. counts/frequencies).

CHAPTER 4

RESULTS

4.1 RESULTS

This study has been conducted with the participation of 114 women,having both educated and less-educated background. The minimum age of the participants was 18 and the maximum age was 35 years. The average age of the participants was 22 (Figure 4.1). Within group 1 (Less-educated group), the minimum age was 18 and the maximum age was 35. While within group 2 (Educated group), the minimum age was also 18 and the maximum age was 33.
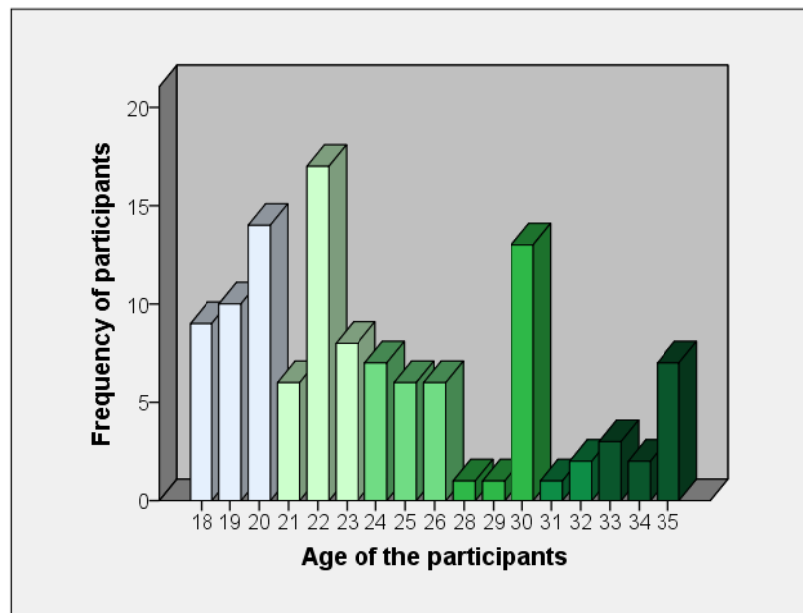
Figure 4.1: Frequency of ages of the participants

Among 114 participants, 105 participants were Muslim. Only 7 participants were Hindu and 2 participants were Christian. There wasno participant from the religious background of Buddhism or other religions (Figure 4.2). In group 1, 91.9% participants were Muslim, 4.8% were Hindu and 3.2% were Christian. Separately, in group 2, 92.3% participants were Muslim and 7.7% were Hindu.
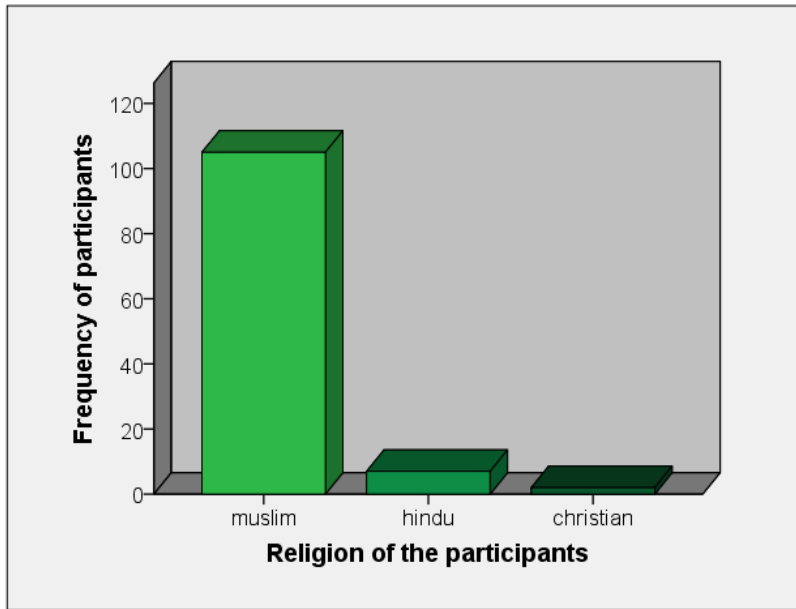
Figure 4.2: Frequency Distribution of Religions of the Participants

Participants were divided into two groups on the basis of their educational level. Women who did not obtainany education or who were educated only upto secondary level were placed into the less-educated group (group 1, n=62). This less-educated group was the study group of this research. Moreover, women, who received education above secondary and onwards, were placed into the educated group (group 2; n=52). This group was the comparison group of this study. From group 1, 18 participants were not at all educated, 38 were educated upto primary and 6 were educated upto secondary level. In contrary, 37 participants were educated upto higher secondary, 11 were graduates and 4 participants were postgraduates from group 2 (Figure 4.3).
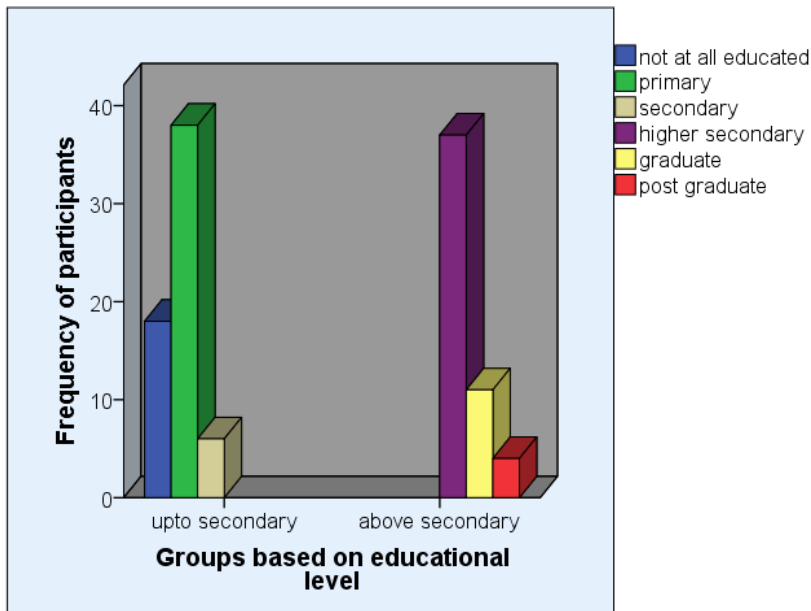
Figure 4.3: Frequency of Participants in Groups Based on Educational Qualification

Highly significant differences (p<0.0001) have been foundin occupations between the groups. Participants from the less-educated group were housemaids, parlour workers, garment workers and housewives. On the other hand, participants from the educated group were students, teachers or wereemployed in publicand private services (Figure 4.4). Maximum participants from group 1 were housemaids (36.1%) and housewives (29.5%) and from group 2 were students (79.1%).
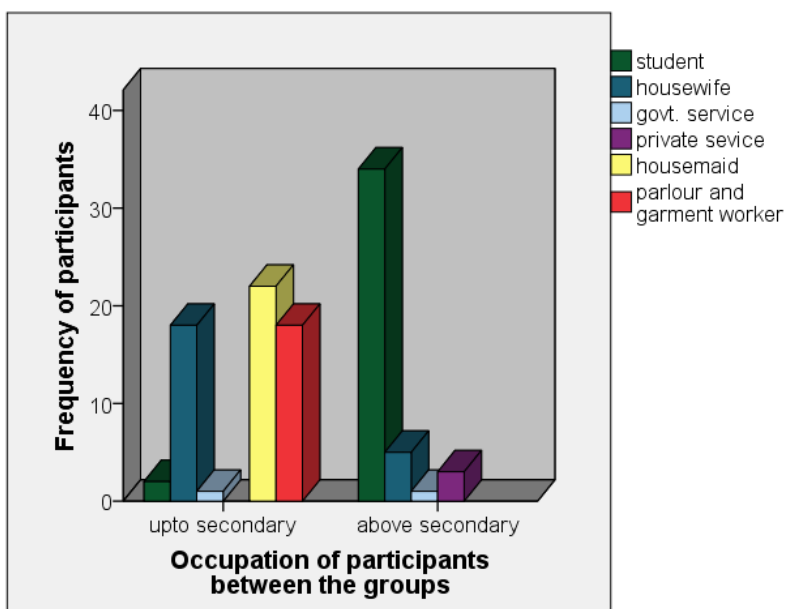
Figure 4.4: Frequency of Participants of Different Occupations betweentheGroups

Due to differences in the occupations, there have been highly significant differences in total income of the participants between the groups (p<0.0001). The range of total family income of the participants from less-educated group is lower than the participants of the educated group (Figure 4.5). This also distinguishes the lifestyles between the groups.
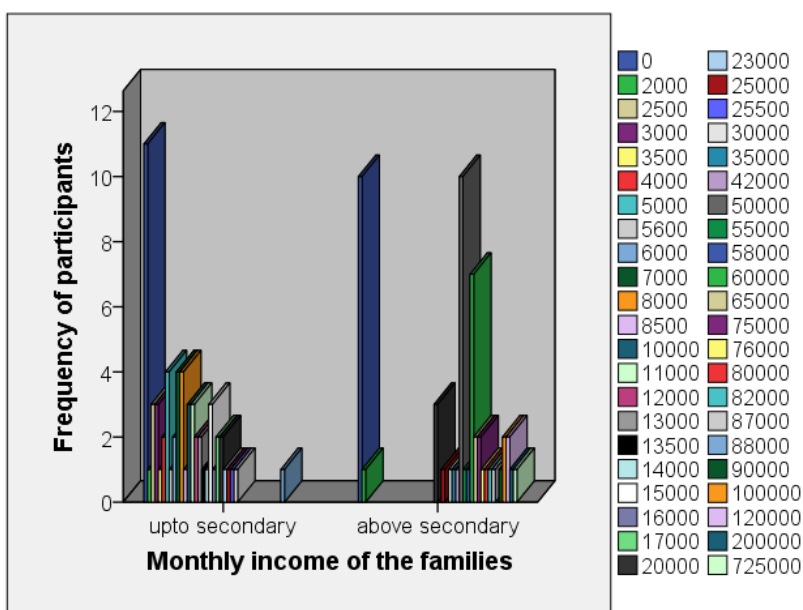
Figure 4.5: Monthly Income of the Families of Participants between the Groups

Personal hobby and occupations could be a source of lead exposure. Ahighly significant difference is observed between the groups in terms of hobby. Gardening is the most common hobby within group 1 participants (37.5%). Whereas, home renovation (18.2%) and pet handling (15.9%) are the common hobbies among the participants of group 2. Most of the participants from group 2 (56.2%) and group 1(59.1%) are not associated with hobbies related to sources of lead (Table 4.1).

Table 4.1: Hobbies or Occupations Related to Lead Exposure between the Groups

Hobbies related to lead	Group 1 (%)	Group 2 (%)	p-value
Gardening	37.5	6.8	
Home renovation (lighting, painting)	0	18.2	x^2=15.584, p<0.004
Glass painting	6.2	0	
Pet handling	0	15.9	LR x^2=18.229,
Others	56.2	59.1	p<0.001

*Results are expressed as the percentage of respondents who answered 'Yes'. **Pearson Chi-square x^2 and Likelihood Ratio (LR) x^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

Lead paint is a major source of human lead exposure. Among 114 respondents, 62 participants live in painted houseswhere 10 participants belong to study group and 52 participants belong to the comparison group (Figure 4.6).
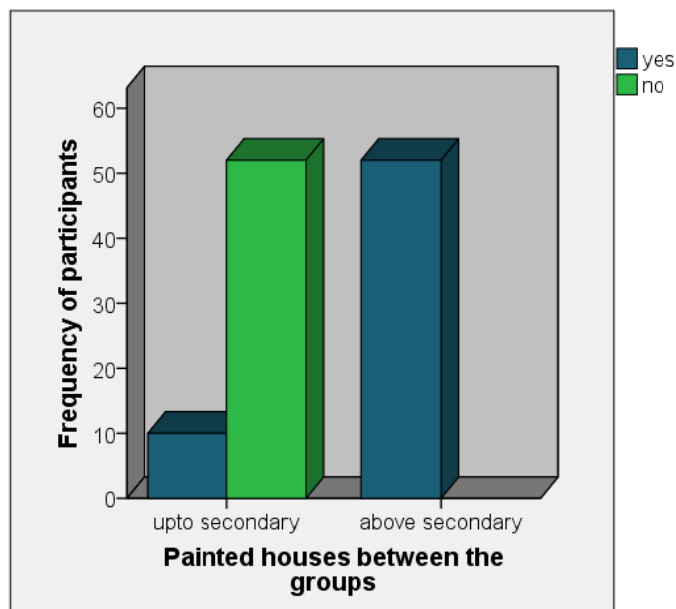
Figure 4.6: Frequency of Participants Living in Painted Houses between the Groups

The results show that the difference between the groups in terms of living in painted houses is highly significant. Only 16.1% participants from group 1 live in painted house whereas all

participants from group 2 live in painted houses (Table 4.2), although they were not sure whether the paint was lead free or not.

