KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI COLLEGE OF HEALTH SCIENCES DEPARTMENT OF HEALTH SERVICES, PLANNING AND MANAGEMENT

HEAVY METAL EXPOSURE AND SYMPTOMS OF RESPIRATORY INFECTION AMONG CHILDREN UNDER-FIVE (5) RESIDING NEAR AN OPEN DUMPSITE: A CROSS-SECTIONAL STUDY AT ABOKOBI

BY

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THIS DISSERTATION IS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER IN ENVIRONMENT AND PUBLIC HEALTH DEGREE

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DECLARATION

I, MICHAEL AFFORDOFE hereby declare that, except for references to other people's work which have been duly acknowledged, this thesis is my own original work and that this thesis has not been submitted to any institution by any student elsewhere.

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DEDICATION

I dedicate this project work to my late lovely Dad Togbui Opeku V. whose fatherly love and support has been the main pillar of my personality. I also dedicate it to My Mum, Regina Okain. Mum I love you so much. This piece of work is also dedicated to all my siblings.

ABSTRACT

The purpose of the study was to assess the prevalence of self-reported symptoms of Acute Respiratory Infection(ARI) defined as Acute Upper Respiratory Infection (AURI) and Acute Lower Respiratory Infection(ALRI), the levels of toxic metals in biological media (blood), and hand washed water among children under five (5) residing near Abokobi dump site in the Ga-East Municipality. Participation in the study was voluntary; based on that, a population of 200 children under five (5) and their parents residing within 200meters around the dumpsite were recruited as participants for the study. Descriptive statistics was used to present data.

It came out that, the proportion of self-reported symptoms of acute upper respiratory infection (AURI) and acute lower respiratory infection (ALRI) was high in all children respectively.

Cadmium was high in children aged 0-2years than 2-4 years and Lead was the same in ages 0-2years and 2-4 years in biological media (blood). Lead was the same in ages 0-2 years and 2-4 years while Cadmium and Mercury were high in Ages 2-4 years than ages 0-2 years in the handwashed water. There was significant association between residual levels of Arsenic in blood samples and symptoms of AURI. Similarly there was significant association between residual levels of Cd and symptoms of ALRI. However, there was no significant association between residual levels of the other toxic metals in blood samples and symptoms of AURI and ALRI. The study therefore recommended Parents should ensure regular medical checkup for children who live close to dumpsites for detection of symptoms of diseases to avert any health risk they may be exposed to. Ministry of Health should intensify public education on good practices in child care to avert the development of preventable diseases such as acute respiratory infections. The Ministry of Local Government through the Ga-East Municipal should create awareness on proper waste management practices. Finally, Local Government Ministry and the Ministry of Sanitation and Water Resources should permanently ban or prohibit the use of the dumpsite.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Open dumpsite technique is one of the poorest services provided by municipal officials in Africa and parts of Asia as the facilities are unscientific, obsolete and in-efficient. Solid waste disposal sites are located in and out of urban development towns. This waste is dumped into municipal disposal sites and owing to bad and ineffective leadership, dumpsites are turning to sources of environmental and health risks for individuals residing near them. (Sankoh et al. 2003)

Over the last three decades there has been increasing global concern over public health impacts attributed to environmental pollution, in particular, the global burden of disease. The World Health Organization estimates that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution (UNEP, 2015). Most of these environment-related diseases are however not easily detected and may be acquired during childhood and manifested later in adulthood (United Nations Environment Programme (UNEP), 2015).

Globally, dumpsites receive about 40 percent of the world's waste and serve about 3.5-4 billion individuals (ISWA, 2015). The 50 largest dumpsites impact 64 million people's daily life, a population of France's size (ISWA, 2015). As urbanization and population growth proceed, dumpsites are anticipated to serve more than several hundred million individuals, mainly in the developing world

(International Solid Waste Association Report (ISWA), 2014).
However, heavy metals maybe released into the environment from metal smelting and refining industries, scrap metal, plastic and rubber industries, and various consumer products and from burning of waste containing these elements. The

elements that are of concern include lead, mercury, cadmium, arsenic, chromium, zinc, nickel and copper. On release into the atmosphere, they travel for large distances and are deposited onto the soil, vegetation and water depending on their density. Once deposited, these metals are not degraded and persist in the environment for many years poisoning humans through inhalation, ingestion and skin absorption. Acute exposure leads to nausea, anorexia, vomiting, gastrointestinal abnormalities and dermatitis (UNEP, 2015)

In Ghana, management of waste is a very big challenge to most Metropolitan, Municipal and District Assemblies (MMDA'S) especially how to effectively dispose it. Abokobi is in no exception.

The populace of Ledzokuku-krowor, Madina-Nkwantanang, Ga-East and West and Adenta Municipalities all use Abokobi dump site of about 8,150.47 tons per month. Waste pickers sift through the waste to retrieve materials considered to be of value economically. They therefore set a portion of the dump site on fire enabling them to easily obtain some materials like copper and other metallic materials (Ga-East Municipal Assembly, 2014).

Children who like to play around the dumpsite are exposed to the smoke that emanates from the dumpsite because of the activities of the waste pickers making the children prone to respiratory tract infection and other health conditions. Furthermore, the dumping of electronic materials that has cadmium, mercury and arsenic as parts of its content may be left in the soil during the dumping or burning process of these metals (Jerie, 2016). Most Children especially those under the age of 5 are mostly naive and are found playing in the soil making them highly exposed to these trace metals which will highly make them prone to respiratory tract infection.

Therefore, it is a necessity to assess the levels of trace metals and the linkage with the effect of respiratory tract infection on children under five (5).

1.2 Problem Statement

Infectious diseases remain the main cause of death among children globally leading in nearly 4.4 million deaths in 2010 among children under the age of 5, despite significant improvements in immunization and sanitation programmes (Schuchat 2012; WHO 2010).

It is estimated that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution (UNEP, 2015). Most of these environmentally related diseases are however not easily detected and may be acquired during childhood and manifested later in adulthood (UNEP, 2015).

In Ghana, respiratory infections remain number two (2) on the top-ten causes of death (Global Burden of Disease Study (GBD) Compare 2018, Ghana).

These conditions may be attributed to the high level of environmental pollutions (improper management of waste (solid, liquid and gas). The major sources include; Hospital Waste, Agricultural Waste, Industrial Waste Domestic waste among others. Introduction of hazardous materials into the dumpsite releases heavy metals like Cadmium, Arsenic, Mercury, Lead etc. and other pollutants and contaminants into the environment.

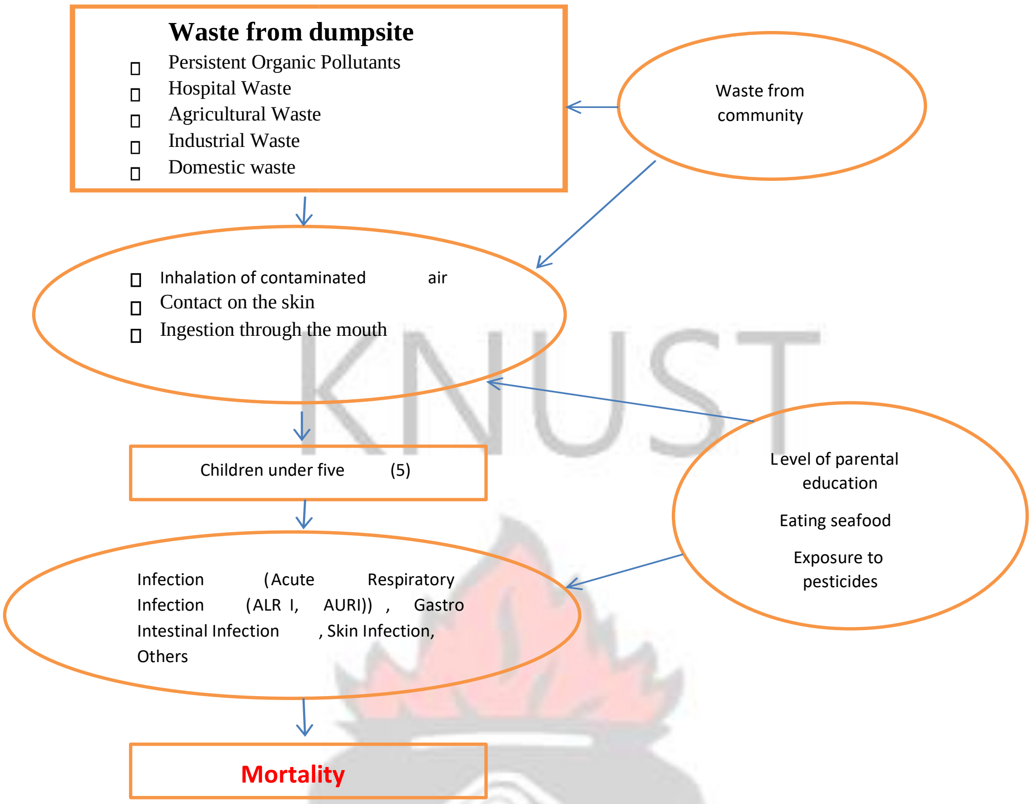
Exposure to this metals/pollutants/contaminants can lead to respiratory, gastroenteritis, neurological, immuno-suppression in the exposed individual (Donahoe et al., 2015).

There has been a public concern on the environmental hazards in connection with the Abokobi dumpsite. Mismanagement of the dumpsite has led to serious environmental hazards, which may dangerously bring about health consequences.”

At the Abokobi dumpsites, individuals, especially, children have visible health problems, including irritation and red eyes, runny nose, respiratory diseases, skin infection and stunted growth and so on (Personal Communication: Medical Officer at Pantang Hospital).

The research therefore seeks to assess the levels of exposure to heavy metals and self-reported symptoms of Acute respiratory infection among children under five(5) residing near the Abokobi dumpsite.

1.3 Conceptual framework



Source: Author's own construct

The figure above shows the relationship between toxic metals and other contaminants with acute respiratory tract infections in children under five (5).

Cadmium and Arsenic in municipal solid waste (MSW) landfill enters the waste stream from variety components of consumer products example used refrigerators, microwaves, among others. The total amount of Cd found in the municipal solid waste, enters the waste stream in the combustible fraction and can account for a major share of the Cd and As observed in fly ash and in atmospheric particulates. The most likely sources of Cd and As in the landfill are plastics, pigments, various industrial used and Nickel-Cadmium (NiCd) batteries (Edwin and Howell, 1990; ATSDR, 1999). The ingestion or inhalation of Cd may cause nausea, abdominal cramps, short breath, chocking fits, renal dysfunction and inhibition of iron absorption. Catarrhal and ulcerative gastroenteritis, congestion, pulmonary infarcts and subdural hemorrhages also may be found at necropsy (Donahoe et al., 2015).

Mercury in small, but varying concentrations can also be found virtually in all geological media (UNEP, 2010). Elemental and some forms of oxidized mercury are permanently coming to the atmosphere due to their volatility.

Arsenic exposure on the other hand affects virtually all organ systems including the cardiovascular, dermatologic, nervous, hepatobiliary, renal, gastro-intestinal, and respiratory systems (Tchounwou & Patlolla, 2003).

1.4 Justification of the Study

Different things are introduced into the environment in the quest of man to improve lives and make things easier. However, this can lead to contamination of the environment affecting both the soil and water as a whole. Contamination relates to the condition of soil or water where any chemical substance or waste has been added to the above ground level and is, or may be, an negative health or environmental impact (Worksafe, 2005). The persistence of heavy metals can lead to bioaccumulation and bio-magnifications that cause some bacteria to be more exposed than is the case in the ecosystem alone. (Adelekan & Abegunde, 2011). Contamination of heavy metals threatens the human population with agriculture and other food sources as well as bad vegetation development and lower plant resistance to forest pests. This scenario presents a distinct kind of remediation challenge. People can also be subjected to soil contaminants by ingestion (eating or drinking), dermal exposure (skin contact) or inhalation (breathing), penetration via the skin or eyes (includes exposure to dust) (Shayley et al., 2009; Worksafe, 2005). Heavy metal exposure is usually chronic due to food chain transfer (exposure over a longer period of time). But acute (instant) poisoning by ingestion or dermal contact is uncommon, but it is feasible (Kumar et al., 2010; USDA and NRCS, 2000; Wei & Yang, 2010). Heavy metal toxicity is one of the main environmental health issues and is possibly hazardous due to bioaccumulation through the food chain (Rajaganapathy, 2011). Globally, human operations have influenced the biogeochemical cycling of heavy metals, leading to a gradual increase in the flow of bioavailable chemical types into the atmosphere (Yildiz et al., 2010). The metals are dispersed, focused and chemically altered through human operations, which can boost their toxicity. Although very little is known about their combined impacts, the combination of heavy metals with other chemical substances produces hazardous cocktails. The existence of heavy metals in water undermines their quality, which ultimately impacts human health (Rajaganapathy, 2011). Discarded computers, televisions, stereos, copiers, fax machines, electrical lamps, cell phones, audio equipment and batteries if disposed incorrectly, lead and other substances can leach into soil and groundwater (Ramachandra & Saira, 2004). This improves the activity of recycling to retrieve heavy metals from different equipment, increasing the heavy metals concentrations in the setting. Therefore, the presence of heavy metals in soil and water must be determined. This will serve as a guide to assist with different remediation operations and to raise awareness about their exposure to animals.