Table 4.2: Participants Living in Painted Houses between the Groups

Groups	Yes (%)	No (%)
Group 1	16.1	83.9
Group 2	100.0	0.0
Chi square test	χ^2=80.191, p<0.000***	
Likelihood Ratio	LR χ^2=102.376, p<0.000***	

*Results are expressed as the percentage of respondents. **Pearson Chi-square χ^2 and Likelihood Ratio (LR) χ^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

Among 114 respondents, 28 participants have been found to live in houses situated near highways, busy streets or vehicle depot area, including 5 participants from group 1 and 23 from group 2. Separately, 86 participants live in the houses away from highways, busy streets or vehicle depot area, including 57 participants from group 1 and 29 from group 2 (Figure 4.7).
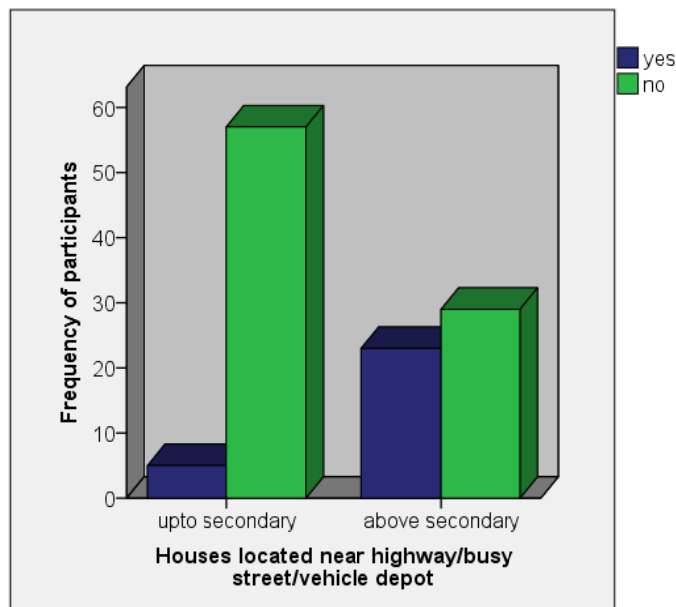
Figure 4.7: Location of the Houses of Participants between the Groups

The difference in location of the houses of participants between the groups is highly significant. In this study, 8.1% participants from group 1 have been found to live near highway or busy street or vehicle depot area. On the other hand, about 44.2% participants from group 2 live near highway or busy street or vehicle depot area (Table 4.3).

Table 4.3: Comparison of Location of the Houses between the Groups

Groups	Yes (%)	No (%)
Group 1	8.1	91.9
Group 2	44.2	55.8
Chi square test	χ^2=19.964, p<0.000***	
Likelihood Ratio	LR χ^2=20.946, p<0.000***	

*Results are expressed as the percentage of respondents. **Pearson Chi-square χ^2 and Likelihood Ratio (LR) χ^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

Highly significant difference has been found between the groups regarding the use of pesticides. It has been shown that, locally manufactured coil (90.9%) and aerosol (9.1%) are being used by the participants of the study group. On the other hand, Aerosol and liquid mosquito killer (60.6%), ant killing powder, cockroach chalk and rat killer (12.1%), harpic (3.0%) and local coil (24.2%) are the common pesticides used by the participants from comparison group (Table 4.4).

Table 4.4: Comparison of Pesticides Use between the Groups

Uses of pesticides/herbicides	Group 1 (%)	Group 2 (%)	p-value
Aerosol, liquid mosquito killer	9.1	60.6	χ^2=23.615, p<0.000***
Ant killing powder, cockroach chalk, rat killer	0	12.1	
harpic	0	3.0	
Local coil	90.9	24.2	LR χ^2=20.913, p<0.000***

*Results are expressed as the percentage of respondents who answered 'Yes'. **Pearson Chi-square χ^2 and Likelihood Ratio (LR) χ^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

Kajal is a potential source of human lead exposure. Use of kajal/surma is higher among the participants of the comparison group than the participants of the study group (Figure 4.8). It has been found that, 72 participants use kajal. Among them, 21 participants belong to group 1 and 51 participants belong to group 2.
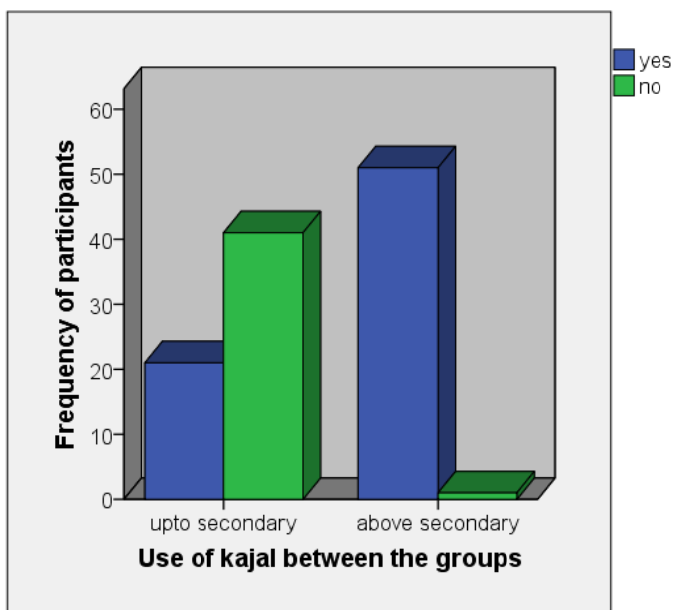
Figure 4.8: Use of Kajal by the Participants between the Groups

Highly significant difference has been found in the use of kajal between the groups (Table 4.5). In the study group, 33.9% participants have been found to use kajal. On the other hand, 98.1% participants from the comparison group have been found to use kajal.

Table 4.5: Comparison of Kajal Use between the Groups

Groups	Yes (%)	No (%)
Group 1	33.9	66.1
Group 2	98.1	1.9
Chi square test	x^2=50.104, p<0.000***	
Likelihood Ratio	LR x^2=60.784, p<0.000***	

*Results are expressed as the percentage of respondents. **Pearson Chi-square x^2 and Likelihood Ratio (LR) x^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

Among 114 respondents, 64 participants have been found to use lipsticks. The difference in the use of lipsticks by participants between the groups is highly significant (Table 4.6). Like kajal, the use of lipsticks is also higher in comparison group (86.5%) than the study group (30.6%)

Table 4.6: Comparison of the Uses of Lipsticks between the Groups

Groups	Yes (%)	No (%)
Group 1	30.6	69.4
Group 2	86.5	13.5
Chi square test	X^2=35.881, p<0.000***	
Likelihood Ratio	LR X^2=38.814, p<0.000***	

*Results are expressed as the percentage of respondents. **Pearson Chi-square X^2 and Likelihood Ratio (LR) X^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

The difference between the groups in terms of frequency of lipstick use is not significant (p<.201). From less-educated participants, 21.1% use lipsticks daily, 15.8% use twice or thrice a week and 63.2% use occasionally. Regular use of lipsticks is higher among the members of the educated group. The percentage of participants who use lipstick daily is 43.8%, who use twice or thrice a week is 14.6% and who use lipsticks occasionally is 41.7% (Figure 4.9).
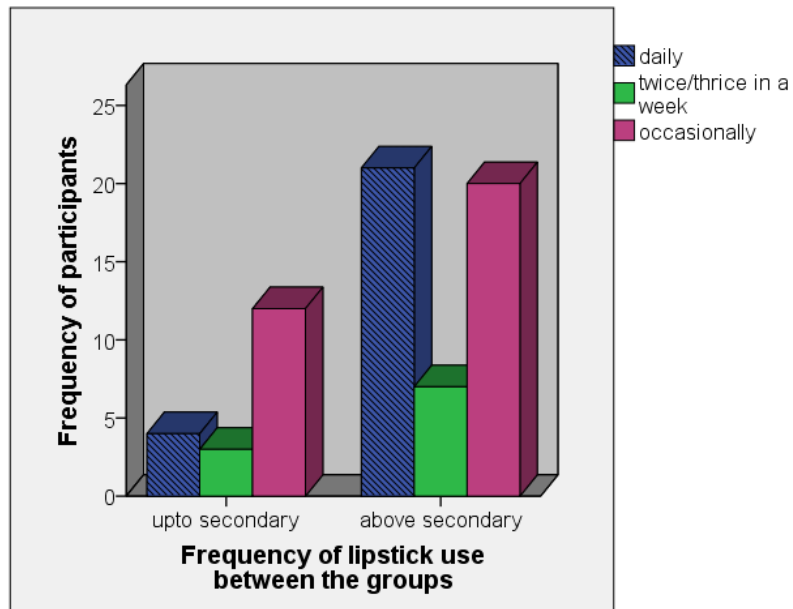
Figure 4.9: Frequency of Lipstick Use by the Participants between the Groups

It has been shown that 86 participants used to eat canned foods. Consumption of canned food is higher among the members of the educated group (Figure 4.10). Forty five participants from educated group and 41 participants from less-educated group have been found to consume canned foods. The difference in the consumption of canned food between the groups is significant (p<.012).
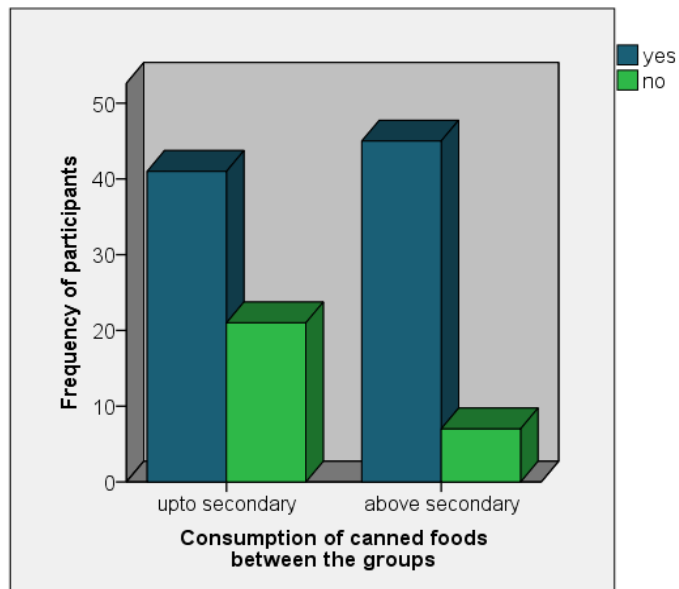
Figure 4.10: Consumption of Canned Foods by the Participants between the Groups

Cola drinks and fruit juice are the most common canned foods consumed by the participants ofboth groups. It has been found that consumption of cola drinks, fruit juice and ghee is higher in group 1 (97.6%) than group 2 (88.9%) and the difference is significant (Table 4.7). No participants from group 1 have been found to consume canned olive, pickles or fish.