1.5 Research Questions

1. What is the prevalence of self-reported symptoms of Acute Respiratory Infection (ARI)?

2. What are the levels of toxic metals in biological media (blood)?
3. What are the levels of toxic metals in handwashed water?
4. Are there any association between toxic metals (Cd, Pb, As and Hg) in blood & handwashed water and self-reported symptoms of ARI?

1.6 Objectives of the Study

1.6.1 General Objective

The general objectives of this study is to assess the prevalence of self-reported symptoms of Acute Respiratory Infection (ARI) defined as Acute Upper Respiratory Infection (AURI) and Acute Lower Respiratory Infection(ALRI), the levels of toxic metals in biological media (blood), and hand washed water among children under five(5) residing near Abokobi dump site in the Ga-East Municipality.

1.6.2 Specific objective

1. To determine the prevalence of self-reported symptoms of Acute Respiratory Infection (ARI)
2. To quantify levels of toxic metals in biological media (blood)
3. To quantify levels of toxic metals in handwashed water?
4. To determine the association between toxic metals (Cd, Pb, As and Hg) in blood & handwashed water and symptoms of ARI

1.7 Significance of Study

The outcome of this research would provide an overview of the crucial state of children living around dumpsites to enable stakeholders like Ministry of Health, Ministry of Local Government and Rural Development, Ministry of Environment, Science and Technology and Ministry of Sanitation and Water Resources to be properly motivated to act in the mitigation of these extensive exposures to heavy metals.

1.8 Limitations of the Study

Factors such as time were the researcher's limitation. Due to that, the researcher was not able to carry out the study on a large sample size.

1.9 Scope/Delimitation

The target group was limited to residents around the dumpsite only but could be applied elsewhere.

1.10 Structure of Report

The study comprises six main chapters. The synopsis of the study was given as: chapter one gives the introductory of the study, related literature was reviewed in chapter two, chapter three details out the method, concept and parameters used for the study. The data collection method and instrument were explained here. Analysis, interpretation and illustrations with appropriate tables and figures were discussed in chapter four. Chapters five and six concludes the study with a summary of the findings, conclusion and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Scope of the Review

The study comprises review of theoretical and empirical literature relevant to the study. These include; types of heavy metals, dumpsites and environment, dumpsite and respiratory infection.

2.2 Types of Heavy Metal

Heavy metal	Source of exposure to the environment	Minimium Level of hazard	Chronic exposure toxicity effects
Lead	Industrial and vehicular emissions, paints and burning of plastics, papers etc	Blood lead levels below 10mg per decilitre of blood	Impairment of neurological development, Suppression of the haematological system (anaemia), Kidney failure, immunosuppression etc.
Mercury	Electromagnetic and polymer waste, pesticides, pharmacological(production etc) and dental(syringe etc) waste	Less than 10 micrograms per deciliter of blood; oral RfD 4mg/kg/da	Digestive and lung irritation, renal failure, neurotoxic
Cadmium	Electromagnetic and polymer waste, batteries-diet and water	Under 1 microgram per decilitre of blood	Local irritation of the lungs and gastrointestinal tract, kidney damage and defects of skeletal system
Arsenic	Herbicides and pesticides, equipment, waste combustion containing the hazardous elements, contaminated water	Oral exposure of 0.0003mg/kg/day	Liver peripheral nerve infection-neuropathy, hepatitis, neck and lung disease, upper respiratory system infection-pharyngitis, laryngitis, rhinitis, anaemia, heart (circulatory) disease

(*Agency for Toxic Products and Disease Registry (ATSDR). Toxicological profile for lead.US Department of Health and Human Services; Public Health Services), (Young R. Toxicity summary for Mercury, Cadmium. 1992) and (Opresko DM. Toxicity summary for Arsenic.1992.)*

2.3 Dumpsites and Environment

Mercury (Hg)

Mercury is generally found at very low concentrations and is very reactive in the environment. Total mercury levels are generally less than 10 ng/g in crustal materials such as granites, feldspars and clays (Davis et al., 1997), and in the range of 40 to 200 ng/g in soils and sediments that are not directly impacted by anthropogenic discharges. Generally, the majority of mercury in aquatic systems is in organic forms (about 95 to 99%) and is found in sediments rather than the dissolved phase. There are both natural and anthropogenic sources of mercury to the environment. For example, mercury is a trace component of many minerals and economic ore deposits for mercury occur as native mercury and Cinnabar (HgS). Various industrial discharges, coal combustion and medical waste incineration are important anthropogenic sources. Abandoned mines, where mercury was used for extraction purposes, are also important sources.

General Waste Information

Inorganic mercury exists in three known oxidation states: as elemental mercury (Hg°), as mercurous ion (Hg+) and as mercuric ion (Hg2+). The oxidation state of mercury in an aqueous environment is dependent upon the redox potential, the pH, and the nature of the anions and other chemical forms present with which mercury may form stable complexes (Reimers*et al.*, 1974). Mercurous compounds (Hg+) are not common as they are rapidly oxidized to mercuric forms (Hg2+) by hydrolysis (Booer, 1944). The presence of organic matter in the sediments can either enhance mercury mobility, by forming soluble organic complexes, or retard mobility, by creating an environment conducive to precipitation of mercuric sulphides. The presence of iron oxyhydroxides (precipitated from the seepage waters) at the sediment surface may also scavenge mercury by absorption onto the hydrated oxyhydroxide surface. In general, the sediment water interface tends to accumulate inorganic mercury, and both pore water and the water column are possible sites for mercury methylation (Beak International Incorporated, 2002).

An important characteristic of mercury is its low solubility as a result of its high probability to coagulate that is to be removed from the soluble aqueous phase. This can occur by a number of physicochemical processes, example, precipitation as mercuric sulphide, co-precipitation with hydrated iron and manganese oxides, complexation with organic matter. The solubilization/coagulation of mercury depends on the forms of mercury present, on the amounts and nature of the organic and inorganic matter present, as well as on the environmental conditions, example, pH and chloride levels. Balogh et al. (1998) showed that total mercury levels in water are strongly correlated with total suspended solids concentrations, suggesting that mercury can remain suspended in the water column attached to colloidal and particulate matter. In aquatic systems, dissolved mercury can be partitioned between inorganic and organic forms and this is largely controlled by rates of methylation and demethylation by microorganisms (Pak and Bartha, 1998). Organic mercury can occur as an organomercuric salt (RHgX), example, methylmercuric chloride, or as an organomercuric compound (R_2Hg), example, dimethylmercury. While the majority of mercury in aquatic ecosystems is in the inorganic form (about 95 to 99 %) (Krabbenhoft, 1996), organic mercury complexes remain important influences on the mobility and bioavailability of mercury. Evidence suggests that, when dissolved mercury in natural water systems exists mostly in organic forms, a high level of mercury in fish tissues is observed

(Gill and Bruland, 1990). Mercury methylation is a biologically mediated process between dissolved inorganic mercury and, primarily, sulphate reducing bacteria (Driscoll, et al., 1994).

The factors that influence the amount of methyl mercury present in an aquatic system include the amount of dissolved inorganic mercury and physicochemical characteristics of the aquatic system such as pH, organic matter, dissolved sulphate and sediment sulphide (Pak and Bartha, 1998). For example, mercury methylation activity in sediments was found to be positively correlated with the level of organic matter (Driscoll *et al*., 1994). Thus, anaerobic zones such as the basins of small lakes, flooded forest soils and wetlands provide ideal conditions for mercury methylation.

However, the science of mercury methylation and dimethylation is not fully understood, and rates of methylmercury formation are not readily predictable. The relative abundance of methylated mercury species is of particular concern since these compounds are highly toxic, they are the major form of mercury that accumulates in fish tissues, and they can enter the food chain by direct uptake from solution (Driscoll, et al., 1994). Two aspects of chemical structure confer the unique toxic properties of methyl mercury. The bond between mercury and the methyl group is stable, with the methyl group providing a lipophilic character to the compound, while Hg (II) has a tendency to bind with sulfhydryl (or selenol) groups (Craig, 1986; Carty & Malone, 1979). Consequently, methylmercury is both membrane permeable and thiol reactive, properties which contribute to the toxicity, the long biological half-time, and the tendency toward bioaccumulation of mercury in aquatic organisms.

The organomercuric salts exhibit properties and reactions similar to those of inorganic mercuric salts, and thus do not bioaccumulate as well as methylmercury.

The organomercuric compounds other than methyl mercury species are generally subject to abiotic environmental degradation, being volatile, thermally unstable and light sensitive, example, decomposition by ultraviolet radiation to elemental mercury and free radicals.

Considerations for Mine Effluents and Receiving Waters

Mine effluent likely contains dissolved inorganic species of mercury. The behaviour of inorganic mercury species is well known and thermodynamic data are available. Two mercury compounds are predominant: hydrated mercuric oxide ($HgO·H2O$) at high pH and mercuric chloride ($HgCl2$) at low pH. However, at high concentrations of chlorides (and low pH), the very stable and water-soluble mercuric tetrachloride complex ($HgCl4$) will form. The receiving environment has a variety of biogeochemical conditions that may influence the behaviour of mercury. The formation and dissolution of inorganic Hg solids is controlled by redox and pH conditions and redox conditions in particular occur over a wide range in surface water environments. Under aerobic conditions, at lower pH, mercuric chloride is the dominant solid, and at higher pH hydrated mercuric oxide is found. Waters in equilibrium with these solids would have very high concentrations of mercury. For example, water in equilibrium with mercury hydroxide $Hg(OH)_2$ has mercury concentrations that range from approximately 350 mg/L at pH 6 to approximately 75 mg/L at pH 8 to 11. Because mercury is not found in effluents at concentrations near these levels, it is unlikely that solids precipitation will affect mercury concentrations in mill effluent.

Under anaerobic conditions, mercury is stable in two forms: elemental mercury and mercuric sulphide. Mercury exhibits a very high affinity for sulphide in mildly reducing environments such as stream and lake sediments, forming the relatively insoluble mercury sulphide (HgS (s)) (Davis et al., 1997; Wang & Driscoll, 1995). Typical pore water concentrations range from approximately 2 ng/L at pH 6 to several mg/L at pH values greater than 8.5. In highly anaerobic systems, the mercuric sulphide may be reduced to elemental mercury and sulphide, whereas under alkaline conditions with high levels of sulphides the more soluble mercuric disulphide complex (HgS22-) may exist.

Cadmium

Contrasting numerous other metals, cadmium has been used by man, only relatively in recent times. It was discovered independently and almost simultaneously by the two German investigators, (ATSDR, 1999). It is an element that occurs naturally in the earth's crust and got rank 7 of ATSDR's "Top 20 list" (ATSDR, 1999). Because Cadmium is found in insecticides, fungicides, sludge, and commercial fertilizers which are consistently used in agriculture; its percentage in the upper soil has been snowballing. Dental alloys, electroplating, motor oil and exhaust are other sources of Cd pollution. Hence, anthropogenic activities have augmented Cd magnification in the environment. 10% of total Cadmium in the environment is consequential from natural sources, whereas remaining 90% is derived from anthropogenic activities (Okada, et al., 1997). Volcanic activities contribute about 62%of natural emissions and other natural causes include decaying of vegetation (25%) airborne soil particles (12%) and forest fire (2%). Its non-corrosive and accumulative nature has made it very important to its applications in electroplating or galvanizing. Cadmium is used for the following: batteries (83%), pigments (8%), coating and plating (7%), stabilizers for plastic (1.2%), nonferrous alloys, photovoltaic devices, and other uses (0.8%) (Thornton, 1992). Anthropogenic undertakings like; smelting operations, use of phosphate fertilizers, pigment, cigarettes' smokes, automobiles etc. have contributed to the admittance of cadmium into human and animal food chain (WHO, 1992; Okada, et al.,1997; Kumar, et al., 2007).

Chemical and physical properties of cadmium

In crystalline form, cadmium forms a close-packed hexagonal, silver white metal (Dunnick et al., 1979). The only valence state for cadmium is Cd^{2+}

Major compounds of cadmium include Cadmium Acetate, Cadmium Chloride, Cadmium Nitrate, Cadmium Oxide, Cadmium Sulphates and Cadmium Sulphide. Some physical and chemical properties of cadmium include atomic number 48 a.m.u, Atomic weight 112.411g/mol, electronegativity 1.5, crystal ionic radius 0.97, ionization potential 8.993, 0xidation state of +2, electronic configuration [Kr] $4d15s^2$, density of 8.64g/cm^3, melting point of 320.9^oC, boiling point of 76^oC.

Effluents from industries involved in mining, manufacturing, electroplating, agriculture, motor oil, paints etc. are sources of cadmium into aquatic environments. Most aquatic organisms have the capability of concentrating metals by feeding and metabolic processes, which can lead to accumulation of

extraordinary concentrations of metals in their tissues. Metals interact with ligands in proteins particularly; enzymes and may inhibit their biochemical and physiological activities (Passow, et al., 1961) metals by feeding and metabolic processes, which can lead to accumulation of extraordinary concentrations of metals in their tissues. Metals interact with ligands in proteins particularly; enzymes and may inhibit their biochemical and physiological activities (Passow, et al., 1961). Cadmium belongs to Group II of the Periodic Table. It is found mainly in magmatic and sedimentary rocks with concentrations up to 0.3 μg/g. In the weathering process of the rock minerals; it moves enthusiastically into the soil solution, where it is generally found in the form Cd^{2+}. This chemical form is the most common form of Cd. Other ionic forms that may be found in the soil solution

are: $CdC^{l+,}$ $CdOH^{+}$, $CdHCO^{3+}$, $CdCl^{3-}$, $CdCl_4^{2-}$, $Cd(OH)^{3-}$ and $Cd(OH)_4^{2-}$ (KabataPendias, et al., 1992). Cadmium and other metals released from mining sites can contaminate drinking and other water sources (Pep low et al. 2004; Younger et al. 2002). As metals are both; persistent and toxic; metal contamination in aquatic systems is a particular apprehension (Clark, 1992). When, where, and how an animal consumes cadmium can play a role in behavior of its effect. Animals that accumulate cadmium in their bodies ("body burden") can be eaten by others, and so on, such that cadmium will both accumulate and biomagnified in the food chain (EPA, 2000). Fish can accumulate cadmium from the water and by eating foods contaminated with cadmium (contaminated food chain). It is important to note that bioaccumulation as well as bio magnification occur when a substance cannot be easily metabolized or excreted. Cadmium exhibits this persistence (ATSDR Medical Fact-Sheet, 2008).

Arsenic

According to (Tchounwou, et al., Author manuscript; available in PMC 2014 August 26), Arsenic is a ubiquitous element that is detected at low concentrations in virtually all environmental matrices. Arsenic as a ubiquitous element that is found in all small concentrations in atmosphere, in aquatic environments, in soils and sediments and in organism, occurs as a major constituent in more than 200 minerals as elemental (World Health Organization ,1981).

Environmental pollution by arsenic occurs as a result of natural phenomena or processes (such as weathering, biological and volcanic eruptions, soil erosion) and anthropogenic activities. Study shows that in Ghana as well as Finland a typical anthropogenic sources has been mining activities, paint oil refinery industries, and landfills (Hakala & Hallkainen, 2004). Several arsenic-containing compounds are produced industrially, and have been used to manufacture products with agricultural applications such as insecticides, herbicides, fungicides, algicides, sheep dips, wood preservatives, and dye-stuffs. They have also been used in veterinary medicine for the eradication of tapeworms in sheep and cattle. Arsenic compounds have also been used in the medical field for at least a century in the treatment of syphilis, yaws, amoebic dysentery, and trypanosomaiasis (Hutchinson, 1887). Arsenic-based drugs are still used in treating certain tropical diseases such as African sleeping sickness and amoebic dysentery, and in veterinary medicine to treat parasitic diseases, including filariasis in dogs National Academy of Science (1977).

It was estimated that several million people are exposed to arsenic chronically throughout the world, especially in countries like Ghana, Bangladesh, India, Chile, Uruguay, Mexico, and Taiwan, where the ground water is contaminated with high concentrations of arsenic. Exposure to arsenic occurs via the oral route (ingestion), inhalation, dermal contact, and the parenteral route to some extent (ATSDR, 2000., Tchounwou, et al., 1999). Arsenic concentrations in air range from 1 to 3 ng/m^3 in remote locations (away from human releases), and from 20 to 100 ng/m^3 in cities. Its water concentration is usually less than 10μg/L, although higher levels can occur near natural mineral deposits or mining sites like Obuasi, Tarkwa, and Konogo and among others in Ghana. Its concentration in various foods ranges from 20 to 140ng/kg. Natural levels of arsenic in soil usually range from 1 to 40 mg/kg, but pesticide application or waste disposal can produce much higher values.

Analyzing the toxic effects of arsenic is complicated because the toxicity is highly influenced by its oxidation state and solubility, as well as many other intrinsic and extrinsic factors. Several studies have indicated that the toxicity of arsenic depends on the exposure dose, frequency and duration, the biological species, age, and gender, as well as on individual susceptibilities, genetic and nutritional factors. Most cases of human toxicity from arsenic have been associated with exposure to inorganic arsenic. Inorganic trivalent arsenite (As_{III}) is 2–10 times more toxic than pentavalent arsenate As (V). By binding to thiol or sulfhydryl groups on proteins, As (III) can inactivate over 200 enzymes. This is the likely mechanism responsible for arsenic's widespread effects on different organ systems. As (V) can replace phosphate, which is involved in many biochemical pathways. One of the mechanisms by which arsenic exerts its toxic effect is through impairment of cellular respiration by the inhibition of various mitochondrial enzymes, and the uncoupling of oxidative phosphorylation. Most toxicity of arsenic results from its ability to interact with sulfhydryl groups of proteins and enzymes, and to substitute phosphorous in a variety of biochemical reactions (Tchounwou, et al., 2014). Arsenic in vitro reacts with protein sulfhydryl groups to inactivate enzymes, such as dihydrolipoyl dehydrogenase and thiolase, thereby producing inhibited oxidation of pyruvate and beta-oxidation of fatty acids. The major metabolic pathway for inorganic arsenic in humans is methylation. Arsenic trioxide is methylated to two major metabolites via a non-enzymatic process to monomethylarsonic acid (MMA), which is further methylated enzymatically to dimethyl arsenic acid (DMA) before excretion in the urine (Tchounwou, et al., 2003, Hughes, 2002). It was previously thought that this methylation process is a pathway of arsenic detoxification, however, recent studies have pointed out that some methylated metabolites may be more toxic than arsenite if they contain trivalent forms of arsenic (Tchounwou, et al., 2003).

Tests for genotoxicity have indicated that arsenic compounds inhibit DNA repair, and induce chromosomal aberrations, sister-chromatid exchanges, and micronuclei formation in both human and rodent cells in culture and in cells of exposed humans.

Reversion assays with Salmonella typhimurium fail to detect mutations that are induced by arsenic compounds. Although arsenic compounds are generally perceived as weak mutagens in bacterial and animal cells, they exhibit clastogenic properties in many cell types in vivo and in vitro (Basu, et al., 2001). In the absence of animal models, in vitro cell transformation studies become a useful means of obtaining information on the carcinogenic mechanisms of arsenic toxicity. Arsenic and arsenical compounds are cytotoxic and induce morphological transformations of Syrian hamster embryo (SHE) cells as well as mouse C3H10T1/2 cells and BALB/3T3 cells (Landolph, 1989; Takahashi, et al., 2002).

Based on the comet assay, it has been reported that arsenic trioxide induces DNA damage in human lymphophytes and also in mice leukocytes (Saleha, et al., 2001). Arsenic compounds have also been shown to induce gene amplification, arrest cells in mitosis, inhibit DNA repair, and induce expression of the c-fos gene and the oxidative stress protein hemeoxygenase in mammalian cells (Saleha et al., 200; Hartmann & Peit, 1994). They have been implicated as promoters and comutagens for a variety of toxic agents (Barrett, 1989).

Diet, for most individuals, is the largest source of exposure, with an average intake of about 50 µg per day. Intake from air, water and soil are usually much smaller, but exposure from these media may become significant in areas of arsenic contamination. Workers who produce or use arsenic compounds in such occupations as vineyards, ceramics, glassmaking, smelting, refining of metallic ores, pesticide manufacturing and application, wood preservation, semiconductor manufacturing can be exposed to substantially higher levels of arsenic (National Research Council, 2001). Arsenic has also been identified at 781 sites of the 1,300 hazardous waste sites that have been proposed by the U.S. EPA for inclusion on the national priority list (National Research Council, 2001). Human exposure at these sites may occur by a variety of pathways, including inhalation of dusts in air, ingestion of contaminated water or soil, or through the food chain (Tchounwou & Centeno, 2008).

Contamination with high levels of arsenic is of concern because arsenic can cause a number of human health effects. Several epidemiological studies have reported a strong association between arsenic exposure and increased risks of both carcinogenic and systemic health effects (Tchounwou, et al., 2003). Interest in the toxicity of arsenic has been heightened by recent reports of large populations in Ghana including West Bengal, Bangladesh, Thailand, Inner Mongolia, Taiwan, China, Mexico, Argentina, Chile, Finland and Hungary that have been exposed to high concentrations of arsenic in their drinking water and are displaying various clinic pathological conditions including cardiovascular and peripheral vascular disease, developmental anomalies, neurologic and neurobehavioral disorders, diabetes, hearing loss, portal fibrosis, hematologic disorders (anemia, leukopenia and eosinophilia) and carcinoma (Tchounwou, 2004; ATSDR, 2000; Centeno 2005).

Arsenic exposure affects virtually all organ systems including the cardiovascular, dermatologic, nervous, hepatobiliary, renal, gastro-intestinal, and respiratory systems (Tchounwou et al. 2003)

Again according to (Tchounwou et al., 2003), research has also pointed to significantly higher standardized mortality rates for cancers of the bladder, kidney, skin, and liver in many areas of arsenic pollution. The severity of adverse health effects is related to the chemical form of arsenic, and is also time- and dosedependent. Although the evidence of carcinogenicity of arsenic in humans seems strong, the mechanism by which it produces tumors in humans is not completely understood.

Environmental Effects of Arsenic

As is considered one of the most toxic metals for humans, animals and plants. The toxicity of Arsenic is dependent on chemical forms, speciation, oxidation state and its complexes with organic ligands and inorganic substances (e.g. Cullen & Reimer, 1989; Pongratz, 1998; Huang, et al., 2011). The volatile arsines, arsine, monomethylarsine (MMAA), dimethylarsine (DMA) and trimethylarsine (TMA) are the most toxic As compounds to mammals (Petrick et al. 2000). They are anyhow readily oxidized to less toxic As products and in general, inorganic forms arsenite (III) and arsenate (V) are known to be the most toxic predominant As species (Poser, 2006; Zavala et al., 2008; Huang et al. 2011). Organic forms like monomethylarsonic acid (MMAA) and dimethylarsinic acid (DMAA) are less toxic and organ Asarsenonobetaine (AsB) and arsenocholine (AsC) are considered to be non-toxic (Cullen & Reimer 1989, Pongratz 1998). Among inorganic forms, arsenite is 25-60 times more toxic than arsenate (Violante et al. 2008). Inorganic As have capability to alter metabolic pathways (Peralta-Videa et al.2009). Because different species exhibit wide-ranging levels of toxicity to various organism, the toxicity of As should be examined by analyzing As should be examined by analyzing As speciation instead of total concentration.

2.4 Dumpsite and Respiratory Infection

The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of age, race, religion, and political belief, economic or social condition (WHO 1998). WHO (1979, 1984) and Grant (1980) have stressed that the health status of children in any country is very crucial because it is an indicator for measuring socio-economic development as well as for determining the future prospects of a country. Gwatkin, (1980) has also stated that for children to grow into healthy able adults, and to live through the perilous first years of life, they need good food, clean water, education, and medical care. Besides these factors, they also need to be boom healthy and need mothers who are healthy as well as the families that can give them care and attention.

Childhood diseases in developing countries are mainly malaria, diarrhoea, measles, neonatal tetanus, whooping cough, tuberculosis and bronchopneumonia (Morley & Mac William, 1961; Ghana Statistical Service 1998). Out of every three deaths that occur in the world one is a child under the age of five. Grant, (1990) has noted that almost all childhood diseases are preventable. With vigorous public education on health promotional practices coupled with compulsory immunization for all children in developing countries, the wide gap in infant mortality between developed and developing countries will be narrowed. Grant, (1990) has anticipated that every week more than a quarter of a million children will die in a quiet carnage of infection and under nutrition. In sub-Saharan Africa, this problem has assumed worse dimension due to frequent political and tribal upheavals coupled with poor management of the National economy.

In Ghana, since the attainment of political independence many policies and programmes have been adopted to improve the health status of children. Such interventions include the establishment of Ghana National Commission on Children in 1979, the adoption of Primary Heath Care Programme, and the ratification of the United Nations Convention on the Right of the Child and Education on Nutrition and Vitamin Supplements.

Through such interventions, Ghana has reduced infant mortality from 100 per 1000 live births to 57 per 1000 live births in the past 20 years. This led to a percentage decline of 43 while under five mortality fell by an equal amount from 187 to 108 deaths per 1000 live births in 1996 (Ghana Demographic and Health Survey, 1998). GDHS (1998) has indicated that childhood morbidity in Ghana is attributed mainly to acute respiratory infection (ARI), malaria and diarrhoea. Acute respiratory infections (ARI) are found in either the upper or lower respiratory tract. Signs and symptoms for upper respiratory tract infections include common cold, frequent sneezing, and restlessness and cough while that of the lower tract include foul breath, fast breathing, difficult breathing, cough and chest in-drawing.

"In Ghana, 14 percent of children under five years of age show symptoms of ARI (GDHS, 1998). The prevalence of ARI varies by age of the child. Children aged between 6 - 1 1 months are the most vulnerable to this disease. Rural children are more susceptible to ARI than urban children. Children of mothers with little or no education are also very vulnerable than those with post-secondary education. This is because mothers with higher educational levels may be more aware of the causes of ARI and preventive health care strategies than the mothers with little education. ARI could be treated with antibiotics when diagnosed early (GDHS, 1998). The use of health facility for the treatment of ARI symptoms is low in Ghana. One in every four children suffering from the symptoms of ARI uses modem health facility. The most preferred facility for the treatment of ARI is through pharmacies and or drugstores, which signifies that self- medication is an important treatment outlet for ARI in Ghana (GDHS 1998). This scenario should prompt policy makers on the enormity of the task in promoting child health. In this light, health-seeking behaviour should be sought in a more diversified manner to include all ranges of practices that exist in both the traditional and western bio-medical health care systems. Omorodion, (1993) has stressed that it is when the above realization has been met that total health belief that influences mother's treatment decision and behaviour would be understood and subsequently help in the effective management of childhood diseases.