Table 4.7: Consumption of Different Types of Canned Foods between the Groups

Canned foods	Group 1 (%)	Group 2 (%)	p-value
Cola drinks, Fruit juice, Ghee	97.6	88.9	x^2=5.827, p<0.054
Olive, Pickles, fish	0	11.1	LR x^2=8.132, p<0.017

*Results are expressed as the percentage of respondents who answered 'yes'.**Pearson Chi-square x^2 and Likelihood Ratio (LR) x^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

Turmeric powder can be a potential source of lead as lead has been found in packaged turmeric powder. 69 participants have been found to use packaged turmeric powder available in the market (Figure 4.11). Use of marketed turmeric powder is higher in the participants of group 2 (71.2%) than the participants of group 1(51.6%) and the difference is significant (p<.034).
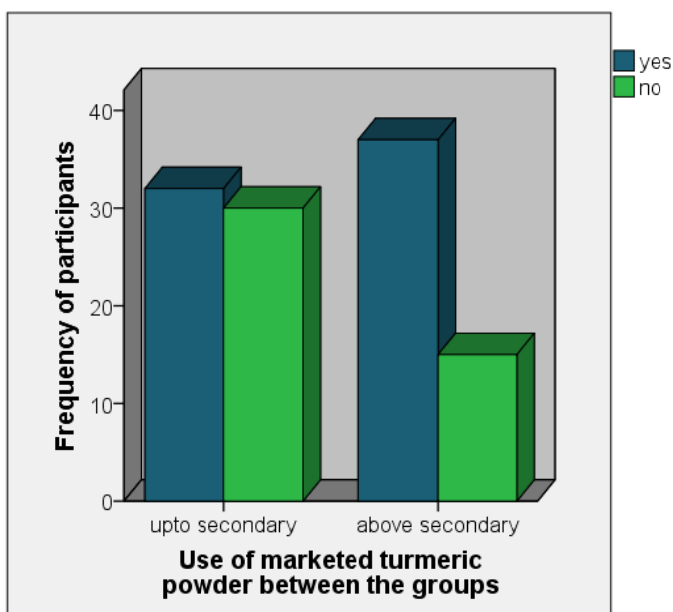
Figure 4.11: Use of Marketed Turmeric Powder by the Participants between the Groups

It has been shown that fat intake is higher amongthe participants of group 1 than the participants of group 2 and the difference is statistically highly significant (p<0.0001). 51.6% participants from group 1 eat all or most of the fat, whereas about 11.5% participants from group 2 eat all or most of the visible fat (Table 4.8).

Table 4.8: Comparison of Visible Fat Intake between the Groups

Consumption of visible fat	Group 1 (%)	Group 2 (%)	p-value
Eat all or most of the fat	51.6	11.5	x^2=37.512, p<0.000***
Eat some	16.1	21.2	
Eat as little as possible	9.7	57.7	LR x^2=40.605, p<0.000***
Do not eat	22.6	9.6	

*Results are expressed as the percentage of respondents who answered 'Yes'. **Pearson Chi-square x^2 and Likelihood Ratio (LR) x^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

The rate of use of coloring agent is higher in comparison group than the study group (Figure 4.12). Among 114 participants, 25 respondents use coloring agent in their foods, including 1 participant from group 1 and 24 participants from group 2.
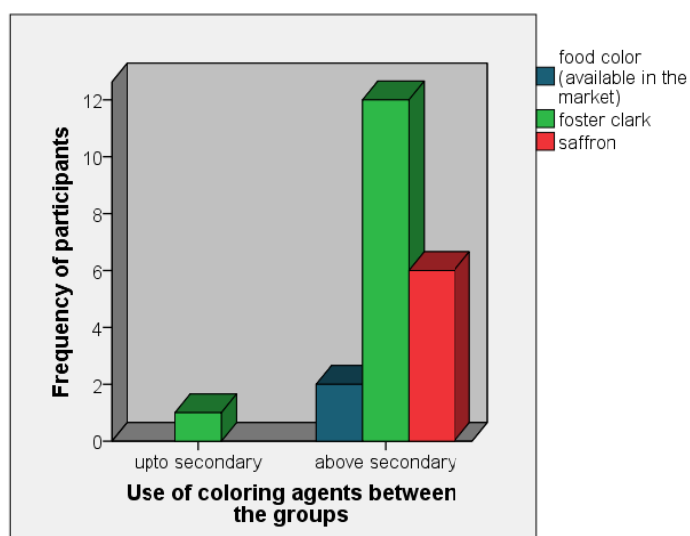
Figure 4.12: Use of Coloring Agents by the Participants between the Groups

It has been shown that, 7.7% of the participants use Foster Clark from group 1, while, 60% of the participants from group 2use Foster Clark, 30% use saffron and 10% use random food color.

No participants from group 1 has been found to use saffron or any other food color. There has been no significant difference in the use of coloring agents between the groups (Table 4.9).

Table 4.9: Comparison of Coloring Agents Used by the Participants between the Groups

Uses of coloring agents	Group 1 (%)	Group 2 (%)	p-value
Food color (available in the market/random)	0	10	x^2=.646, p<.724 LR x^2=.990, p<.610
Foster Clark	7.7	60	
Saffron	0	30	

*Results are expressed as the percentage of respondents who answered 'Yes'. **Pearson Chi-square x^2 and Likelihood Ratio (LR) x^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

Habit of eating betel leaf, zarda and sadapata ismore common in group 1 than group 2 and the difference is highly significant (p<0.0001). Forty one participants have been found with habits related to lead and among them 39 participants belong to less-educated group, whereas only 2 participants belong to the educated group (Figure 4.13).
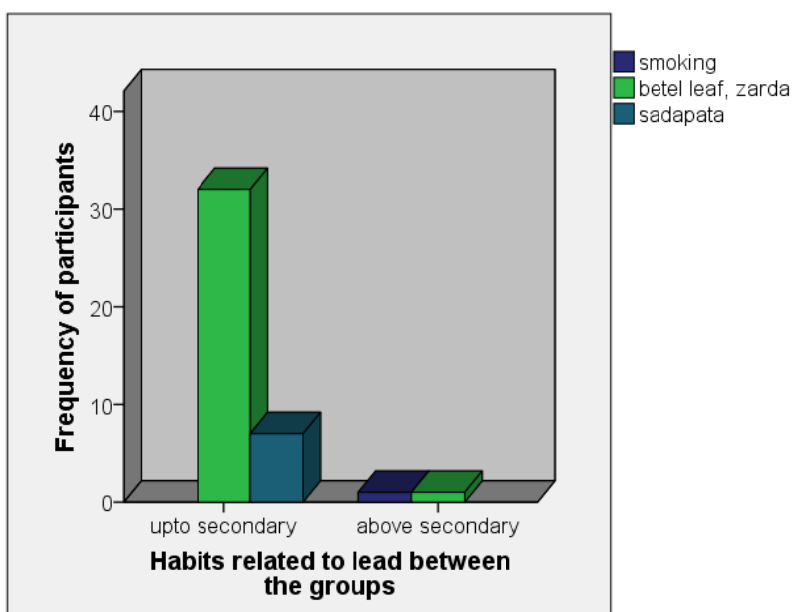
Figure 4.13: Habits of Participants Related to Lead between the Groups

Tea may contain unsafe level of lead. Seventy one participants among 114 have been found to have the habit of drinking tea or coffee, with 21 participants from the study group and 50 participants from the comparison group. All participants from group 1 have the tea drinking habit, while 8 participants from group 2 do not have that habit at all. The habit of having more than one cup of tea or coffee is also higher in group 2 (56.0%) than group 1 (19.1%) and the difference between the groups is statistically significant.

Table 4.10: Number of Cups of Tea Taken by the Participants between the Groups

No. of cup of tea	Group 1 (%)	Group 2 (%)	p-value
No tea at all	0	8	
One cup daily	81.0	36.0	χ^2=12.423, p<0.029
More than one cup daily	19.1	56.0	LR χ^2=14.245, p<0.014

*Results are expressed as the percentage of respondents who answered 'Yes'. **Pearson Chi-square χ^2 and Likelihood Ratio (LR) χ^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

It has shown that consumption of ayurvedic or herbal medicine is higher in group 2 (7.7%) than group 1 (0%) and the difference is significant between the groups (p<0.026). Only 4 participants have been found to consume ayurvedic or herbal medicine, where all of them belong to the comparison group (Figure 4.14).
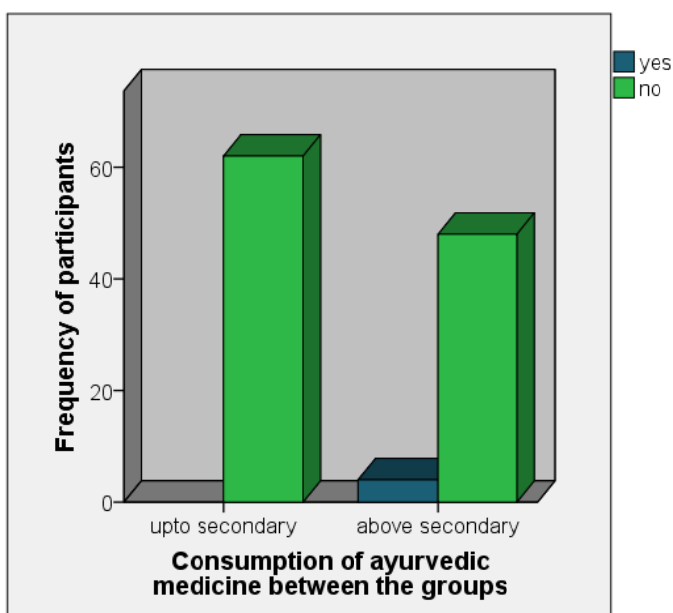
Figure 4.14: Consumption of Ayurvedic Medicine by the Participants between the Groups

Highly significant difference has been observed in the food habit between the groups (Table 4.11). 90.6% of the participants from group 1 and 29.8% participants from group 2 have been found to eat rice, vegetable, fish and sometimes meat on daily basis. Intake of fast food is higher (38.3%) among the participants of group 2 than those of group 1 (1.9%).

Table 4.11: Food Habit of the Participants between the Groups

Foods taken by the participants	Group 1 (%)	Group 2 (%)	p-value
Rice, vegetable, fish, meat	90.6	29.8	χ^2=40.008, p<0.000*** LR χ^2=44.641, p<0.000***
Singara, puri, roll, paratha, biriyani, khichuri	7.5	31.9	
Burger, sandwitch, pasta, chicken fry	38.3	1.9	

*Results are expressed as the percentage of respondents who answered 'Yes'. **Pearson Chi-square χ^2 and Likelihood Ratio (LR) χ^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

Among 114 respondents, 48 participants have heard about'lead'; among them 4 participants are from less-educated group and 44 are from educated group (Figure 4.15).Although not

surprising, it is important to note that the participants with educated background have significantly (p<0.0001) higher knowledge about lead (84.6%) than the participants from less-educated background (6.5%).
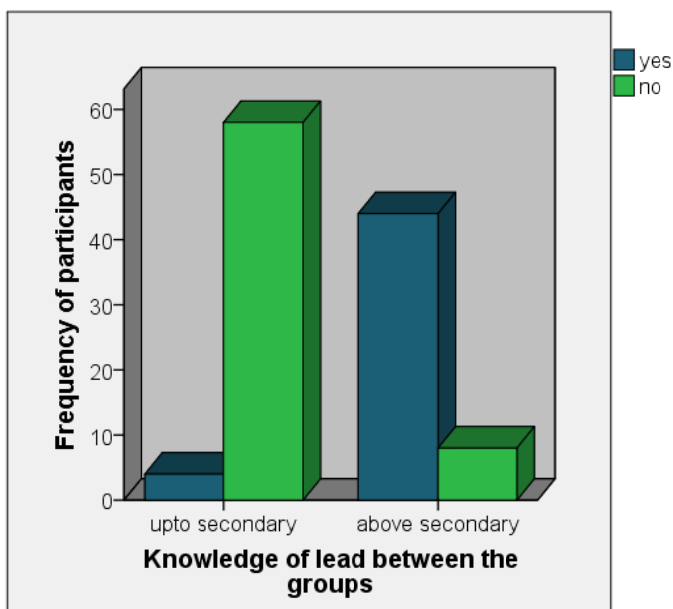
Figure 4.15: Knowledge of Lead among Participants between the Groups

It has been found that having the idea of lead poisoning and diseases related to lead contamination is not very common among participants. Twenty eight participants have been found to know about lead poisoning, where highly significant difference has been observed between the groups about the knowledge of lead poisoning. Only 1.6% of the participants from group 1 know about lead poisoning. On the other hand, about 51.9% participants from group 2 have primary knowledge about lead poisoning (Table 4.12).