A number of writers have written on various aspects on children. These include sociologists and anthropologists, clinicians, and policy makers. Child health attracts writers because it is a critical index for assessing the level of a nation's development. Ruutu et al. (1994) in their expository study on respiratory infections have stated that until 1979, many developed countries did not consider childhood Acute Respiratory Infection (ARI) as a threat to the survival of children. This situation was due to unreliability of official statistics and the inability of health practitioners to establish a relationship between specific causative agents of childhood ARI.

These situations according to them have led to many preventable deaths among children. Most of such deaths were considered mysterious and were thought to emanate from spiritual causes.

Even though Ruutu's study was the collection of other people's work, it is an important source for understanding the history and early perceptions on the etiology of childhood ARI. The educational component in his study is also instrumental in understanding control programs of ARI in developing countries where most mothers home treat their children suffering from ARI.

Lang, et al., (1986) made another important contribution to the understanding of the management of childhood ARI. This was a longitudinal study carried from February 1983 to March 1984 in Bana Township, in Burkina Faso. The study was designed to assess the importance of ARI as a source of morbidity and also to determine the factors that influence its incidence, so that control strategies can be implemented.

The outcome of Lang et al's study was that all children under study have as many as 8 to 13 episodes of ARI in a year. It also indicated that as high as half of the yearly incidence of ARI emanates from acute lower respiratory conditions. Lang et al. further indicated that a child with an aim circumference of less than 13.5cm suffers more episodes of both upper and lower respiratory infections than were children with larger arm circumference. Mtango and Neuvian (1986) also undertook a longitudinal study in Tanzania to evaluate case-management strategies for the control of ARI. These strategies stressed early detection of Acute Lower Respiratory Infection (ALRI) through the identification of danger signs and symptoms such as chest in -drawing and fast breathing. The education on the appropriate antibiotic treatment of primary health care personnel and mothers was also emphasized."

The longitudinal studies (Lang et al, 1986; Mtango & Neuvian, 1986) have proven to be more effective in providing detailed information on the incidence of ARI morbidity and mortality. However, their use is limited by the fact that they are expensive and time-consuming in execution. Due to these constraints, there are very few of such studies on childhood ARI.

Other studies on etiology of childhood ARI have been carried out. One of such studies was undertaken by Wall et al (1986). Their studies researched into bacteria etiology of pneumonia in the Gambia. It was also found that the most dominant bacterium in the culture was streptococcus pneumonia.

Omer, et al. (1985) also undertook a bacteriology study on sore throats in the Sudanese population. A total of 164 outpatients were used for this study. The study found out that bacteria constitute an important cause of sore throat among the outpatients who attend hospital in the Sudan, and their relative isolation rate was 51 percent.

Berman and McIntosh (1985) conducted another study on bacteria etiology on ARI. They aimed at improving strategies for the control of ARI in developing countries. The outcome of their study was that as high as 65 percent of the patients were infected with bacteria causing pneumonia and the dominant bacteria were haemophilus influenza and streptococcus pneumonia.

In Kenya, Mutie, et al., (1976) looked at viral etiology of severe ARI. The study examined 41 children aged less than two years old who were admitted for bronchiolitis or bronchopneumonia. The study found that 39 percent of the patients had Respiratory Syncytial Virus (R S V) infections, 7.3 percent had Parainfluenza Vims and less than 5 percent of the patients were infected with adeno virus, cytomegalo virus, echo virus and rhino virus.

The review of these studies (Mutie, et al., 1976; Berman & McIntosh, 1985; Omer, et al., 1985; Wall, et al., 1985) on bacterial and viral etiology of ARI has established that bacterial infections constitute the most common cause of acute lower respiratory infections. However, some limitations to these studies were that, their studies only concentrated on episodes of acute lower respiratory infections without highlighting upper respiratory tract infections. This weakness does not make the study complete since any holistic study on ARI should include episodes on both lower and upper tract infections. Also these studies were mainly epidemiological in nature. They did not consider ethnomedical perceptions on the etiology of ARI. The lack of ethnomedical perceptions on the etiology of ARI can hamper the effectiveness of any control programme.

Tupasi, et al., (1990) undertook an ARI risk reduction study in the Philippines. The study sought to establish a relationship between malnutrition and acute respiratory tract infections in Filipino children. The study found out that malnourished children Senah, et al., (1994) in their anthropological study in the Kasena and Nankane communities in the Upper East Region of Ghana indicated how sociocultural practices affect childhood mortality and morbidity. The study found among others that, there is extremely high gender bias against women in such communities such that their level of participation in decision-making and access to the acquisition of income and other property are virtually non-existent. The ripple effect of these practices on their children is that women are always constrained in terms of decision - making and material support when their children are sick. It was also found that even though mothers know how to manage childhood diseases such as cough, malaria, diarrhoea and measles, they are not allowed to manage these ailments themselves when their children are ill. This is because such roles are the joint responsibilities of the head and the senior woman in the compound.

Malm, et al., (1994) in their study of caretakers' perceptions of ARI and home management practices in the Dangme West District described the local terminologies that are used to describe ARI. They also determine danger signs and symptoms of ARI, and home management practices associated with ARI. Among others, the study indicated that there are ten (10) ARI related illness terminologies

in the Dangme West District. The choice for health care outlet for the treatment of ARI varies according to what caretakers perceive to be the cause of the illness. Awedoba, et al., (1995), carried out an ethnographic study in the Brong Ahafo, Upper West and Volta regions of Ghana. The study focused on identifying the local terminologies, danger signs, perceived cause, and partners in health seeking for the treatment of childhood ARI. It was found that there was no single term for describing ARI. Different-local names were used to describe such disease episodes. Pneumonia was identified to be the most threatened form of ARI. The main cause was attributed to cold air entering the head or chest of children. It was also observed that fathers were involved in health care decision most of the time (56.7 percent of the cases). Iyun and Goran (1996) focused on mothers' perceptions on etiology and treatment of childhood ARI in rural settlements in Oyo State,
Nigeria. Most mothers regarded ARI episodes as ordinary coughs and cold. Mothers believed that these are mostly caused by exposure to cold. The dominant treatment practices was either the use of irritants (bitter remedies) such as drinking cow urine to help the child vomit obstructed mucus, or the use of remedies with warming and soothing properties.

Muhe, (1996) conducted another ethnographic study. He emphasised on mother's perception on the nature, signs and symptoms of ARI in an urban community in Ethiopia. The study found that mothers considered ARI episodes as cold and cough. ARI was considered to be serious when it becomes persistent. He also found that runny nose, fast breathing, fever, cough, restlessness; body pains are some of the general signs and symptoms of childhood ARI.

Bamikale, et al., (1997) used survey methods to study the impact of cultural beliefs on mother's management of childhood diseases in Yoruba, Nigeria. The main concern for the study was to determine the perceived etiology of measles, diarrhoea and malaria and to determine whether mother's believed in the existence of spirit children. The study showed that 4.4 percent of the mothers have adequate knowledge of the cause of measles, 55.8 percent of diarrhoea, and66.4 percent of malaria. It was also found that majority of mothers (56.2 percent) believed in the existence of spirit children, 30.6 percent did not believe in. While 13.2 percent were not sure of their beliefs. Mothers who believed in indicated that repeated deaths of children of couple, deformity of children, frequent indisposition, are among the evidence of Abiku.

The GDHS (1998) indicated that 14 percent of children in Ghana aged less than five years had symptoms of ARI during the time of the study. It was also seen that the prevalence rate of ARI varies according to the ages of children and it is higher among children aged 6-11 months. In terms of geographical distribution, children residing in rural areas have higher occurrence of ARI than their counterparts in the urban centers.

It was also found out that children of mothers with little or no formal education have higher occurrence rate of ARI than children born to mothers with secondary education. The most dominant treatment outlet for children suffering from ARI is the government health facility followed by the pharmacy shops or drug stores.

Asenso-Okyere, et al., (1998) in their study of malaria care, identified that the health financing reforms that culminated in the introduction of user charges and full cost recovery for drugs in health care facilities have made it very difficult for many people to access modem health care. It was also identified that there is often a delay in reporting illnesses to bio-medical health care providers and during these periods certain home management practices are adopted as cost saving measures. Brokensha (1966) undertook an anthropological study at Larteh to determine the social changes that have taken place. He found among other things that in terms of medicine and health, there are different treatment paths. These are used based on the health-seeker's perception on the nature and cause of the ailment.

Acute respiratory infection is an infection that may interfere with normal breathing. It usually begins as a viral infection in the nose, trachea (windpipe), or lungs. If the infection isn't treated, it can spread to the entire respiratory system.

ARI's are infectious which means they can spread from one person to another. This disease is quite widespread and it is particularly dangerous for children, older adults, and people with immune system disorder.

However, ARIs in children take a heavy toll on life, especially where medical care is not available or is not sought and are classified as upper respiratory tract infections (URIs) or lower respiratory tract infections (LRIs). The upper respiratory tract consists of the airways from the nostrils to the vocal cords in the larynx, including the paranasal sinuses and the middle ear. The lower respiratory tract covers the continuation of the airways from the trachea and bronchi to the bronchioles and the alveoli. ARIs are not confined to the respiratory tract and have systemic effects because of possible extension of infection or microbial toxins, inflammation, and reduced lung function. Diphtheria, pertussis (whooping cough), and measles are vaccine-preventable diseases that may have a respiratory tract component but also affect other systems. Except during the neonatal period, ARIs are the most common causes of both illness and mortality in children under five, who average three to six episodes of ARIs annually regardless of where they live or what their economic situation is (Kamath & others 1969; Monto & Ullman 1974). However, the proportion of mild to severe disease varies between high- and low-income countries, and because of differences in specific etiologies and risk factors, the severity of LRIs in children under five is worse in developing countries, resulting in a higher case-fatality rate. Although medical care can to some extent mitigate both severity and fatality, many severe LRIs do not respond to therapy, largely because of the lack of highly effective antiviral drugs. Some 10.8 million children die each year (Black, Morris, and Bryce 2003). Estimates indicate that in 2000, 1.9 million of them died because of ARIs, 70 percent of them in Africa and Southeast Asia (Williams and others 2002). The World Health Organization (WHO) estimates that 2 million children under five die of pneumonia each year (Bryce and others 2003).

Symptoms of ARI?

The early symptoms of acute respiratory infection usually appear in the nose and upper lungs. These symptoms include**:** Congestion, either in the nasal sinuses or lungs**,** Runny nose**,** Cough**,** Sore throat**,** Body aches**,** Fatigue and if the disease advances, there may be high fever and chills. Other serious symptoms are difficulty in breathing, dizziness, low blood oxygen level, loss of consciousness among others. However complications of acute respiratory infection are extremely serious and can result in permanent damage and even death. They include**:** respiratory arrest, respiratory failure and congestive heart failure. Nevertheless most causes of an acute respiratory infection aren't treatable. Therefore, prevention is the best method to ward off harmful respiratory infections. Practice good hygiene by doing the following**:** Wash your hands frequently, especially after you've been in a public place, always sneeze into the arm of your shirt or in a tissue although this may not ease your own symptoms, it will prevent you from spreading infectious diseases and finally avoid touching your face, especially your eyes and mouth, to prevent introducing germs into your system (India Development Gateway, 2018).

Symptoms of ALRI?

Acute Lower Respiratory tract infection (ALRTI) is infection below the level of the larynx and may be taken to include**:** bronchiolitis**,** bronchitis**,** Pneumonia Laryn, Gotracheobronchitis (croup)the common ALRIs in children are pneumonia and bronchiolitis. The respiratory rate is a valuable clinical sign for diagnosing acute ALRI in children who are coughing and breathing rapidly. The presence of lower chest wall in drawing identifies more severe disease (Mulholland and others

1992; Shann, Hart, and Thomas 1984**).** Currently, the most common causes of viral ALRIs are RSVs. They tend to be highly seasonal, unlike parainfluenza viruses, the next most common cause of viral ALRIs. The epidemiology of influenza viruses in children in developing countries deserves urgent investigation because safe and effective vaccines are available. Before the effective use of measles vaccine, the measles virus was the most important viral cause of respiratory tract– related morbidity and mortality in children in developing countries.

*Symptoms of URI***?**

Upper Respiratory Infections (URI's) are the most common infectious diseases. They include rhinitis (common cold), sinusitis, ear infections, acute pharyngitis or tonsillopharyngitis, epiglottitis, and laryngitis - of which ear infections and pharyngitis causes the more severe complications (deafness and acute rheumatic fever, respectively). The vast majority of URIs have a viral etiology. Rhinoviruses account for 25 to 30 percent of URIs; respiratory syncytial viruses (RSVs), para influenza and influenza viruses, human meta pneumovirus, and adenoviruses for 25 to 35 percent; corona viruses for 10 percent; and unidentified viruses for the remainder (Denny 1995). Because most URIs are self-limiting, their complications are more important than the infections. Acute viral infections predispose children to bacterial infections of the sinuses and middle ear (Berman 1995a), and aspiration of infected secretions and cells can result in LRIs.

CHAPTER THREE

RESEARH METHODS

3.1 Study Design

The study was a population-based cross-sectional study involving 200 households (i.e. children under five (5) and their parent(s)) residing around the Abokobi dumpsite. A questionnaire was administered to the parents of all the 200 children under five (5). Blood samples were taken from the children for lab analysis for heavy metals. Hand washed water was also taken from the children for lab analysis of heavy metals.

3.2 Study Area

Abokobi open dumpsite

The Ga East Municipal Assembly, established in 2004, is located in the northern part of the Greater Accra Region. The Ga East Municipal Assembly is one of the ten Districts in the Greater Accra region and spans an area of about 166 square km (ghanadistricts.com). It is made up of 65 settlements. Abokobi is on the boundary west by the Ga-West Municipal Assembly, on the east by the Adentan Municipal Assembly, the south by Accra Metropolitan Assembly (AMA) and the north by the Akwapim South District Assembly. The 2010 National Population and Housing Census reported that the District's population at 259,668 with a growth rate of about 2.3%. The development of the population is primarily due to the impact of migration inflows. "The population structure is approximately 51 percent male and 49 percent woman. There are 66, 286 households in the municipal. The population constitutes 82% of the district total population with the remaining 18% residing in the rural portion towards the Akwapim Hills. These communities include Ablor Adjei, Evangelical Presbyterian area (EP), Paraku Estates and Pantang. The district can therefore be described as predominantly urban with the population concentrated largely along the urban areas of the district predominantly along the border with AMA to the south" (GEMA, 2013).

The communities have problem of land litigation, encroachment on the few open spaces, rapid waste generation, open defecation, indiscriminate refuse disposal, and construction of illegal structures are some of the development challenges the Assembly has. Malaria continues to be the major cause of Out-Patients Department (OPD) attendance in the Ga East Municipal accounting for approximately 40.8% of morbidity. Frequent outbreaks of cholera in the district are also of great concern and poor environmental sanitation is a known and major contributory factor (GEMA, 2013). Below is the map of the Ga East Municipality and key institution relation to the dumpsite.

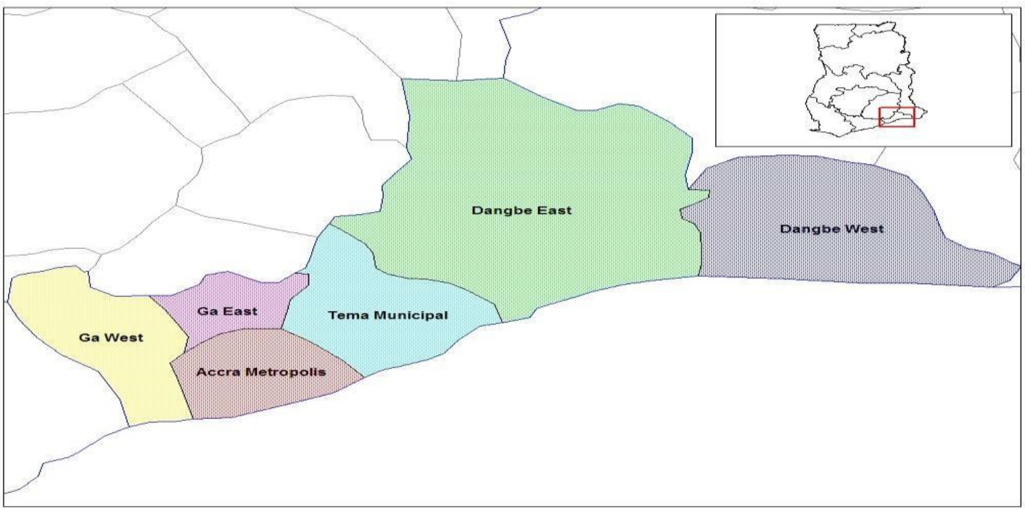


Fig. 3. 1: Map showing Ga East Municipal Assembly

Fig. 3.2: Dumpsite and the Community Living in the Area

3.3 Source/Study Population

The source population for the study includes all children below the age of 5 residing in households within 200meters of the Abokobi open dumpsite. The study population involved 200 children under five (5) and their parents.

3.3 1 Inclusion & Exclusion Criteria

The inclusion criteria adopted for the study includes; households with children under five (5), households should have been staying around the dumpsite for more than a year and individual willing to follow the study protocol. This helps eliminate the influence of selection bias, however households without children under five (5), who have not lived for more than one year and not willing to follow the study protocol were excluded.

3.4 Study Variables

3. 4.1 Main determinants

The main determinants of interest include; blood levels of arsenic, mercury, cadmium and lead and handwashed levels of arsenic, mercury, cadmium and lead.

3.4.2 Outcomes of interest

The main outcome of interest includes self-reported symptoms of acute respiratory infection (ARI). ARI was defined as acute lower respiratory infection (ALRI) and also upper respiratory infection (URI). ALRI refers to cough accompanied by short and rapid breathing at any time in the 2-weeks period preceding the survey interview; and URI defined as symptoms of runny nose, wheezing, cough, phlegm production and breathlessness at any time in the 2-weeks period preceding the survey interview. These definitions are in agreement with literature (Misra, 2003; Bautista, et al., 2009).

3.4.3. Confounding variables

The following variables were considered as potential confounders; level of parental education, gender of child, any sign of illness more than two (2) weeks, and was based on literature (Smith, Samet, Romieu, & Bruce, 2000)

3.5 Sampling (Sample Size and Sampling Procedure)

Participation was voluntary. The children's and their parents were invited to a durbar ground where the research team informed them of the purpose of the research. Other issues such as the benefits and risks involved in the study were made known to the participants. Two hundred (200) children under five (5) and their parents residing within 200meters around the dumpsite voluntarily decided to be part of the study and were recruited.

3.6 Data collection procedure

The fieldwork was implemented in three (3) phases: (i) stakeholder meeting, (ii) selection and enrollment of study participants, (iii) data collection.

Stakeholder meetings

Three separate meetings were held with stakeholders to seek their view on the conditions in and around the dumpsite and also seek their consent to enter the community without any apprehension. Some identifiable stakeholders were (a) The Chief and Elders (b) Waste Landfill Company Ltd. Adenta, (c) The Head Pastor of Faith Anointing Ministry (d) The Assembly Member of the electoral areas (Agbogba, Ablorh Adjei, Pantang and Abokobi) (e) The unit committee members (f) The Head Pastor of the Presbyterian Church and (g) and the rest of the students from KNUST working on the project. The research team was headed by Dr. Reginald Quansah (School of Public Health, University of Ghana, Legon) and Dr. Udofia (University of Ghana Medical School). Other members of the team include; a Laboratory Technicians and reps from Ghana Atomic Energy Commission (GAEC). The Assemblyman of Ablorh Adjei; Hon. Jacob Ablorh was nominated by the elders of the communities to lead the project team to the community. The subsequent meetings were held at the Abokobi District Assembly.

Selection and enrolment of study participants

The study participants were made up of 200 children under 5. Parents of these selected children were asked to express their willingness to participate in the study.

Children with severe illnesses (e.g. dysentery, typhoid fever etc.) were not allowed to take part in the study. Contacts were made with the nearest health facility (Pantang Hospital) for early diagnosis and treatment.

Fig. 3. 3: Participants at a durbar for the commencement of the study

Data Collection

The data collection tools for the study include a modified respiratory questionnaire, blood sampling kit for blood sampling and a container for hand washed. The 200 participants were given an identifiable code starting from 001 to 200. For blood samples the code reads B001-B200c and HW001-HW200 for hand washed respectively. The vitals of the participants were taken. This include; temperature, and height and weight for Body Mass Index (BMI). Participants who were detected of any ailment were referred to a team of Nurses for early diagnosis and treatment.

Questionnaire

A modified questionnaire was used in this study to elicit information on personal characteristics, environmental risk exposures and dietary habits of the respondents. This questionnaire was filled up by the parents or the guardians of the respondents. The questionnaire consists of 3 parts; Part A the socio-demographic background, Part B the respiratory health information, Part C the associated health problems.

The questionnaires were administered by members of the research team.

Participants who cannot read or write were assisted by the research team.

Fig. 3. 4: A member of the research team administering a questionnaire

Blood sample Collection

Following explanation of the test procedure, 2.5ml of whole blood was collected from the median cubital and cephalic veins into three separate haematology tubes (Sarstedt, S-monovette, Germany), two free and one containing Z-gel, an additive carrier and a clot activator (for serum separation) using a butterfly needle and a tourniquet. The blood samples with the additive was centrifuged and the supernatant, the serum collected for subsequent refrigeration at 4-8°C for analysis at the Ghana Atomic Energy Commission.

Fig. 3. 5: A Laboratory technician taking a blood sample from a child assisted by the mother

Blood sample analysis for heavy metals

Blood samples were pretreated with nitric acid and triton. Samples were analyzed using high resolution continuum source atomic absorption spectrophotometry (HRCS-AAS Contr AA 700 Analytik Jena) at the Ghana Atomic Energy Commission for heavy metals.

Fig. 3. 6: Blood sample ready for analysis at Ghana Atomic Energy Commission

Hand washed water collection

The hands of the children were washed and hand-washed water collected in a container for analysis at Ghana Atomic Energy Commission.

Fig. 3.7: Mother assisting the child to undergo handwashing

3.8 Data Analysis

Descriptive statistics such as means ± SD, was used to describe the blood samples. This was by a binary logistic regressions to determine the association between outcome variable and independent variables. Odds ratios (OR), p-values and Confidence Intervals (CI) was determined for each independent variable and statistical significance was accepted at a 5% probability level ($P \leq 0.05$).

The data was crossed checked to identify missing values and other lapses for appropriate treatment. It was examined for validity. The data was double checked to reduce errors and improve results and before entry into Epi- Info 7 (Centre for Disease Control, CDC, USA).

For normally distributed data, means and standard deviations were computed as summary measures and the median and interquartile ranges for skewed data. Chi square and

Wilcoxon ranked-tests were used to compare characteristics of the compared groups as well as the level of awareness of potential respiratory hazards.

3.8.1 Informed consent

Informed consent was sought and obtained and/or assent parents of the children. An oral script introducing the study was read to parents who can read and write and by a translator for those who cannot read nor write. Written consent form was read by the participant and/or by a translator and any questions raised by the subjects was answered. Interested participants were interviewed.

3.8.2 Protection of subjects' privacy

Parents of children do not have to answer any survey questions that they feel was an invasion of their privacy. Also, participants do not have to participate in any particular aspects of the study that they find invasive.

3.8.3 Provision to prematurely end a particular subject's participation in the study

A parent of a child can opt to be interviewed in a location of their choice to increase privacy. In the case of an adverse event or situation of distress, a subject's participation in the study was concluded. There was a little likelihood that such an event or distress may occur, so no specific criteria or parameters can be identified."

3.8.4 Record storage and protection

All research records, data and specimens were protected and retained for at 35years against inappropriate use or disclosure, or malicious or accidental loss or destruction in order to protect the confidentiality of subject data. Hard copy data was under locked and soft copy data were protected with a password on a secured laptop. There was a routine electronic back up and encryption of digital data.

Security software (firewall, anti-virus, anti-intrusion) were installed and regularly updated on all servers, workstations, laptops, and other devices used in the project. There was be safe disposition/destruction of data or devices, as appropriate (e.g., shredding paper documents, destroying disks or thumb drives, secure erasure of electronic media).

3.8.5 The data and/or any specimens will be destroyed at the conclusion of this study

Specimens of blood were destroyed as well as the identifiers on their storage containers after laboratory analysis. The interviews will be destroyed by deleting them from their storage device (digital format) after 10 years' retention. Study survey forms (hard copy) were destroyed at the conclusion of the study. The data/specimens were retained until the completion of the research program. The data collected was linked to subjects' identities in anticipation of the need to be able to return metals analysis results to those participants who desire it, and if significant new knowledge is obtained that must be relayed.

3.8.6 Retention of Data and/or Specimens Detail

Retention was for future research by the investigator and/or the creation of a bank or repository. In the case of return to the community or future research on this area, a longitudinal study can be done to show how conditions have changed over time. Also, in order to deliver individual participants' results on a subsequent return visit, these data must be retained.

3.8.7 Compensation of Subjects or Other Incentives for their time/participation

Subjects received cash and token gift for their participation in the study. A payment of 10 Ghana new cedis (approximately US$3) was given to study participants who complete all proposed data collection elements. Compensation was given at the time of data/specimen collection.

3.9 Ethical Consideration

Ethical clearance was sought from the Kwame Nkrumah University of Science and Technology Ethical Review Board. Permission was also sought from the leaders of the community. Oral or written consent was obtained from every participant. Before the individual respondents give their consent, the participant information leaflet and the consent form, which contained the benefits, risks and the procedures for research was read out and explained to each participant before they append their signatures or thumbprints. They had the liberty to ask questions, and to seek clarifications or withdraw unconditionally.

CHAPTER FOUR

RESULTS

4.1 Demographic characteristics of study participants

Characteristics of the study population of children are shown in Table 4.1. Most of the children were females (58%), aged 2 years (31.0%) and in crèche (38.5%).