Table 4.12: Knowledge of Lead Poisoning among Participants between the Groups

Groups	Yes (%)	No (%)
Group 1	1.6	98.4
Group 2	51.9	48.1
Chi square test	X^2=38.633, p<0.000***	
Likelihood Ratio	LR X^2=44.854, p<0.000***	

*Results are expressed as the percentage of respondents. **Pearson Chi-square X^2 and Likelihood Ratio (LR) X^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

Highly significant difference has been foundregarding the knowledge of harmful effects of lead between the groups (p<0.0001). 38.5% of the participants from group 2 have been found to know about the harmful effects of lead, whereas no participants from group 1 have been found to have that knowledge (Figure 4.16).
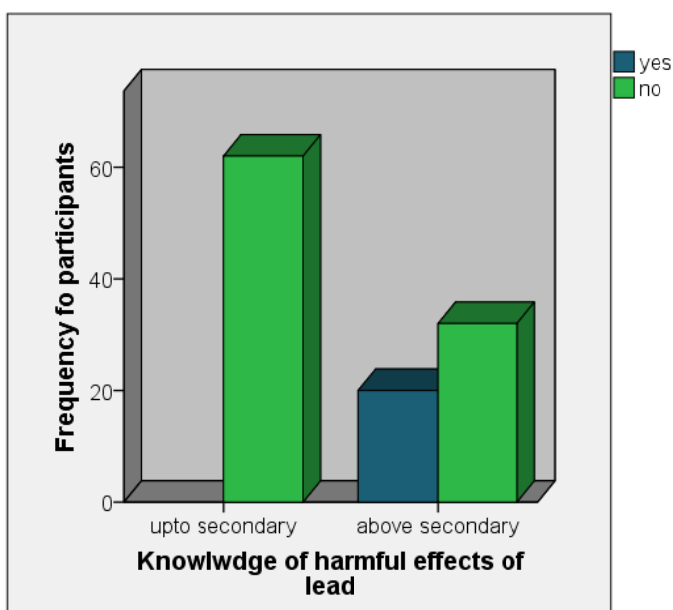
Figure 4.16: Knowledge of Harmful Effects of Lead among Participants between the Groups

In this study, 102 participants have been observed to have no knowledge about the sources of lead. Only 12 participants have been found with the knowledge of lead sources with 11 from group 2 and only 1 participant from group 1. It has been shown that 1.6% of the participants from group 1 and 21.2% from group 2 have knowledge about the sources of lead and the difference is statistically highly significant.

Table 4.13: Comparison of Knowledge about Sources of Lead between the Groups

Groups	Yes (%)	No (%)
Group 1	1.6	98.4
Group 2	21.2	78.8
Chi square test	χ^2=11.466, p<0.001***	
Likelihood Ratio	LR χ^2=12.820, p<0.000***	

*Results are expressed as the percentage of respondents. **Pearson Chi-square x^2 and Likelihood Ratio (LR) x^2 test are used to test for a difference in frequencies across the categories of a variable between two groups ($n_1=62$, $n_2=52$).

Among 114 participants, only 9 from both the groups have mentioned some sources of lead and the difference between the groups is not significant (p<.109). Among these 9 participants, only 1 participant is from group 1 who has mentioned battery and fish net as the sources of lead, whereas the rest 8 participants from group 2 mentioned aerosol, pran[R]turmeric powder (12.5%), water pipe (37.5%), food and paints (12.5%) as the sources of lead (Figure 4.17).
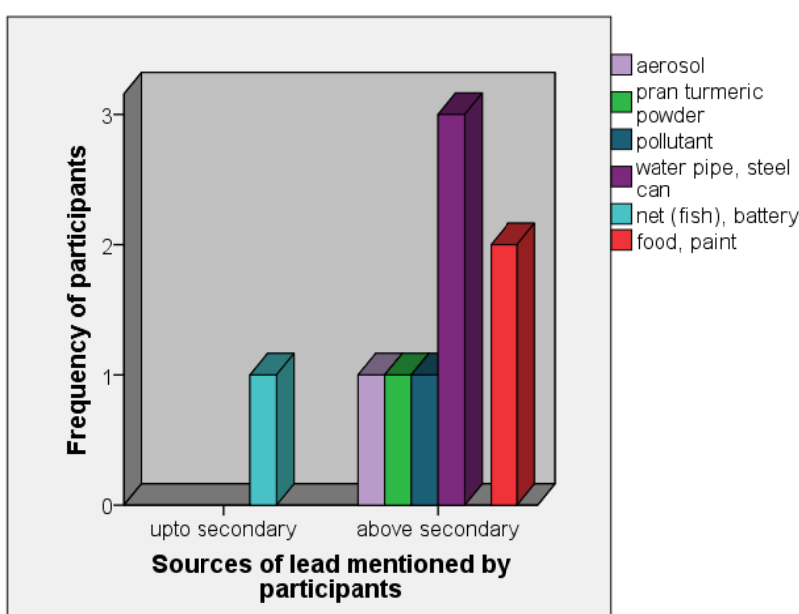
Figure 4.17: Sources of Lead Mentioned by the Participants between the Groups

In this study, it has been found that 112 participants do not know the remedies of lead poisoning. Only 2 participants from group 2 have been found to know the remedies of lead poisoning though they are not confident about their knowledge. No participants from group 1 have found to know the remedies of lead poisoning (Table 4.14). No significant difference has been found between the groups (p<0.400).

Table 4.14: Knowledge on the Remedies of Lead Poisoning between the Groups

Groups	Yes (%)	No (%)
Group 1	0	100
Group 2	3.8	96.2

Chi square test	χ^2=2.427, p<0.119
Likelihood Ratio	R^2 =3.182, p<0.400

*Results are expressed as the percentage of respondents. **Pearson Chi-square χ^2 and Likelihood Ratio (LR) χ^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

Only 3 participants were found very concerned about lead poisoning, while 16 participants were moderately concerned and 12 participants were slightly concerned about lead poisoning. 90.3% of the participants from group 1 and 51.9% from group 2 have not shown any concern about lead poisoning (Figure 4.18) and the difference is highly significant (p<0.0001).
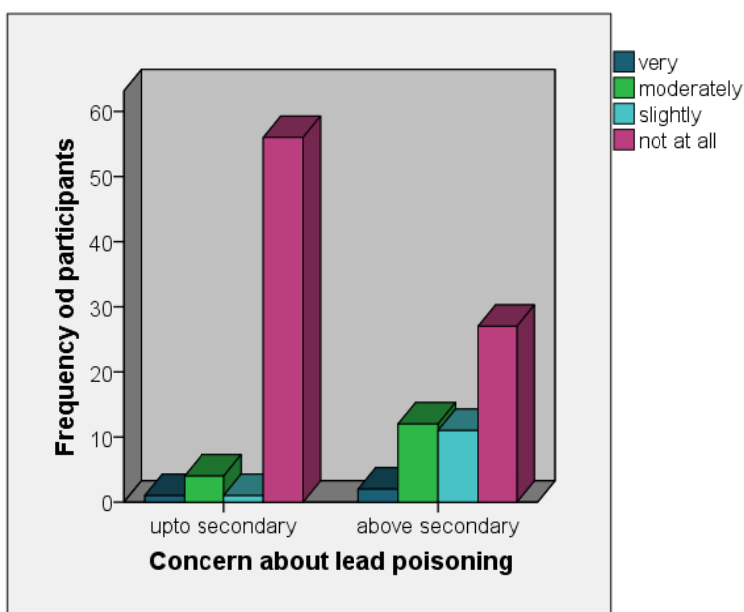
Figure 4.18: Concern about Lead Poisoning among Participants between the Groups

Among 114 respondents, 11 participants are extremely willing, 19 are very willing, 26 are moderately willing and 34 participants are slightly willing to reduce lead poisoning. Interestingly, 24 participants did not show any desire to reduce lead poisoning, including 18 participants from less-educated group and 6 from educated group. Highly significant difference has been found between the groups regarding the willingness to reduce lead poisoning (Table 4.15).

Table 4.15: Comparison of desire to Reduce Lead Poisoning between the Groups

Level of Desire	Group 1 (%)	Group 2 (%)	p-value
Extremely willing	3.2	17.3	χ^2=22.092, p<0.000***
Very willing	11.3	23.1	
Moderately willing	12.9	34.6	
Slightly willing	43.5	13.5	

44

| Not at all willing | 29.0 | 11.5 | LR χ^2=23.748, p<0.000*** |

*Results are expressed as the percentage of respondents who answered 'Yes'. **Pearson Chi-square χ^2 and Likelihood Ratio (LR) χ^2 test are used to test for a difference in frequencies across the categories of a variable between two groups (n_1=62, n_2=52).

According to 11 participants (13.1% from group 1 and 5.9% from group 2), appropriate steps have been taken by Bangladeshi government to prevent lead poisoning, while 28 participants do not have any knowledge about the prevention of lead poisoning (Figure 4.19). Highly significant difference has been found in the opinions of participants between the groups (p<0.0001).
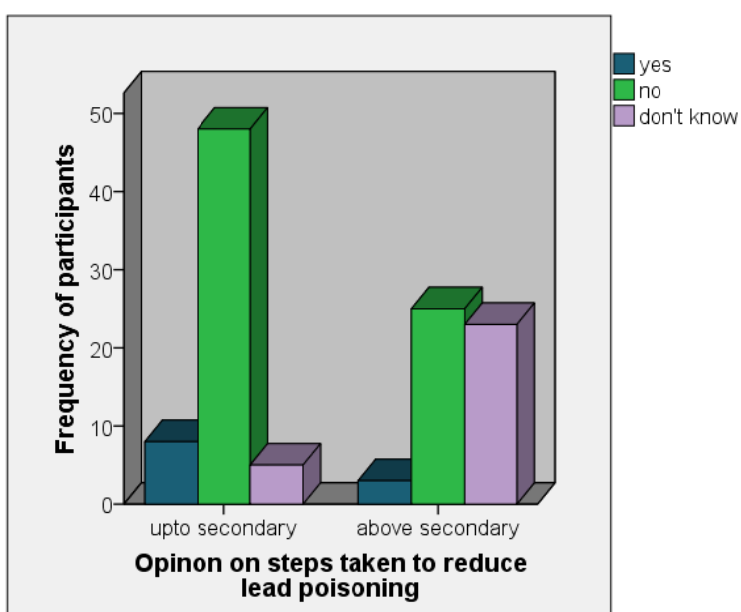
Figure 4.19: Opinion on Lead Poisoning Prevention by Participants between the Groups

CHAPTER 5

GENERAL DISCUSSION

5.1 OVERVIEW OF THE STUDY

Lead had a huge economic impactfrom the ancient times because of its ease of availability and low price. As a result, lead is one of the oldest widely distributed toxicants in the environment (Eisinger, 1977). Lead mining, smelting, refining, manufacturing and recycling allow lead to enter into the air, water and surface soil.Exposure to lead has declined tremendously in Bangladesh from the beginning of 2002 following the ban on leaded petrol. But due to the physical properties of lead, it is still prevalent in the environment. Exposure to lead occurs from several occupational sources as well as hidden sources such as: lead based paint in older homes, contaminated soil and dust, water pipes (lead leaching from old pipes), inhalation in industrial settings and dermal contact, herbal and traditional remedies, ethnic cosmetics, the use of lead glazed pottery, and the like.

Civilized societies have suffered from lead based diseases for thousands of years and still lead continues to be a great threat to public health. The highest burden of diseases in developing countries has been estimated to be caused by lead exposure (WHO, 2015). About 99% of children who get exposed to lead are from low and middle income countries (WHO, 2015). Many developed countries have initiated several programs to prevent lead poisoning like phasing out of lead in paint, fuel and many other consumer products. But due to continuous and rapid industrialization and persistent dissemination of lead in the environment, lead poisoning remains as a major public health problem in many developing countries (Tong, 2000). Exposures to lead not only attributes to adverse effects on public health but also on the development and economic condition of any country by reducing intelligence (WHO, 2010). Therefore, it is necessary for developing countries like Bangladesh to undertakeproper measures and thereby prevent lead poisoning. Several studies have been conducted on the measurement of blood lead level but no research study has been done with the purpose of raising awareness about lead poisoning among mass population. This study focuses on to evaluatethe awareness of the sources and adverse effect of leadamong women of child bearing age. The purpose is to make policy recommendation to the policy maker so that they realize the fact that mother's unawareness can lead their children to lead exposure.

5.2 METHODOLOGICAL OCNSIDERATION AND EMPIRICAL OUTCOME OF DATA

This study has been conducted with the participation of women aged from eighteen to thirty five. In Bangladesh, eighteen has been declared as the minimum age of marriage for women though occurrence of marriage before eighteen is quite frequent, especially in rural areas. However,

most of the women have their children between the ages of eighteen to thirty five. In some cases the maximum age of having children may exceed thirty five which is infrequent. Therefore, in this study, the age range of eighteen to thirty five has been considered as a standard child bearing age range for women aiming that if mothers are aware of lead poisoning, the fetus will be safe from the lead exposure at any concentration.

Participants of this study have been divided into two groups on the basis of their educational level. Group 1 consists of participants who did not get any education or educatedupto secondary level. This group has been named as the 'less-educated group' comprising of 62 participants. On the other hand, group 2 consists of participants who are educated above secondary and onwards. This group has been named as the 'educated group' comprising of 52 participants. During the division of these two groups it has been considered that, the government of Bangladesh has made the education free for girls upto grade ten. After completing secondary level, families with poor economic background cannot bear the educational expenses for girls, and ultimately those girls are dropped out from school. Therefore, women with education upto secondary level have been placed in the less-educated group. Whereas, girls from well off families continue their study after the completion of secondary level. As a result, women with education above secondary and onward have been placed in the educated group. This grouping was necessary as a prerequisite for the study to demonstrate the comparison between the educational groups about their knowledge on sources and harmful effects of lead.

Religions of the participants have been an important factor since it influences lifestyle, use of traditional cosmetics. Thisstudy have been conducted with 91% and 92% Muslims from educated and less educated group, respectively and the rest participants are Hindu and Christian.

Occupations of the members of any family determine the economic and social status of the family. Net income of any family influences the life style directly. Those participants, who have a higher economic background, live their life with more comfort and facilities. Participants with lower income group have a different life style with less facilities and more hardship. For example, they live in slums and do not get proper education andfoods. This evidence is also highlighted by Blandenand Gregg (2004). Since Government of Bangladesh has made education free for girl's upto grad10, continuation of study after secondary level also depends on the income of the family. People with poor economic background cannot afford further study of their children.

When they get older, they do not get any noble job with a good salary because of their lower educational level and this cycle continues and contributes to the burden of poverty. Family members with better educational background get better job, better salary and can afford education of their children up to the mark. Due to difference in lifestyles, risk factors for human lead exposure may also differ between the groups. In this study, most participants from the less-educated group are housemaids or garment workers and have a lower family income. Separately, most of the participants from the educated group are students. Some of the participants are housewives and some are involved in both the government services and private sectors. From the questionnaire, clear lifestyle differences between the groups have been demonstratedand the difference in occupations between the groups is highly significant (p<0.0001).

Many hobbies have strong relationships with human lead exposure which may result in lead poisoning. People, who have gardening as a hobby, may get exposed to lead as they come in direct contact with the soil and pesticides. Historically lead has been used in pesticides to grow vegetable crops. The soil might be contaminated with lead due to the use of pesticides containing lead such as lead arsenate (Mcbride, 2013). Release of lead and lead compounds from industries to soil, air and water have also been reported. Lead which is already available in the air and water ultimately deposited into the soil and sediment as land is the ultimate repository for lead (ATSDR, 2007). Therefore, the persons who are involved in gardening may get exposed to lead and may have a high blood lead level leading to lead poisoning. In this study, it has been found that about 37.5% participants from group 1and about 6.8% participants from group 2are associated with gardening.In several pesticides metals have been found including lead (Meza-Montenegro, 2013). Pesticides containing lead may cause exposure to lead in agricultural regions especially in the rural areas of Bangladesh. Use of pesticides is higher in educated group (67.3%) and the difference between the groups is highly significant (p<00.001).It has been demonstrated that 6.2% from group 1 and 18.2% of the participants from group 2 have been involved with painting as a hobby. Participants from educated group are also associated with pet handling (15.9%) which is another recognized source of potential lead exposure.The difference between the groups is significant (p<0.004).

Occupational lead exposure remains as a continuous hazard in increasing the burden of public health problems by affecting both children and adults (Loghman-Adham, 1997). Some occupations such as working in the battery manufacturing industry, spray painting, working with silver jewelry etc. are directly associated with lead exposure (Patil, 2007). Industrial lead

exposure is a great threat to public health (Loghman-Adham, 1997). From many several studies it has been shown that lead becomes transferred from workplace to home through lead-ladendust on the workers clothes, shoes and vehicles (WHO, 2010).Home renovation and repair work associated with painting increases the risk of elevated blood lead level (Reissman, 2002).Workers associated with the renovation of old buildings are found to suffer most from acute lead poisoning (Gordon *et al*, 2002). Lead based paints have been recognized as one of the most important sources of lead poisoning in children since the twentieth century (Marino, 1990). If leaded paints are used during renovation of buildings, children may get exposed to lead through the dust contaminated with lead generated from deteriorated leaded paints (Reissman, 2002). Crystal glass (colored or stained glass) manufacturing has also been found to cause elevated blood lead level (Tola, 1976) as lead is also used in glass staining in order to give the glass a purplish color. In Bangladesh, women are not usually involved in such occupations like building painting, acid battery manufacturing etc. Therefore, it has been shown from this study thatno participant has been involved with occupations that may increase the risk of lead poisoning. However, if parents or husbands are associated with these occupations, children or wife may become indirectly exposed to lead.

Painted houses and location of homes are also associated with elevated blood lead level. Houses that are painted with lead based paint can become a major source of lead poisoning. Exposure to lead by means of lead based paints mainly occurs during home renovation, repair and remodeling activities (CDC, 2009). Peeling, chipping, chalking or cracking of the painted walls can also cause childhood lead poisoning because of their hand to mouth activity. The uses of lead based paints werebanned in 1978. Therefore, the houses painted before 1978 may increase the risk of lead poisoning by containing lead based paints. In this study, it has been found that majority of the participants live in the houses built about thirty years ago or more. The rate of living in painted houses is higher among the participants of comparison group and highly significant difference has been demonstrated between the groups (p<0.0001). Leaded petrol has caused extensive lead exposure worldwide (Landrigan, 2002). The use of leaded petrol was phased out in the 1980s and early 1990s but lead dust has spread out in the environment, especially in highways, busy streets and vehicle depots. People living in homes situated near busy street or vehicle depot area may have high blood lead level as they may get exposed to the dust with high amount of lead due to the use of leaded petrol. Therefore, locationofhome is also a major factor in terms of lead poisoning. In this study, 52.3%of the participants are found to live near busy street and vehicle depots and the difference between the groups is highly

significant (p<0.0001). 44.2% of the participants are from group 2, therefore, they are at higher risk of developing lead poisoning.

In recent studies it has been found that there is a close association between the use of kajal and elevated blood lead concentration (Goswami, 2011). The main component of kajal is lead sulfide (Caluwé, 2010). Unconscious application of kajal may result in entrance of kajal into the eye. Eye rubbing and lacrimation may cause absorption of lead through the conjunctiva (Goswami, 2011). It has been a tradition for Bangladeshi women to apply kajal into their eyes to enhance their beauty.In this study it has been found that among 114participants,72 participants use kajaland the tendency of using kajal is higher in the participants from the educated group and there is a highly significant difference between the two groups in terms of using kajal (p<0.0001) Lipsticks may also contain lead if the ingredients contain lead naturally or the manufacturing procedure introduces lead into the ingredients (Hepp, 2009). Lead gets its way into the body through ingestion of lipsticksunknowingly.Although women from both the groups use lipsticks, those who have a better economic condition can afford to buy branded lipsticks and the rest participants use local products. Lead may be contaminated in both branded and local lipsticks as no specific lead test in cosmetics is available in Bangladesh. Additionally, adulteration of these cosmetics is also very common.Ithas been found that the percentage of educated women is higher in case of lipstick use on daily basis (43.8%). There has been no significant difference between the groups (p<0.201) in the use of lipstick. Therefore, women from both the groups are becoming exposed to lead in everyday lifeeven at minute level.This may result in elevated blood lead level in women due to long term exposure to lead. Exposure to lead through cosmetics occurs for a long period of time.Use of cosmetic products starts from childhood oradolescentperiodsand continues thereafter. As a result, lead accumulates into the body and the amount of accumulated lead increases simultaneously due to continuous use of cosmetics containing lead. As previously mentioned, lead accumulated into hard tissues such as bones and teeth; during normal growth of the bones, this accumulated lead releases into the blood causing elevated blood lead level. Accumulation of lead into the body may also affect the fetus. During pregnancy stored lead mobilizes from the bone into the systemic circulation and may cross the placenta barrier resulting in adverse effects on the fetus (Jarrell, 2006).

Ingestion of food is one of the largest contributors to the daily intake of lead. Several canned foods have been reported to be contaminated with lead. In the canning process, soldering is a source of lead contamination. Foods and beverages with lead-soldered cans may increase the lead content of the foods or beverages including acidic foods or drinks (WHO, 2010).

Contamination of lead in canned foods may also occur during transportation, storage and handling process (Nasser, 2014). In Bangladesh, canned fish, meat, olive, pickles are available in almost all the super shops. The use of this canned foods are increasing day by day due to its ease of handling. Outside home, whenever people get thirsty, they prefer to buy cola drinks rather than buying a bottle of water. But, leaching of lead from the seal of the can may contaminate cola drinks whichmaybecome potential source of lead. This study states that consumption of cola drinks and canned pickles is high in both educated and less-educated women whereas canned fish, meat, olive are consumed most by the educated womenwith significant difference (p<0.054). High lead levels have been detected in many spices, especially in commercially processed turmeric powders. Recently, Pran[R] turmeric powder, one of the most common brands used by the Bangladeshi people, has been recalled by the Food and Drug Administration as it has been found to contain elevated lead level (FDA, 2013). Lead contaminated spices often remain undetected due to the lacking of proper inspection. The main reason of lead contamination into spices is the addition of lead oxide, an orange or red powder which has a similar appearance to many spices (ADHS, 2012). In Bangladesh, similarly as canned foods, the use of packaged spices have increased extensively in all classes of families from low to high. So, use of these packaged spices without detecting metals remains as a risk factor for lead exposure among masses. In this study, the rate of using packaged turmeric powder is higher in the comparison group and this study demonstrates significant difference (p<0.034) between the groups.