Table 4.1: Demographic characteristics of study participants (n=200)

	Frequency	Percentage
Gender of child		
Male	84	42.0
Female	116	58.0
Age of child		
≤1	39	19.5
2yr	62	31.0
3yrs	58	29.0

4yrs	41	20.5
Education		
Not started school	37	18.5
Crèche	77	38.5
Nursery	59	29.5
Kindergarten	27	13.5

4.2 Proportion of children under five (5) years with self-reported symptoms of AURI and ALRI

The proportion of children reporting symptoms of acute upper respiratory infection (AURI) was higher among all children representing (50.5%) and also among children age 0-2 years (53.6%) and least common among children age 2-4 years old (46.6%). Also the proportion of children reporting symptoms of acute lower respiratory infection (ALRI) was higher among children age 2-4 years (51.6%) (Figure 4.1)

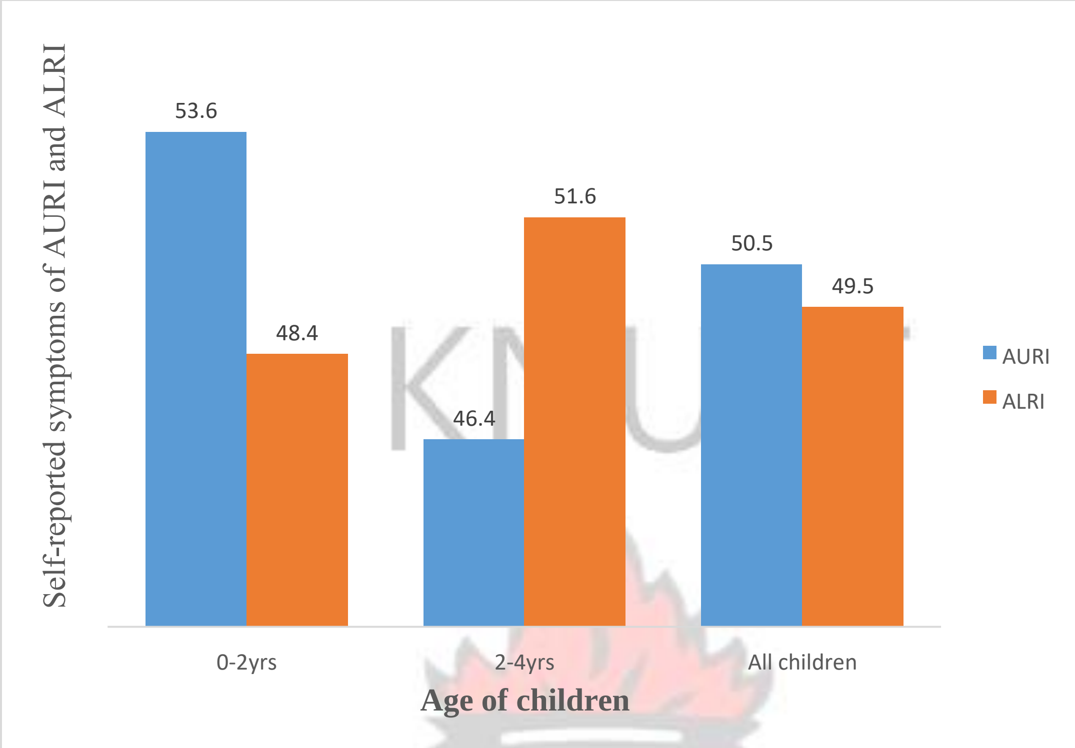


Fig. 4.1: Proportion of children under five (5) years with self-reported symptoms of AURI and ALRI

4.3 Concentration of toxic metals in blood among children under five (5) Four (4) traces of toxic metals were detected in the extract of blood samples of children under five years (Table 4.2). The mean residue and standard deviation of

"As" was higher in children aged 2-4yrs (1.82 µg/L; 0.61) compared to children aged 0-2yrs (1.67 µg/L; 0.49). On the contrary, the mean residue concentration and standard deviation of Cd was higher in children aged 0-2yrs (2.74 µg/L; 0.46) compared to children aged 2-4yr (2.68 µg/L; 0.42).

Table 4.2: Concentration of toxic metals in blood samples of children under 5 living near Abokobi dumpsite (n=200)

				All children				
Toxic metals	**LOD**	**Mean**	**SD**	**Median**	**LQ**	**UQ**	**Min**	**Max**
Hg	0.01	1.47	0.33	1.34	1.21	1.72	1.03	2.32
Cd	0.01	2.71	0.44	2.67	2.51	2.90	1.95	3.91
As	0.01	1.74	0.56	1.75	1.21	2.08	1.01	3.23
Pb	0.01	3.64	1.27	3.54	2.45	5.01	1.99	5.98
				0-2yrs				
Hg	0.01	1.45	0.33	1.31	1.21	1.67	1.04	2.32
Cd	0.01	2.74	0.46	2.67	2.51	2.90	1.95	3.91
As	0.01	1.67	0.49	1.62	1.21	1.99	1.01	3.19
Pb	0.01	3.64	1.25	3.54	2.45	5.01	1.99	5.98
				2-[1]yrs				
Hg	0.01	1.50	0.33	1.36	1.22	1.74	1.03	2.32
Cd	0.01	2.68	0.42	2.71	2.51	2.89	1.95	3.91
As	0.01	1.82	0.61	1.91	1.21	2.12	1.01	3.23
Pb	0.01	3.64	1.31	3.54	2.43	5.01	1.99	5.98

LOD=Level of detection SD=Standard deviation LQ=Lower quartile UQ=Upper quartile Min=Minimum Max=Maximum

4.4 Correlation between levels of metals in blood samples

There was no significant correlation between levels of metals in blood samples of the children (Table 4.3).

Variables	Hg
Hg	1.000

[1] .5 Concentration of toxic metals in hand wash water samples among children under five (5)

Four (4) traces of toxic metals were detected in the hand washed water of children under five years (Table 4.4). The mean residue and standard deviation of Hg was higher in children aged 2-4yrs (0.21 µg/L; 0.15) compared to children aged 0-2yrs

Cd	0.011	1.000		
As	0.039	-0.008	1.000	
Pb	0.098	0.070	0.115	1.000
		Cd	**As**	**Pb**

Table 4. 3: Correlation between levels of metals in blood samples

(0.15 µg/L; 0.14). However, the mean residue concentration and standard deviation of 'As' was same in children aged 0-2yrs (0.03 µg/L; 0.02) and children aged 2-4yrs respectively.

Table 4. 4: Concentration of toxic metals in hand wash water samples of children under 5 living near Abokobi dumpsite (n=200)

Toxic metals in hand wash water	**LOD**	**Mean**	**SD**	**Median**	**LQ**	**UQ**	**Min**	**Max**
				All children				
Hg	0.01	0.19	0.15	1.34	0.03	0.40	0.01	0.40
Cd	0.01	1.27	0.16	1.30	1.10	1.40	1.00	1.50
As	0.01	0.03	0.01	0.04	0.02	0.05	0.01	0.06
Pb	0.01	4.61	0.29	4.67	4.33	4.87	4.01	4.99
				0-2yrs				
Hg	0.01	0.15	0.14	0.10	0.02	0.30	0.01	0.40
Cd	0.01	1.27	0.15	1.30	1.10	1.40	1.00	1.50
As	0.01	0.03	0.02	0.03	0.02	0.05	0.01	0.06
Pb	0.01	4.62	0.30	4.65	4.33	4.87	4.01	4.99
				2-4yrs				
Hg	0.01	0.21	0.15	0.20	0.10	0.40	0.01	0.40
Cd	0.01	1.28	0.16	1.30	1.10	1.40	1.00	1.50
As	0.01	0.03	0.02	0.04	0.02	0.05	0.01	0.06
Pb	0.01	4.62	0.30	4.67	4.33	4.91	4.01	4.99

4.6 Correlation between levels of metals in hand wash water samples

There was negative significant correlation between of metals Pb and 'As' in hand wash water. However, no significant associated was established among the other metals (Table 4.5).

Table 4. 5: Correlation between levels of metals in blood samples

Variables	Hg	Cd	As	Pb
Hg	1.000			
Cd	0.116	1.000		
As	-0.044	0.040	1.000	
Pb	-0.184	-0.006	-0.299*	1.000

*p>0.05

4.7 Concentration of toxic metals in blood samples and ARI

Four (4) traces of toxic metals were detected in the extract of blood samples of children under five years (Figures 4.2-4.5). The concentrations of all the residue in the blood samples were above the level of detection. The mean residue and standard deviation of Pb contributes to ALRI than AURI (3.74 µg/L; 1.21 vs 3.67 µg/L; 1.39). Also, concentration of Cadmium contributes to ALRI (3.60 µg/L; 1.20) more than AURI (3.58 µg/L; 1.27). On the contrary, the mean residue concentration and standard deviation of Hg contributes more to AURI than (1.52 µg/L; 0.35) ALRI (1.35 µg/L; 0.26).

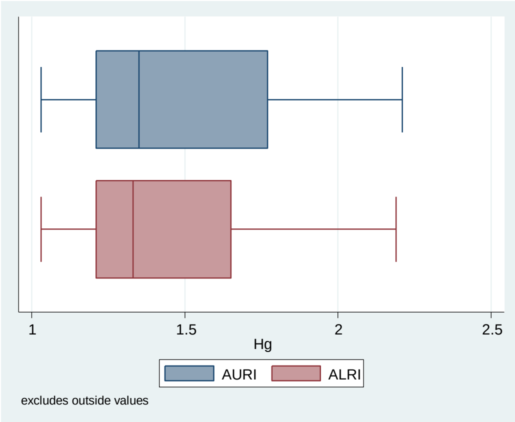


Fig. 4.2: Mercury and ARI

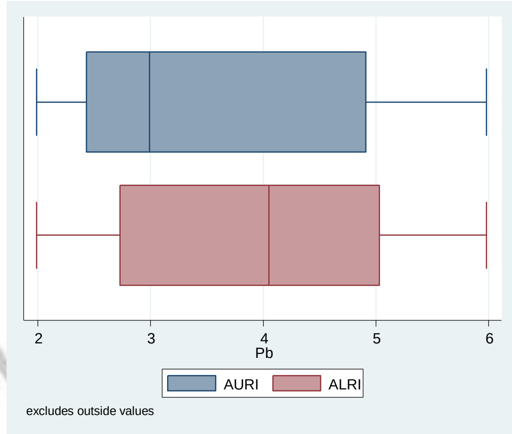


Fig. 4.3: Lead and ARI

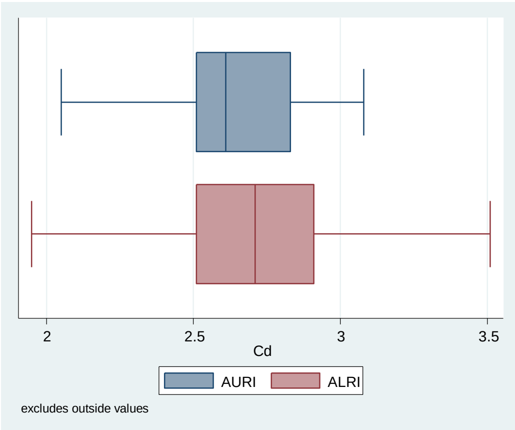


Fig. 4.4: Cadmium and ARI

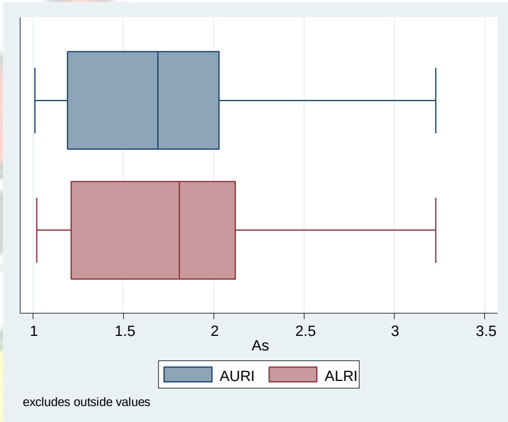


Fig. 4.5: Arsenic and ARI

4.8 Mean concentration of toxic metals in hand wash water and symptoms of ALRI and AURI among children under five (5) living near Abokobi dumpsite

Four (4) traces of toxic metals were detected in the extract of hand wash water of children under five years (Figures 4.6-4.7). The mean residue and standard deviation of Hg contributes to ALRI than AURI in hand wash water (1.47 µg/L; 2.77 vs 0.21 µg/L; 1.29).