Blood lead level increases with increasing intake of fat and calories (Gallicchio, 2002) as visible fat increases the absorption of lead into the body. Intake of most of the visible fat on the meat is quite common in women from less-educated background (51.6%).Whereas,educated women try to avoid fat and calories. The difference in fat intake between the groups is highly significant (p<0.0001). Color additives from naturally occurring vegetables and mineral sources have been used to color foods, drugs and cosmetics from ancient times (FDA, 2003). Coloring agents containing lead can be a potential source of human lead exposure. According to this study, the most commonly used food colors in Bangladesh are saffron (also known as jafran) and Foster Clark, imported from Malta. These coloring agents are available almost all nearby markets. The prices of these coloring agents are surprisingly less whereas these coloring agents should be highly expensive in terms of availabilityand purity. It is obvious that the reason behind this secret is none other than food adulteration. At present, food adulteration in Bangladesh has reached an extreme situation. Moreover, adulteration of these coloring agents may result in even

higheramount of lead contamination.Group 2 participants use more coloring agent (47.1%) than group 1 participants (1.9%) and the difference between the groups are highly significant (p<0.0001).

Tobacco production and consumption both are harmful for human. Both radioactive and non-radioactive lead can be trapped withintobacco leaves. These trapped lead contributes in tobacco toxicity and radioactive lead may results in lungs cancer (Taylor, 2010). In this study, no significant difference is observed between the groups in habit of smoking. Sometimes plain tobacco flakes, commonly known as sadapata, are incorporated into betel quid combination of betel leaf, areca nut, and slaked lime. Flavored tobacco flakes such as zarda may also be incorporated into the betel quid. Betel quid chewing has been reported to cause elevated blood lead level (Al-Rmalli, 2011) which is quite common in Bangladeshi women especially in rural areas. In this study it has been demonstrated that 40participants are associated with these habits of betel leaf, sadapata and smoking among 114participantsand these habits are more common within group 1 participants than the participants in group 2(p<0.0001).

Worldwide Tea is a common refreshing drink. If the soil is contaminated with lead then lead may get contaminated into tea leaves (Zazouliet al, 2010) Lead has also been found in commercial herbal tea products (Solidum, 2014). Tea is a very common beverage in Bangladesh and most of the people use to drinktea or coffee at least once or even more than once in a day. This study showedthatthe habit of drinking tea, once or more than once in a day, is higher within group 2 participants (90.4%) and the difference in drinking tea is highly significant between the groups (p<0.0001).

Folk or herbal medicines including powders and tablets given for the treatment of arthritis, infertility, upset stomach, menstrual cramps, colic and other illnesses have been found to contain lead (CDC, 2013). According to the findings of this study, the tendency of using herbal or folk medicines is higher in educated women than less-educated women with significant difference (p<0.026). This is because many of the educated women do not want to take allopathic medicines because of the possible side effects rather they prefer taking traditional medicines which are claimed to be free from side effects. On the other hand, women from less-educated group do not have specific knowledge about allopathic or traditional medicines and they use to have allopathic medicines as most of the allopathic medicines are cost effective and are easily available in Bangladesh. However, they do not have any knowledge that these traditional medicines may contain toxic metal like lead.

Questions about food habits have been incorporated in order to find out the diet of the women from both educated and less-educated background and to uncover the risk factors related to lead they are being exposed from diet.Consumption of fast foods is higher in group 2 participants and highly significant difference has been observed between the groups (p<0.0001).

The knowledge about lead and its poisonous effects among women of child bearing age has been evaluated in this study. Women from less-educated background have been found to have less knowledge than the educated women and the difference is highly significant (p<0.0001). However, those who have been found to have knowledge about lead poisoning do not have any clear concept about the sources or even the toxic effects of lead. Only a few participants (22.8%) mentioned some sources of lead exposure while most of the participants from both educated and less-educated groups do not have any knowledge about the primary and potential sources of lead(p<0.109). No women from group 1 and only 3.8% women from group 2 are found aware of the remedies of lead poisoning with no significant difference between the groups (p<0.119). In this study, the concern level of women about lead poisoning has also been uncovered with the finding that most of the women (90.3% from less educated group and 51.9% from educated group) are not at all concerned about this public health threat. Even they are reluctant to reduce the sources of lead as they do not have proper idea about the harmful effects of lead. Opinions of the participants about the prevention of lead poisoning have been disclosed with highly significant difference (p<0.0001) between the groups.It is also apparent from the questionnaires that some participants (13.1% from group 1 and 1.9% from group 2) have the view that the Government has taken proper steps to prevent lead poisoning. However, their knowledge is limited in this context. Such lacking increases the burden of lead and also leads to procrastination in minimizing lead exposure simultaneously. Understanding the harmful effectsof lead and identifying the sources of lead should be the major concern in preventing lead poisoning as well as in ensuring the public health and safety.

5.3 LIMITATIONS OF THE STUDY

➢ The sample size of this study was one hundred and fourteen which is satisfactory for any pilot study. However, since no research study has been conducted prior to this study about the awareness of lead poisoning, the level of significance from the sample size cannot be assured.

➢ This study represents different sources of lead exposure and knowledge of poisonous effects of lead in both less-educated and educated women living in urban areas. True reflection of the rural women of Bangladesh did not come out properly as no survey has been conducted in rural areas. Therefore, the whole scenario of lead poisoning in Bangladeshi women cannot be analyzed through this study.

➢ During the data collection process, some of the participants did not answer all the questions. Some of them were not willing to give all the answers while some participants thought that this survey was killing their valuable time and so skipped some of the questions to fill out the questionnaire quickly. As a result, there were some incomplete data which may have affected the result to some minimal extent.

➢ Considering the child bearing age, the age limit of the participants to be recruited has been specified from eighteen to thirty five. But in rural areas many girls are conceiving at ages below eighteen while in urban areas occurrence of conceiving at ages above thirty five is quite frequent. Therefore, the age limit of women of this study between 18-35 years may be a limitation.

CHAPTER 6

CONCLUSION

6.1 BENEFITS OF THE STUDY

Bangladesh is one of the developing countries where majority live below the poverty line (Titumir and Rahman, 2011). Class discrimination based on social status is a common feature of Bangladesh. Currently, the economic condition of this country is not up to the mark to ensure education population. Moreover, educated people are also not completely aware of the sources and harmful effects of environmental pollutants, especially lead. Leaded petrol and lead based paints has been diminished throughout the world. However, such products are still being used in developing and underdeveloped countries (WHO, 2013). Lack of awareness towards lead poisoning is also contributing to the body burden of lead. This study seeks to focus on the knowledge and awareness level of lead among women of child bearing age aiming to mitigate the lead burden from the next generation. It is expected that the findings of this study will help the policy makertoincrease the awareness of lead among people. Thereafter, it can assist the government to take proper steps to prevent lead poisoning. As per thefindings,this is an important area which requires further study in order to develop strong policy decisions and implementations.

6.2 CONTRIBUTION OF THE STUDY

There have been a substantial number of studies published assessing the levels of lead in adults using different bio-matrices (e.g. blood, hair, urine). However, no study has been conducted to evaluate the awareness of the people about lead in developing country or even in developed country. Since lead can cross the placental barrier and affect the fetus, it is therefore, very important to assess the awareness about lead in women at child bearing age. As a result, the strength of this study lies in its contribution to empirical, methodological and policy issues.

6.3 OVERVIEW OF MAJOR FINDINGS

From the study it has been shown that educational level, as well as lifestyles of the participants differs with the participant's economic condition. Highly significant differences have been observed in the food habit, use of cosmetic, hobby, home location etc. But the difference between the groups in the frequency of lipstick use, in coloring agent use is not significant.Although, participants in the comparison group showed higher awareness on lead, however, their knowledge on the sources of lead is not adequate. Moreover, they are not fully aware of the adverse effect of lead as well as remedies of lead poisoning.

6.4 IMPLICATIONS FOR RESEARCH/GUIDELINE FOR WOMEN

Taking as a whole, although educated group have shown higher awareness about lead than the less-educated group, there is still knowledge gap about the sources and adverse effect of lead among the participants. This study also identified factors associated with participants' lifestyle which may place them at greater risk of lead exposure. As a consequence, it would seem prudent to attempt to generate certain recommendations aimed at disseminating knowledge about lead.

1. The findings from this study, if made the focus of an educational initiative, might help women improve their understanding of the likely sources of lead in their everyday lives; including potentially hidden sources of lead exposure.

2. Women should be aware of using traditional medicines and cosmetics. Similarly, the purchase of these products from 'cheap' shops may be associated with an increased risk of lead exposure.

3. Awareness must also be elevated about the hazards associated with removing old lead-based paints, the use of pesticides, and of traditional cosmetics. The guiding principle should be that, by purchasing lead-free products, they are helping to protect the health of their children.

6.5 POLICY RELEVANCE, RECOMMENDATIONA/GUIDELINES FOR WOMEN

The study findings have identified the need to formulate policy recommendations, on the basis that 'exposure to lead' could be reduced by undertaking appropriate policy measures.   In particular, the government has an important role in formulating necessary integrated policies. A minimal set of recommendations, supported in part by the findings of this study, are as follows:

1. Specific practices, such as the use of traditional cosmetics (e.g. *sindoor, kajal, surma*) were identified as carrying an intrinsic risk. Therefore, the quality of these products should be highly monitored especially when these products are purchased from 'cheap shops'.

2. 'Cheap shops', selling traditional cosmetics targeted at the women should be subject to scrutiny and surveillance to ensure that they only sell products approved by BSTI.

3. Quality of canned foods should be monitored and metal contamination should be investigated. The packaging system can be changed in case of canned foods identified with leaching of metals from the containers.

4. Women can be introduced with diet that can help preventing lead poisoning. For example, foods containing vitamin E, calcium and iron reduce the absorption of lead. Additionally, foods rich in vitamin B1 and vitamin B9 helps in the excretion of lead (Taylor, 2010).

5. Government should use electronic and printing media to increase the awareness of lead among the people highlighting that minute amount of lead can reduce the IQ level or even responsible to involve people with crime.

6.6 CONCLUDING REMARKS

Exposure to lead is immensely detrimental to human health and may cause irreversible life-long health impacts on both adults and children. According to WHO (2015), about 99% of children highly exposed to lead live in low and middle income socio economic background. If outbreak of lead poisoning occurs in Bangladesh, it will be extremely difficult to overcome the health problems as the economic condition of Bangladesh is not satisfactorily well. Before this happens, proper measurements should be taken to identify the existing sources of lead exposure. This study has a policy implecation for the development of awareness among the people of Bangladesh for the prevalence of raised lead levels. Lead poisoning prevention and awareness programs should be designed, developed and implemented with the participation of both public and private sectors to ensure the safety of public health.

REFERENCES

Abdullahi., (2013). "Toxic effects of lead in humans: an overview." Global Advanced Research Journal of Environmental Science and Toxicology**2**(6): 157-162.

Ahmed S. G, Rahman M.M, Pal M (2010). "Dropout Rate in Secondary Level Education in Bangladesh." Publisher(s): The University Press Limited (UPL).

Ahmed S, Nasrin S, Luthful K ARM, Mohammad Z AB, Seraji MSI, Rahman M, Alauddin M. Blood lead levels of secondary school students in Dhaka, Bangladesh after the elimination of leaded gasoline and phase-out of two-stroke vehicles: study on one hundred children. Journal of Pediatric Sciences. Vol 3, No 3.

Al-Rmalli, S. W., Jenkins, R. O., Haris, P. I., (2011). "Betel quid chewing elevates human exposure to arsenic, cadmium and lead." J Hazard Mater.**190**(1-3): 69-74.

Arora, M., Weuve, J., Weisskopf, M. G., Sparrow, D., Nie, H., Garcia, R. L., Hu, H., (2009). "Cumulative Lead Exposure and Tooth Loss in Men: The Normative Aging Study." Environ Health Perspect. **117**(10): 1531–1534.

Barkat, A., Chowdhury, A. U., Nargis, N., Rahman, M., Kumar, P. K.A., Bashir, S., Chaloupka, F. J., (2012)."The Economics of Tobacco and Tobacco Taxationin Bangladesh." Paris: International Union Against Tuberculosis and LungDisease.

Bellinger, D. C. (2008)."Very low lead exposures and children's neurodevelopment." Current Opinion in Pediatrics **20**(2): 172-177.

Blanden, J., Gregg, P., (2004). "Family Income and Educational Attainment: A Review of Approaches and Evidence in Britain." Centre for the Economics of Education, London School of Economics, Houghton Street, London.

Borja-Aburto V.H., Hertz-Picciotto I., Lopez M.R., Farias P., Rios C., Blanco J., (1999). "Blood Lead Levels Measured Prospectively and Risk of Spontaneous Abortion." American Journal of Epidemiology **150**: 590-7

Burnham, J.C., (1999). "Biomedical communication and the reaction to the Queensland Childhood lead poisoning cases elsewhere in the world."MedicalHistory**43**: 155-172.

Caluwé, D., (2009). "Lead poisoning caused by prolonged use of kohl, an underestimated cause in French-speaking countries." Journal français d' Opthalmologie**32**(7): 459-63.

Casas, J. A., Sordo, J., (2011). <u>Lead: Chemistry, analytical aspects, environmental impact and health effects</u> Amsterdam, The Netherlands.

Castellino, N., Sannolo, N., Castellino, P., (1994). <u>Inorganic Lead Exposure and Intoxications</u> CRC Press, Inc.

CDC (2004). In: Preventing lead exposure in young children: A house-based approach to primary prevention of lead poisoning. Atlanta, GA.

CDC (2010)."Guidelines for the identification and management of lead exposure in pregnant and lactating women."U.S. Department of Health and Human Services. Atlanta, GA.

CDC (2010)."Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women."U.S. Department of Health and Human Services, Atlanta, GA.

CDC,S.A., Te´ llez-Rojo, M.M., Amarasiriwarden, C.,Peterson, K.E., Schwartz, J., Aro, A., Hu, H., Herna´ndez-Avila, M., (2006). "Influence of Maternal Bone Lead Burden and Calcium Intake on Levels ofLead in Breast Milk over the Course of Lactation." <u>American Journal of Epidemiology</u>**163**:48–56

Chandramouli, K., Steer, C.D., Ellis, M., Emond, A.M. (2009). "Effects of early childhood lead exposure on academic performance and behavior of school age children." <u>Archives of Disease in Childhood</u>**94**: 844-884.

D'souza, H.S., D'souza, S.A., Menezes, G., Venkatesh, T., (2011)."Diagnosis, Evaluation and Treatment of Lead Poisoning in General Population."<u>Ind J ClinBiochem</u>**26**(2): 197-201.

Defoe, P. P., Hettiarachchi, G. M., Benedict, C., Martin, S., (2014)."Safety of Gardening on Lead- and Arsenic-Contaminated Urban Brownfields." <u>Journal of Environmental Quality</u>**43**: 2064–2078.

Eisinger, J., (1978). "Biochemistry and measurement of Environmental lead intoxication." <u>Quarterly Reviews of Biophysics</u>**11**: 439-466.

Emsley, J., (2005). <u>The Elements of Murder: A History of Poisons</u> Oxford University Press, New York.

ESDO (2013)."Completion Report on 'International Lead Poisoning Prevention Week of Action' in Bangladesh."

Flora, S.J.S., (2009). "Metal poisoning: threat and management." <u>Al Ameen J Med Sci</u>**2**(2):4-26

Gallicchio, L., Scherer, R. W., Sexton, M., (2002)."Influence of Nutrient Intake on Blood Lead Levels of Young Children at Risk for Lead Poisoning." <u>Environmental Health Perspectives</u>**110**: A767–A772.

Gilbert, S. G., Weiss, B. (2006). "A rationale for lowering the blood lead action level from 10 to 2 µg/dl "<u>Neurotoxicology</u>**27**(5): 693-701.

Gordon, J.N., Taylor, A., Bennett, P.N., (2002). "Lead Poisoning: case studies." <u>Blackwell Science Ltd Br J ClinPharmacol</u>**53**: 451-458

Goswami, K., (2013). "Eye Cosmetic 'Surma': Hidden Threats of Lead Poisoning." <u>Indian Journal of clinical Biochemistry</u>**28**(1):71–73.

Grandjean, P., Landrigan, P. J., (2006). "Developmental neurotoxicity of industrial chemicals." Department of Environmental Health, Harvard School of Public Health, Landmark Center 3E-110, 401 Park Drive, Boston, MA 02215, USA.

Gunturu, K.S., Nagarajan, P.,McPhedran, P., Goodman, T.R., Hodsdon, M.E., Strout, M.P., (2011)."Ayurvedic herbal medicine and lead poisoning."<u>Journal of hematology and oncology</u> **4**:51

Hepp, N. M., Mindak, W. R., Cheng, J., (2009). "Determination of total lead in lipstick: Development and validation of a microwave-assisted digestion, inductively coupled plasma–mass spectrometric method." <u>Journal of Cosmetic science</u>**60**: 405-414.

Hernberg, S., (2000)."Lead Poisoning In a Historical Perspective."<u>American journal of industrial medicine</u>**38**:244-254.

Hill, R. (1998). What sample size is "enough" in internet survey research? Interpersonal Computing and Technology: An Electronic Journal for the 21st Century, 6(3-4). Retrieved July.

International Lead Association, (2014).<u>In: Lead Action 21, The Evolution of an Element</u>

Isaac, S., & Michael, W. B. (1995).Handbook in research and evaluation. San Diego, CA: Academic Press.

Jain, N.B., Laden, F., Guller, U., Shankar, A., Kazani, S., Garshick, E., (2005)."Relation between Blood Lead Levels and Childhood Anemia in India."American Journal of Epidemiology **161**: 968–973.

Jarrell J.F., Weisskopf M.G., Weuve J., Téllez-Rojo M.M., Hu H., Hernández-Avila M., (2006)."Maternal lead exposure and the secondary sex ratio."HumanReproduction**21**: 1901–1906

Jarup, L., (2003). "Hazards of heavy metal contamination" **68**: 167-82

Johanson, G. A., Brooks, G.P. (2010). "Initial Scale Development: Sample Size for Pilot Studies." Educational and Psychological Measurement**70**: 394-400.

John C Burnham (1999). Biomedical communication and the reaction to the Queenslandchildhood lead poisoning cases elsewhere in the world. Medical History **43**: 155-172

Juberg, D. R., (2000). "Lead and Human Health: An Update." American Council on Science and Health (ACSH): 5-62

Jusko, T. A., Henderson, C.R., Lanphear, B.P., Cory-Slechta, D.A., Parsons, P.J., Canfield, R.L. (2008). "Blood lead concentrations <10 µg/dl and child intelligence at 6 years of age." Environmental Health Perspectives**116**(2): 243-248.

Krishnaswamy, K., (1998). "Lead Toxicity."Indian pediatrics: Editorial**35**: 209-216.

Lessler, M.A., (1988). "Lead and Lead Poisoning from Antiquity to Modern Times."The Ohio Journal of Science**88**(3): 78-84.

Loghman-Adham, M., (1997)."Renal Effects of Environmental and Occupational Lead Exposure." Environmental Health Perspectives **105**: 928-939.

Marino, P. E., Landrigan, P. J., Graef, J., Nussbaum, A., Bayan, G., Boch, K., Boch, S., (1990)."A Case Report of Lead Paint Poisoning during Renovation of a Victorian Farmhouse."Am J Public Health**80**: 1183-1185.

Mcgrath, J. J., Barnes, C. D., (1982). Air Pollution-Physiological effects, Academic Press, Inc., New York.

Meza-Montenegro M. M., Valenzuela-Quintanar A. L., Balderas-Cortés J. J., Yañez-Estrada L, Gutiérrez-Coronado M. L., Cuevas-Robles A, Gandolfi A. J. (2013). "Exposure assessment of

organochlorine pesticides, arsenic, and lead in children from the major agricultural areas in Sonora, Mexico."Arch Environ ContamToxicol**64**(3): 519-27.

Nasser, L. A., (2014). "Molecular identification of isolated fungi, microbial and heavy metal contamination of canned meat products sold in Riyadh, Saudi Arabia." Saudi Journal of Biological Sciences.

Needleman, H. L., (1991). Human Lead Exposure CRC Press, Inc.

Needleman, H., (2004). "Lead Poisoning."Annu. Rev. Med. **55**:209-222

Nordberg, G. F., Fowler, B. A., Nordberg, M., Friberg, L., (2007).Handbook on the Toxicology of Metals Academic Press, USA.

O'Grady, K., Perron, A., (2011). "Reformulating Lead-Based Paint as a Problem in Canada."American Journal of Public Health**101**: 176–187.

Oskarsson, A., (1989). Exposure of Infants and Children to Lead Food and Agricultural Organization of the United Nations, Rome.

Patil A. J., Bhagwat V. R., Patil J. A., Dongre N. N., Ambekar J. G., Das K. K, (2007). "Occupational lead exposure in battery manufacturing workers, silver jewelry workers, and spray painters in western Maharashtra (India): effect on liver and kidney function." J Basic ClinPhysiolPharmacol.**18**(2): 87-100.

Rabin R., (1989). "Warnings Unheeded: Ahistory of child lead poisoning." American Journal of Public Health**79**: 1668-1674

Radošević Z., Šarić M., Beritić, T., Knežević, J., (1961)."The Kidney in Lead Poisoning."British journal of industrial medicine**18**(3): 222–230.

Reissman, D. B., Matte, T. D., Gurnitz, K. L., Kaufmann, R. B., Leighton, J., (2002). "Is Home Renovation or Repair a Risk Factor for Exposure to Lead Among Children Residing in New York City?" Journal of Urban Health: Bulletin of the New York Academy of Medicine**79**(4): 502-511.

Reyes, J.W., (2007). "Environmental policy as social policy? The impact of childhood lead exposure on crime." National Bureau of Economic Research

Rhainds, M., Levallois, P., (1997)."Effects of Maternal Cigarette Smoking and Alcohol Consumption on Blood Lead Levels of Newborns."American Journal of Epidemiology**145**: 250-257.

Rusyniak, D.E., Ibrahim, D., Froberg, B., Wolf, A., (2006). "Heavy Metal Poisoning: Clinical Presentations and Pathophysiology." Clinics in Laboratory Medicine**26**:67–97

Solidum, N. J., (2014). "Lead Levels in Fresh Medicinal Herbs and Commercial Tea Products from Manila, Philippines."**10**: 281 – 285.

Surkan, P. J., Zhang, A., Trachtenberg, F., Daniel, D.B., McKinlay, S., Bellinger, D.C. (2007). "Neuropsychological function in children with blood lead levels <10 μg/dl."NeuroToxicology**28**: 1170-1177.

Taylor, R. (2010). "Tobacco and lead toxicity."Reported to The LEAD Group Inc., Australia.

Taylor, R. J., (2010). "Nutrients that reduce lead poisoning."The LEAD Group Inc., Australia.