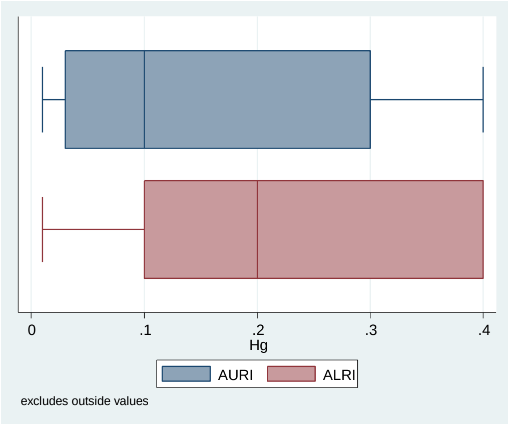


Fig 4.2a: Mercury and ARI in handwash water

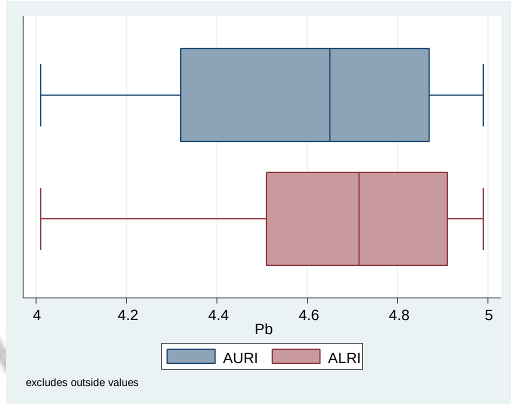


Fig. 4.3a: Lead and ARI in hand wash water

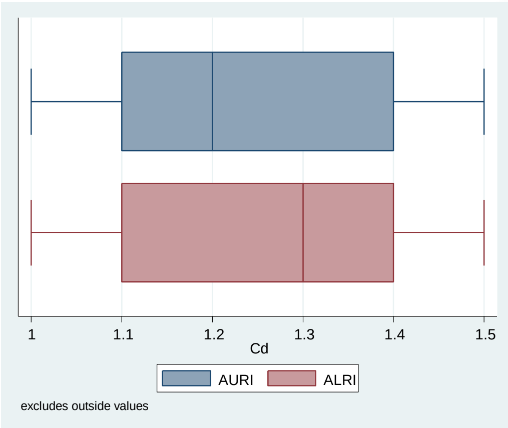


Fig. 4.4a: Cadmium and ARI in hand wash water

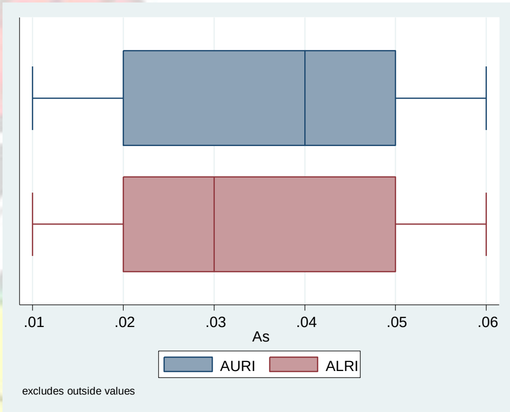


Fig. 4.5a: Arsenic and ARI in hand wash water

4.9 Levels of heavy metals in blood and hand wash water and symptoms of AURI and ALRI among children under five years in Abokobi

There was significant association between residual levels of Arsenic in blood samples and symptoms of AURI. Similarly there was significant association between residual levels of Cd and symptoms of ALRI (COR=1.84; 95%CI, 0.92-3.68)). However, there was no significant association between residual levels of the other toxic metals in blood samples and symptoms of AURI and ALRI (Table 4.6).

The association between mean concentration of metals in hand washed water in blood and symptoms of ALRI and URI is shown in Table 4.7. The odds of suffering ALRI is 1.79 folds greater as a result of Hg in hand wash water (AOR=1.79; 95%CI, 1.00-3.18).

There was no significant association between metals in blood samples and levels of metals in in hand washed water (Table 4.8).

Table 4.

6: Mean concentration of toxic metals in blood and symptoms of ALRI and URI

	ARI		AURI		ALRI	
Toxic metals	**Crude OR**	**Adjusted OR****	**Crude OR**	**Adjusted OR****	**Crude OR**	**Adjusted OR**
Hg	0.76(0.32-1.81)	0.84(0.36-1.95)	1.04(0.41-2.63)	0.97 (0.39-2.42)	0.74 (0.31-1.78)	0.80 (0.34-1.88)
Cd	1.72(0.90-3.31)	1.77(0.92-3.38)	1.02(0.51-2.05)	1.01 (0.51-2.01)	1.84 (0.92-3.68)	1.86 (0.94-3.69)
As	1.15(0.69-1.92)	1.18(0.72-1.96)	0.64(0.37-1.10)	0.63 (0.37-1.08)	1.31 (0.77-2.23)	1.32(0.78-2.23)
Pb	1.20(0.96-1.50)	1.21(0.97-1.51)	0.93(0.73-1.18)	0.91 (0.72-1.15)	1.11 (0.89-1.41)	1.14 (0.91-1.43)

*Hg-Silver Cd-Cadmium As-Arsenic Pb-Lead AURI-Acute upper respiratory infection ALRI-Acute lower respiratory infection ARIAcute respiratory infection ** Age, gender and parent education*

Table 4.

7: Mean concentration of metals in hand washed water and symptoms of ALRI and URI

	ARI		AURI		ALRI	
Metals in hand washed water	**Crude OR**	**Adjusted OR****	**Crude OR**	**Adjusted OR****	**Crude OR**	**Adjusted OR****
Hg	1.08 (0.52-2.28)	1.48 (0.85-2.59)	1.15 (0.51-2.58)	1.22 (0.66-2.24)	1.37 (0.64-2.90)	**1.79 (1.00-3.18)**
Cd	1.18 (0.58-2.38)	1.27 (0.73-2.24)	1.82 (0.83-3.99)	1.68 (0.90-3.17)	0.69 (0.33-1.42)	0.82 (0.46-1.46)
As	1.35 (0.58-3.14)	**1.73 (0.98-3.03)**	0.93 (0.37-2.35)	1.44 (0.78-2.64)	1.51 (0.64-3.62)	1.57 (0.89-2.78)
Pb	1.65 (0.72-3.76)	**1.90 (0.92-3.93)**	1.50 (0.59-3.83)	1.42 (0.62-3.22)	1.11 (0.46-2.67)	1.65 (0.76-3.57)

*Hg-Silver Cd-Cadmium As-Arsenic Pb-Lead AURI-Acute upper respiratory infection ALRI-Acute lower respiratory infection ARIAcute respiratory infection ** Age, gender and parent education*

Table 4.

8: Association between levels of metals in blood and metals in in hand washed water

	Metals in hand washed water			
	Hg	**Cd**	**As**	**Pb**
Levels of metals in blood	**Coef (95%CI)**	**Coef (95%CI)**	**Coef (95%CI)**	**Coef (95%CI)**
Hg	0.90 (0.25-3.31)	1.41 (0.80-2.46)	0.57 (0.14-2.32)	0.96 (0.52-1.77)
Cd	1.65 (0.56-4.84)	1.62 (0.91-2.89)	1.22 (0.39-3.76)	1.02 (0.55-1.91)
As	0.45 (0.19-1.05)	0.66 (0.36-1.22)	0.78 (0.37-1.66)	1.57 (0.88-2.78)
Pb	0.74 (0.42-1.29)	0.75 (0.35-1.61)	0.79 (0.43-1.46)	0.77 (0.43-1.36)

CHAPTER FIVE

DISCUSSION

5.1 Main findings

The proportion of children reporting symptoms of acute upper respiratory infection (AURI) was higher among all children representing (50.5%) and also among children age 0-2 years (53.6%) . Also the proportion of children reporting symptoms of acute lower respiratory infection (ALRI) was higher among children age 2-4 years (51.6%)

Also, there was significant association between residual levels of Arsenic and Cadmium in blood samples and symptoms of AURI and ALRI. However, there was no significant association between residual levels of the other toxic metals in blood samples and symptoms of AURI and ALRI in children. The association between mean concentration of metals in hand washed water in blood and symptoms of ALRI and URI is greater as a result of Hg in hand wash water. However, the mean residue and standard deviation of Hg contributes to ALRI than AURI in blood than in hand wash water. Also, concentration of Cadmium contributes more to ALRI in blood than in hand wash water.

The mean residue and standard deviation of Hg was higher in children aged 2-4yrs compared to children aged 0-2yrs. However, the mean residue concentration and standard deviation of 'As' was same in children aged 0-2yrs and children aged 2-4yrs respectively

There was negative significant correlation between metals Pb and 'As' in hand wash water. However, no significant associated was established among the other metals.

5.2 Methodological validity

The residents (children) in Abokobi who live close to the dumpsite, from which samples were selected for this study, had a high participation rate therefore, minimizing selection bias. Trained Nurses were involved in the collection of the samples. The population for this study comprised parents with children (<5years) who were voluntarily recruited. Data on heavy metals exposure was collected objectively and subjectively and findings on the heavy metals body burden and prevalence of exposure experience were the same. Thus, the effect of information bias in this study was minimal. The study population was homogeneous with regard to culture and by socio-economic status, reducing the potential effect of unmeasured confounding. Again, to the researcher, this is the first study in Ghana to look at this association.

Irrespective of the strength of this study, the study had some limitations. The study used voluntary participation to select participants; it was possible that some residents (children) and vital information may have been missed. Self-reporting of outcomes was another limitation that is whether the participants understood the questions. Different people administering the questionnaire cannot guarantee the consistency of the outcome but it was not proven in the study. However, the effect of this on the study estimates need to be verified. Irrespective of the fact that traces of Lead are metabolized easily in humans, it was measured and traces was detected. To still detect Lead residues in the urine samples suggested that exposure to heavy metals was common in the study population and that a single measurement as applied in this present study reflects average exposure over a longer period. Again, the cross-sectional design restricted the ability to discern any temporality. Future studies that follow residents that live close to dumpsites prospectively and collect data on occupational and non-occupational exposures

will help to clarify this possibility.

5.3 Comparison of present findings with previous studies

The proportion of self-reported symptoms of acute upper respiratory infection (AURI) and acute lower respiratory infection (ALRI) was high in children aged 2 years and 3 years respectively. The proportion of children reporting symptoms of respiratory infection is in agreement with a study which found that children under five years of age show symptoms of ARI varies with age with children aged between 6-11 months the most vulnerable to this disease (GDHS, 1998). The high proportion of children suffering ARI in the study area could be due to their restrictive arm circumference as confirm by a study which found that a child with an aim circumference of less than 13.5cm suffers more episodes of both upper and lower respiratory infections than were children with larger arm circumference (Lang et al. 1986). Another major danger from the waste dump is the regular unpleasant odours which can pose problems by causing congestion, either in the nasal sinuses or lungs.

Bad mouthing behavior, poor food handling behavior; bad hygiene practices and poor hand washing behavior was common among all children. The finding means that children who like to play around the dump site are exposed to the smoke that emanates from the dump site making the children prone to respiratory tract infection and other health conditions. Furthermore, the dumping of electronic materials that has cadmium, mercury and arsenic as parts of its content may be left in the soil during the dumping or burning process of these metals. Most of the children especially those under the age of 5 are mostly naive and are found playing in the soil making them highly exposed to these trace metals which will highly make them prone to respiratory tract infection.

A significant association was observed between residual levels of Arsenic and Cadmium in blood samples and symptoms of AURI. The finding is consistent with a study which found that the there is a significant association between Arsenic and ARI in children. The study continued that the relationship depends on the absorption and subsequent metabolism of Arsenic and the effects in children greatly depends on the chemical form, the length of exposure and the absorption path (Hakala & Hallkainen, 2004). The finding is consistent with a study which found that the ingestion or inhalation of Arsenic may cause nausea, abdominal cramps, short breath and inhibition of iron absorption (Donahoe et al., 2015). The finding was confirmed by results that soil around dump site is usually rich in toxic heavy metals as a result of the dumped waste and used by the people living around the dump for planting vegetables and fruits. These plants bio-accumulates heavy metals from the soil and when they are eaten by children, the heavy metal accumulate in the body with serious health effects (USEPA, 2002; UNDP, 2006; Rotich et al., 2006).

This study was conducted among children under five years in a predominately dumping site community where precautionary and safety measures are problematic. To the best of my knowledge, this study is the first to have investigated the association between heavy metals exposure and ARI among children under five years living close to a commercial dumpsite.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The proportion of self-reported symptoms of acute upper respiratory infection (AURI) and acute lower respiratory infection (ALRI) was high in all children respectively.

Lead was high followed by Cadmium in all children; Cadmium was high in children aged 0-2yrs than 2-4yrs and Lead was the same in ages 0-2yrs and 2-4yrs in biological media (blood). Again Lead and Cadmium was higher in all children, Lead was the same in ages 0-2yrs and 2-4yrs while Cadmium and Mercury were high in Ages 2-4yrs than ages 0-2yrs in the handwashed water.

There was significant association between residual levels of Arsenic in blood samples and symptoms of AURI. Similarly there was significant association between residual levels of Cd and symptoms of ALRI. However, there was no significant association between residual levels of the other toxic metals in blood samples and symptoms of AURI and ALRI.

6.2 Recommendations

1. Parents should ensure regular medical checkup for children who live close to dumpsites for detection of symptoms of diseases to avert any health risk they may be exposed to.
2. Ministry of Health should intensify public education on good practices in child care to avert the development of preventable diseases such as acute respiratory infections
3. The Ministry of Local Government through the Ga-East Municipal should create awareness on proper waste management practices.

4. Local Government Ministry and the Ministry of Sanitation and Water Resources should permanently ban or prohibit the use of the dumpsite.

6.2.1 Recommendation for further studies

Longitudinal studies are encouraged to ascertain the findings of this study. Further research is encouraged on toxic metal exposure and gastrointestinal tract infection among children under five (5) residing near Abokobi dumpsite.