Téllez-Rojo M.M., Hernández-Avila M., Lamadrid-Figueroa H., Smith D., Hernández-Cadena L., Mercado A., Aro A., Schwartz J., Hu H., (2004). "Impact of Bone Lead and Bone Resorption on Plasma and Whole Blood Lead Levels during Pregnancy."American Journal of Epidemiology**160**:668–678

Tellez-Rojo, M. M., Bellinger, D.C., Arroyo-Quiroz, C., Lamadrid-Figueroa, H., Mercado-Garcia, A., Schnaas-Arrieta, L., Wright, R.O., Hernandez-Avila, M., Hu, H. (2006). "Longitudinal associations between blood lead concentrations lower than 10 μg/dl and neurobehavioral development in environmentally exposed children in Mexico city." Pediatrics**118**(2): e323-e330.

Titumir, R. A. M., Rahman, K. M. M., (2011) "Poverty and Inequality in Bangladesh."UnnayanOnneshan-The Innovators, Dhaka, Bangladesh.

Tola, S., Hernberg, S., Vesanto, R., (1976)."Occupational lead exposure in Finland.VI.Final report."Scand J Work Environ Health.**2**(2): 115-27.

Tong, S., Schirnding, Y.E., Prapamontol, T., (2000). "Environmental lead exposure: A public health problem of global dimensions." In: Bulletin of the world health organization**78**(9): 1068-1077.

Tripathi, R.K., (2008). "Lead in drinking water" <u>In: Virginia department of health: Division of environmental epidemiology.</u>

Vigeh, M., Yokoyama, K., Shinohara, A., Afshinrokh, M., Yunesian, M. (2010). "Early pregnancy blood lead levels and the risk of premature rupture of the membranes." Reproductive Toxicology 30: 477-480.

Wedeen, R.P., (2011). "Lead poisoning: the evolving definition." <u>Scientific Journal of Occupational and Environmental Medicine</u>**2**:1-3

Wexler, P., (2014). <u>History of Toxicology and Environmental Health</u>: Toxicology in Antiquity II, Volume 2, Academic Press.

WHO (2006)."Inorganic and Organic Lead Compounds."In: International Agency for Research on Cancer. World Health Organization, Geneva.

WHO (2010)."Exposure to lead: A major public health concern."In: preventing disease through healthy environments. World Health Organization, Geneva.

WHO (2010)a. "childhood lead poisoning."World Health Organization, Geneva.

WHO (2011). "Lead in Drinking-water." In: Background document for development of WHO Guidelines for Drinking-water Quality. World Health Organization, Geneva.

WHO (2014). In: International Lead Poisoning Prevention Week of Action, International programme on chemical safety. World Health Organization, Geneva.

Zazuli, M. A., Bandepi, A. M., Maleki, A., Saberian, M., Izanloo, H., (2010)."Determination of Cadmium and Lead Contents in Black Tea and Tea Liquor from Iran."<u>Asian Journal of Chemistry</u> 22(2): 1387-1393.

APPENDIX

Appendix 1: Questionnaire on sources of lead contamination and awareness among Bangladeshi women of child bearing age.

<u>Part I: Biography of the participant</u>

1.General information:

2.Religion (give tick mark to the left):

    a. Muslim
    b. Hindu

Name: _____ Date of birth: _____   Phone no :_____Address: _____ _____

    c. Christian
    d. Buddhist
    e. Others

3.Educational qualification (give tick mark to the left):

    a. Primary
    b. Secondary
    c. Higher secondary
    d. Graduate
    e. Post graduate

<u>Part II: questions regarding occupation</u>

4.Occupation:_____ ____Monthly income: _____

5.Do you do paid work outside the home?   Yes ☐   No ☐

6.Please mention your everyday work description:

7.Father's occupation: _____Monthly income: _____

8.Mother's occupation: _____Monthly income: _____

9.Husband's (if any) occupation: _____Monthly income: _____

10.Hobbies/occupations related to lead exposure (give tick mark on the left if you have any):

   a. Gardening
   b. Home renovation (e.g. painting, lighting)
   c. Stained glass/glass painting
   d. Pet handling
   e. Work in battery manufacturing industry
   f. Other: [_____]

Part III: questions regarding home and community

11. Age of the building you are living in [_____]

12. Is your house painted?   Yes [___]   No [___]

13. Do you use any insect killer/pesticide/herbicide at home?   Yes [___]   No [___]

14. If yes, what insect killer/pesticide/herbicide do you use? [_____]

15. Is your home near the highway/busy street/vehicle depot?   Yes [___]   No [___]

Part IV: questions regarding the use of cosmetics

16.Do you use kajal/surma?   Yes [___]   No [___]

17.Which brands kajal do you use? [_____]

18.Do you use lip stick? Yes [___]   No [___]

19.If yes, Which brands lipstick do you use? [_____]

20.How frequently do you use lipstick?

   a. Daily

b. Twice/thrice in a week
c. occasionally

<u>Part V: Questions regarding food habit</u>

21. Do you consume canned food?   Yes ☐   No ☐

22. If yes, What type of canned food do you usually eat?

   a. Fish
   b. Fruit juice
   c. Olive
   d. Cola drink
   e. Pickles
   f. Ghee

23. Do you use marketed turmeric powder?   Yes ☐   No ☐

24. What do you do with the visible fat on your meat?

   a. Eat all/most of the fat
   b. Eat some
   c. Eat as little as possible
   d. Don't eat meat

25. Do you use coloring agent in your food?   Yes ☐   No ☐

26. If yes, please mention the name:

27. If you have any of the following habit give tick mark to the left:

   a. Smoking cigarette
   b. Beetle leaf
   c. Sadapata
   d. Jorda

28. Do you have tea/coffee?   Yes ☐   No ☐

29. How many cups of tea/coffee do you drink per day?

   a. One
   b. Two
   c. More than two

30. Do you consume Ayurvedic or herbal medicine? Yes ☐   No ☐

31. What food did you take yesterday and day before yesterday? (please mention each and every item)

Yesterday	day before yesterday

Part VI: Questions regarding awareness

32. Have you ever heard of lead?   Yes ☐   No ☐

33. Do you know about lead poisoning is?   Yes ☐   No ☐

34. Do you know about the harmful effects of lead poisoning?   Yes ☐   No ☐

35. Do you know the sources/causes of lead poisoning?   Yes ☐   No ☐

36. If yes, please mention: _____

37. Do you know the remedies of lead poisoning?   Yes ☐   No ☐

38. From whom/where have you heard of lead? _____

39. How concerned are you about present lead poisoning condition in Bangladesh?
    a. Extremely concerned
    b. Very concerned
    c. Moderately concerned
    d. Slightly concerned
    e. Not at all concerned

40. How willing are you to reduce lead contamination?
    a. Extremely willing
    b. Very willing
    c. Moderately willing
    d. Slightly willing
    e. Not at all willing

41. Do you think Bangladesh government has taken proper steps to prevent lead contamination?
        Yes ☐   No ☐   Others (Explain if any _____)

42. Any suggestion regarding lead contamination and its awareness:

Apendix 2: Some Lead related study on Bangladesh at a Glance

No. of papers	01	02	03
Title	Lead poisoning: An alarming public health problem in Bangladesh.	Blood lead levels and health problems of lead acid battery workers in Bangladesh.	Blood lead levels of secondary school students in Dhaka, Bangladesh after the elimination of leaded gasoline and phase-out of two-stroke vehicles: study on one hundred children.
Author	Mitra *et al.*	Ahmed *et al.*	Ahmed *et al,*
Year	2009	2014	2011
Name of journal	Int. Journal of Environmental Research and Public Health.	The Scientific World Journal.	Journal of Pediatric Sciences.
Location	Bangladesh	Bangladesh	Bangladesh
Sample size	345	118	100
Method	Portable Lead Care instrument (ESA Inc., Chelmsford, MA, USA)	Stripping Voltammetry Technique	CDC, Atlanta (USA) approved protocols (ESA Inc., Chelmsford, MA, USA)
Material/Bio marker	Blood	Blood	Blood
Result	In urban nonindustrial area BLL ranged 0.50 -17.0 µg/dL, in rural nonindustrial area BLL ranged 1.4-63.1 µg/dL and in urban industrial area BLL ranged 9.5-64.0 µg/dL.	The mean blood lead level of the workers was found to be 65.25±26.66 µg/dL.	The overall geometric mean of BLLs was 15.31 µg/dL. Eighty four percent of the children had BLLs above CDCs permissible level lead for children.
Conclusion	Lead screening program for preschool and school children and a mass lead education program are recommended in order to increase parent's awareness of lead poisoning in Bangladesh.	High BLL and illness attributable to lead toxicity were prevalent amongst workers of the LAB manufacturing industries and this requires attention especially in terms of occupational hygiene and safety.	There is a substantial amount of accumulated lead in dust from earlier depositions and lead is still being used in an uncontrolled and un-regulatory manner in paints, batteries and other industrial works contributing to persistently high environmental lead levels.

No. of papers	04	05	06
Title	Lead, cadmium and nickel contents of vegetables grown in industrially polluted and non-polluted areas of Bangladesh.	Cadmium and lead pollution in sediments of the river Karatoa in Bangladesh.	Contaminated turmeric is a potential source of lead exposure for children in rural Bangladesh.
Author	Naser *et al*,	Zakir *et al*,	Mazumdar *et al*,
Year	2009	2013	2014
Name of journal	Bangladesh J. Agril. Res.	International Journal of Engineering Sciences.	Journal of Environmental and Public Health.
Location	Bangladesh	Bangladesh	Bangladesh
Sample size	3	28	309
Method	Atomic absorption spectrometry	Atomic absorption spectrometry	Portable Lead Care II instruments (Magellan Diagnostics, Billerica, MA, USA)
Material/Biomarker	Soil and edible vegetables	Sediment	Blood
Result	Lead content was found to be highest in tomato with a range of 1.027 to 1.968 µg/g, in spinach with a range of 0.767 to 1.440 µg/g and in cauliflower 0.486 to 1.119 µg/g.	The status of lead in sediments ranged between 5.94 to 99.99 µg/g having a mean value of 69.46 µg/g Out of 28 samples; 19 samples had lead concentration above the mean value.	The overall median finger stick blood lead concentration at approximately the age of 2.5 was 8.1 µg/dL. The mean venous blood lead concentration was 8.0 µg/dL (range 2.0-36.3 µg/dL).
Conclusion	Industrial effluents and urban pollution associated with sewage sludge, municipal waste water might have increased the levels of lead, cadmium and nickel intake of the vegetables and soils.	The degree of contamination of cadmium and lead in the study area is comparatively high, so it is desirable to take necessary initiative to minimize the pollution level as well as to monitor their concentrations in water and sediments routinely in future.	. Turmeric, a spice commonly used in Bangladeshi cooking, is a potential source of lead exposure. Further testing is needed to confirm these sources. Once identified, preventative measures can be taken.

No. of papers	07	08	09
Title	High levels of lead and cadmium in blood of children of Dhaka.	Blood lead levels of primary school children in Dhaka, Bangladesh.	Symptomatic lead poisoning in Bangladeshi children.
Author	Wahed *et al*,	Kaiser *et al*,	Khan, *et al*
Year	1999	2001	1999
Name of journal	-	Environ Health Perspect.	-
Location	Bangladesh	Bangladesh	Bangladesh
Sample size	49	779	-
Method	Atomic absorption spectrometry	Portable Lead Care instrument (ESA Inc., Chelmsford, MA, USA)	-
Material/Biomarker	Blood	Blood	Blood
Result	Blood lead level was higher in children of Tejgaon industrial area than Mohammadpur and Keraniganj area.	87.4% students have found with blood lead level more than 10µg/dL.	Children with psychomotor delay and behavioral problems were identified with extremely high blood lead levels.
Conclusion	General contamination of lead is high in Dhaka city and blood lead level is alarmingly high in children who live in high risk area.	Strategies should be planned to raise public awareness about lead. The laboratory capacities of Dhaka should be improved so that blood lead level can be measured.	. Damage of nervous system and brain may occur due to lead poisoning. Children from poor families are at high risk as they suffer from malnutrition.