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APPENDICES

APPENDIX A: PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

Title of Research:

Toxic metal exposure and symptoms of respiratory infection among children (under-five) residing near open dumpsite: a cross-sectional study at Abokobi

Name(s) and affiliation(s) of researcher(s):

This study is being conducted by Mr Michael Affordofe of the KNUST African Institute of Sanitation and Waste Management (K-AISWAM), Accra.

Background (Please explain simply and briefly what the study is about):

Globally, open dumpsite approach also referred to as crude dumping of solid waste is seen as a primitive stage of solid waste management. Open dumpsite method is one of the most poorly rendered services by municipal authorities in Africa and parts of Asia as the systems applied are unscientific, outdated and in- efficient. Solid waste disposal sites are found both within and on the outskirts of developing urban cities. Increase in the global population, rising demand for food and other essentials led to the increase in the amount of waste being generated. This waste is ultimately thrown into municipal disposal sites and due to poor and ineffective management, the dumpsites turn to sources of environmental and health hazards to people living in the vicinity of such dumps. One of the main aspects of concern is the pollution caused to the earth-be it land, air and water (Sankoh et al, 2013). Over the last three decades there has been increasing global concern over public health impacts attributed to environmental pollution, in particular, the global burden of disease. The World Health Organization estimates that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution (UNEP, 2015).Most of these environment-related diseases are however not easily detected and may be acquired during childhood and manifested later in adulthood (UNEP, 2015).

Dumpsites across the globe receive roughly 40% of the world’s waste and they serve about 3.5-4 billion people (ISWA, 2015). The 50 biggest dumpsites affect the daily lives of 64 million people, a population the size of France (ISWA, 2015). As urbanization and population growth will continue, it is expected that at least several hundreds of millions more people will be served by dumpsites, mainly in the developing world (International solid waste association report, 2014).

However, heavy metals maybe released into the environment from metal smelting and refining industries, scrap metal, plastic and rubber industries, and various consumer products and from burning of waste containing these elements. The elements that are of concern include lead, mercury, cadmium, arsenic, chromium, zinc, nickel and copper. On release into the atmosphere, they travel for large distances and are deposited onto the soil, vegetation and water depending on their density. Once deposited, these metals are not degraded and persist in the environment for many years poisoning humans through inhalation, ingestion and skin absorption. Acute exposure leads to nausea, anorexia, vomiting, gastrointestinal abnormalities and dermatitis (UNEP, 2015)

In Ghana, management of waste is a very big challenge to most Metropolitan, Municipal and District Assemblies (MMDA'S) especially how to effectively dispose it. Abokobi is in no exception.

The populace of Ledzokuku-krowor, Madina-Nkwantanang, Ga-East and West and Adenta Municipalities all use Abokobi dump site of about 8,150.47 tons per month (Ga-East Municipal Assembly, 2014). Waste pickers sift through the waste to retrieve materials considered to be of value economically. They therefore set a portion of the dump site on fire enabling them to easily obtain some materials like copper and other metallic materials

Purpose(s) of research:

The general purpose of this study is to assess the prevalence of symptoms of acute respiratory infection defined as Acute Lower Respiratory Infection (ALRI) and Upper Respiratory Infection (URI), the levels of toxic metals in environmental (soil, water, dust and leachate) and biological (urine, blood) media, and the association between toxic metals and symptoms of respiratory infection among under five children residing around Abokobi Dump site in the Ga East Municipality.

Procedure of the research, what shall be required of each participant and approximate total number of participants that would be involved in the research:

The source population for the study will include all children below the age of 5 residing in households within >1 to 4km of the Abokobi open dumpsite. From this population 300 parents of the children in these households will be interviewed. One child per a household will be selected into this study. A sample of 300 children will be randomly selected to provide urine and blood samples. Any child who will be included in the study should come from a household who meets the eligibility criteria of the main study. In the main study a household will be defined as home that has a man and/or a woman who are the biological parents of a child under five.

Urine Sample collection

Parents of the children under five (5) will be provided with clean water and soap for hand washing before handing out to them sterile meta-free plastic urine containers for urine collection. They will be cautioned to void out the first portion of the urine stream before collecting 75 mls midstream urine into the plastic urine container. 10mls of the urine will be drawn into four sterile sample tubes

(Sarstedt, S-monovette, Germany).

Blood Sample Collection

Following explanation of the test procedure, 7.5ml of whole blood will be collected from the median cubital and cephalic veins into three separate haematology tubes (Sarstedt, S-monovette, Germany), two free and one containing Z-gel, an additive carrier and a clot activator (for serum separation) using a butterfly needle and a tourniquet

Risk(s):

There is not much risk in using urine samples for analysis of heavy metals. However, 7.5mls of blood samples from under 5 children may cause weakness. It is therefore advisable for parents to properly feed children involve in the study before samples are taken. Children with severe illnesses example typhoid and dysentery will be withdrawn from the study.

Benefit(s):

The study will serve as a guide to help in various remediation activities and also to create awareness concerning exposure of heavy metals to humans.

The outcome of this research would provide an overview of the crucial state of children living around dumpsites so stakeholders like Ministry of Health and Ministry of Environment would be properly motivated to act in the mitigation of these extensive exposures to heavy metals.

Confidentiality:

I would like to assure you that whatever information provided will be handled with strict confidentiality and will be used purely for the research purposes. Your responses will not be shared with anybody who is not part of the research team. Data analysis will be done at the aggregate level to ensure anonymity. No name will be recorded. Data collected cannot be linked to you in anyway. No name or identifier will be used in any publication or reports from this study. However, as part of our responsibility to conduct this research properly, we may allow officials from the Ecolab University of Ghana, Noguchi Memorial Institute for Medical Research (NMIMR) University of Ghana, Central Lab of Korle-Bu Teaching Hospital, Supervisors, and Committee on Human Research Publication and Ethics (CHPRE) of KNUST to have access to your records.

Voluntariness:

Participation in this study is voluntary and one can choose not to answer any particular question or all questions. You are at liberty to withdraw from the study at any time. However, it is encouraged that you to participate since your opinion is important in determining the outcome of the study.

Alternatives to participation:

If you choose not to participate, this will not affect you in any way.

Withdrawal from the research:

Parents of children do not have to answer any survey questions that they feel are an invasion of their privacy. Also, participants do not have to participate in any particular aspects of the study that they find invasive.

Consequence of Withdrawal:

There will be no consequence or loss of benefit to you if you choose to withdraw from the study. Please note however, that some of the information that may have been obtained from you without identifiers like name, before you chose to withdraw, may have been modified or used in analysis reports and publications. These cannot be removed anymore. We do promise to make good faith effort to comply with your wishes as much as practicable.

Costs/Compensation:

Subjects will receive Cash and token gift for their participation in this study. A payment of 10 Ghana new cedis (approximately US$5) will be given to study participants who complete all proposed data collection elements. Compensation will be given at the time of data/specimen collection.

Contacts:

If you have any question concerning this study, please do not hesitate to contact Mr Michael Affordofe (Principal Investigator) on 0245406516/0206060495.

Further, if you have any concern about the conduct of this study, your welfare or your rights as a research participant, you may contact:

The Office of the Chairman

Committee on Human Research and Publication Ethics

Kumasi

Tel: 03220 63248 or 020 5453785

CONSENT FORM

Statement of person obtaining informed consent:

I have fully explained this research to ______________________________________ and have given sufficient information about the study, including that on procedures, risks and benefits, to enable the prospective participant make an informed decision to or not to participate.

DATE: ____________________

NAME: ______________________________

Statement of person giving consent:

I have read the information on this study/research or have had it translated into a language I understand. I have also talked it over with the interviewer to my satisfaction.

I understand that my participation is voluntary (not compulsory).

I know enough about the purpose, methods, risks and benefits of the research study to decide that I want to take part in it.

I understand that I may freely stop being part of this study at any time without having to explain myself.

I have received a copy of this information leaflet and consent form to keep for myself.

NAME:____

DATE: ___________

SIGNATURE/THUMB PRINT: __________________

Statement of person witnessing consent (Process for Non-Literate Participants):

I ____________________________ (Name of Witness) certify that information given to

____________________________ (Name of Participant), in the local language, is a true reflection of what l have read from the study Participant Information

Leaflet, attached.

WITNESS' SIGNATURE (maintain if participant is non-literate): ____________

MOTHER'S SIGNATURE (maintain if participant is under 18 years): _________

MOTHER'S NAME: ____

FATHER'S SIGNATURE (maintain if participant is under 18 years):

____

FATHER'S NAME:

____

APPENDIX B: QUESTIONNAIRE

ID: AB/………./……..…

A. GENERAL INFORMATION

1. Date………………………….. Name: ,,,,,,,,,,,,,,,,,,,,,,,,,,,,………………

2a. Age: ……………………….. 2b. Age of child:…………………

3a. What is your gender? □ Male □Female 3b. Gender of child? □ Male □Female

4. What is your highest level of education? □ No formal education □ Primary □ secondary □ Tertiary □ Trade/technical/vocational training

4b. Is your child at School □ Yes □ No 4c. If yes which class? ....

4c. Is your child breastfeeding? □ Yes □ No

5. Occupation? □Employed □Unemployed □Scavenger □Dumpsite worker

6. Type of Housing? □ Brick House □ Wooden structure or Shed □ Squatter

7. Number of people in a household? 1 2 3 4 5 6

8. Proximity to Dumpsite (in kilometers)? Under 1 1 – 2 2 – 3 3 – 4 4 - 5

9. Number of years at current residence? < 1year 1-2 2-3 3-4 4-5 >5

10. Source of Water? □Borehole □Well □ Stream □Tap-water

11. Toilet Facilities? □VIP □WC □ Pour flush □Pit latrine □ Public toilet [□ KVIP,

□ WC □Pit latrine] □ Open defecation

B. THE NEXT SET OF QUESTIONS IS ABOUT RESPITATORY HEALTH INFORMATIONS

Children

12a. Has your child been ill with cough in the last 12 months? a. Yes b. No
12b. If yes, is the child's cough accompanied by fast breathing than usual with short and/or rapid breathing? a. Yes b. No

13a. Did the child have any wheezing during the last 12 months? (Wheezing refers to wheezing caused by bronchi, not by nose) a. Yes b. No

13b. Two (2) weeks before this survey did the child experienced any wheezing? a. Yes b. No

14. Did the child have any cold with or without flu during the last 12 months? a. Yes b. No

15. Two (2) weeks before this survey did the child experienced cold? a. Yes b. No

16. Did the child have any difficulty in breathing or chest tightness during the last 12 months? a. Yes b. No

17. Two (2) weeks before this survey was the child having difficulty in breathing or chest tightness?
a. Yes b. No

18. Did the child have any ache in the ear during the last 12 months? a. Yes b. No

19. Two (2) weeks before this survey was the child having any arch in the ear?

a. Yes b. No

20. Did the child have any eye problems during the last 12 months? a. Yes b. No

21. Two (2) weeks before this survey did the child experienced this eye problem?
a. Yes b. No

22. Did the child have any skin problems during the last 12 months? a. Yes b. No

23. Two (2) weeks before this survey did the child experienced this skin problem?
a. Yes b. No

24a. When the child is allowed to play outside the home, how often does your child eat food dropped on the floor?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

24b. When the child is allowed to play outside the home, how often does the child eat food with fingers?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

25. When the child is allowed to play with friends, how often does the child wash hands before eating?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

26. When the child is allowed to play with friends, how often does the child come into contact with the contaminated soil(Examples-modify it)?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

27. When the child returns from the playground, how often does the parent hold or carry the baby when he has not changed into clean clothes?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

28. When the child is at home, how often does the child eats pick soil on the floor at home?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

29. When the child is at home, how often does the child crawls on the floor?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

30. When the child is at home, how often does the child places thumb/fingers in the mouth?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

31. When the child is at home, how often does the child pick nonfood items from the floor into the mouth?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

32. When the child is at home, how often does the child eat food dropped on floor?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

33. When the child is at home, how often does the child eat food with fingers?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

34 When the child is at home, how often does the child eat on the floor while sitting or lying on the floor?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

35. When the child is at home, how often does the child wash hands before eating?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

36. When the child is at home, how does the father hold or carry the baby when he has not changed into clean clothes?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

37. When the child is at home, how does the mother hold or carry the baby when she has not changed into clean clothes?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

Past illnesses - Children

38a. Did your child experience any other health problem before the current age? a. Yes b. No

38b. If you answered yes to question 71b, did a doctor diagnose it? a. Yes b. No

39 Did your child ever had any attacks with asthma? a. Yes b. No

40. Do your child experience any other chest illness?
a. Never b. Rarely c. Sometimes d. Most of the time e. Always

C: THE NEXT SET OF QUESTIONS IS ON ANTHROPOMETRIC MEASUREMENTS

41. Weight__________ Kg

42. Height___________ meters

43. BMI_______________ Kg/m2

D: THE NEXT SET OF QUESTIONS IS ON ANTHROPOMETRIC MEASUREMENTS

44 BP	1st reading	2nd reading	3rd reading	Mean
Systolic (mmHg)	………….	…………..	………….	…………….
Diastolic (mmHg)	…………	…………..	………….	……………..

Thank you very much. We really appreciate your participation in this study

(Schuchat 2012; WHO 2010).

(UNEP, 2015).”

(Global Burden of Disease Study (GBD) Compare 2018, Ghana).

(Donahoe et al., 2015)

(Personal Communication: Medical Officer at Pantang Hospital).