KWAME NKRUMAH UNIVERSITY OF SCIENCE AND

TECHNOLOGY, KUMASI

COLLEGE OF HEALTH SCIENCES

DEPARTMENT OF COMMUNITY HEALTH

HEALTH ASSESSMENT OF MINING ACTIVITIES ON CONCESSION COMMUNITIES IN THE NIMBA COUNTY: REPUBLIC OF LIBERIA

BY

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NOVEMBER, 2014

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A THESIS SUBMITTED TO THE DEPARTMENT OF COMMUNITY HEALTH, SCHOOL OF MEDICAL SCIENCES, COLLEDGE OF HEALTH SCIENCES, SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF PUBLIC HEALTH IN HEALTH SERVICES PLANNING AND MANAGEMENT

BY

EDDIE MIAWAY FARNGALO

NOVEMBER, 2014

CERTIFICATION

I hereby declare that, except for the references to other people's works, results, and others' ideas which have been properly acknowledged, this work is the result of my own original research.

I hereby declare that, this work has neither in full nor in part been presented for a degree elsewhere.

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DEDICATION

This thesis is dedicated to my entire family for their constant love and supports during the period I was away from home, especially to my precious mother Madam Laytopoe S. Farngalo, my late father Hon. Martin M. Farngalo, Mrs. Charlene W. B. Farngalo and Ms Edna T. Farngalo.

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ABBREVIATIONS

AML ArcelorMittal Liberia

As Arsenic

Cd Cadmium

DRC The Danish Refugee Council

Hg Mercury

HIV Human Immune Virus

LAMCO The Liberia- Americo Mining Company

LISGIS The Liberia Institute Statistics Geo-Information Services

NCDA The Nimba County Development Agenda

NRC The Norwegian Refugee Council

Pb Lead

TDS Total Dissolved Solids

WHO The World Health Organization

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ABSTRACT

BACKGROUND

Globally, nearly 13 million people are presently involved in iron ore and other mining activities while 80-100 million are indirectly affected by these activities. Iron ore mining alone produces about one billion tonnes in 2013 worldwide. Currently, the world had discovered an iron ore reserved of about 230 billion tons (Bt) that may be available for nearly 50 years. Small scale mining serves as a source of employment for more youth where mineral deposits originate. Despite its environmental, health and social challenges, it is established that the adverse effects of mining activities on communities in close proximity are mixed with both positive and negative consequences. The main objective was to assess the public health adverse effects in the mining communities in terms of their health characteristic, levels of heavy metals in water sources, and on affected communities. The study was conducted from July to September, 2014. The number of sample from each community was calculated using probability proportional to size (PPS), while purposive and simple random sampling were employed in selecting the affected communities and household heads respectively. A structured questionnaire was administered to households' heads that had lived in the studied areas for two or more years and were 18 years and above, and has consented to participate in the research. Water samples were analysed at the Nuclear Chemistry and Environmental Research Centre, Ghana Atomic Energy Commission in Accra for heavy metals (Cd, As, Hg, Pb), total dissolved solids, and pH.

Reference standards used were those of the World Health Organization (WHO) standards for drinking water, which was used to determine the level of heavy metals in water bodies. Logistic regression statistical analysis was employed in drawing inferences on the probably health effects of the mining activities on the ten communities. Twenty nine per cent of the respondents was within the age group of 41-50 years while 24.7% falls within the ages between 31-40 years.

Malaria prevalence was high among both the household heads and other members with 81.6% of household heads and 80.9% of other household members reported to have experienced the disease over the past 12 months. The average household size was 3 members above 18 years and 4 children summing to seven (7) people per house respectively. There was a statistically significant association between having a household size ≥7 and experiencing the malaria disease (adjusted odds ratio=1.40, p-value=0.003). Heavy metals such as As, Hg and Pb were above the WHO permissible levels in Zolowee (As=0.064, Hg=0.0285mg/l) and Liabala (Pb=0.064mg/l). Averagely, the underground water sources had higher than WHO acceptable levels in terms of Arsenic (0.0022mg/l), Lead (0.008mg/l), Hg (0.0071mg/l) and Arsenic (0.051mg/l) for surface water. Average pH level (6.47) in the community was slightly alkaline. The results gathered indicated that there was a high prevalence of malaria while water sources within the communities are polluted with some heavy metals (As, Hg, and Pb).

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Globally, about 13 million people are currently involved in iron ore and other minerals mining while about 80-100 million are affected by it activities indirectly (Hentschel et al.,2002). In 2013, about one billion tonnes of iron ore were produced worldwide (www.worldsteel.org) with about 230 billion tonnes that will last for over 50 years recognized as reserved (Yellishetty *et al*., 2010). On the other hand, 350-800 tonnes of gold per year are produced thus contributing about 20-30 per cent of global output. Small-scale gold mining serves as a source of employment for more youth where gold and ore deposits originate despite the environmental, health and social challenges. However, it has been established that the effects of mining activities on surrounding communities are mixed as they produce both positive and negative effects.

In spite of all the positive aspects of mining, one of the lessons that developing countries can learn from China's experience is that resource exploitation for fast economic growth without due consideration of environmental implications can indeed be a cause of poverty due to land degradation, over exploitation of natural resources, and pollution of water sources as well as the environment for the well-being of humans and animals (Huang and Han, 2006). Basically, mining has been found to be associated with some negative spill over effects on limited housing, social change, and social vices such as prostitution, sexually transmitted infections, community division and a sense of powerlessness within the community, especially on the part of the indigenes. Vegetation and biodiversity loss, deterioration of physical and psychological health, increase or

more severe respiratory diseases, and environmental degradations like increase of dust, noise, and vibration which are sources of inhabitants or communities closer to the mining concession concerns (Connor et al.,2004, Brereton *et al*.,2005, Franks *et al.*,2009).

Furthermore, it had been emphasized by Fargher et al.(2003) that, due to the huge expenditure of mining on communities including wages, infrastructure and other operating costs, mines provide direct economic stimulus into the economies of communities within which they operate (Fargher et al.,2003). However, in the studies of, Corden (1984) and Corden and Neary (1982), they argued that mining may introduce "Dutch Disease", a notion which translates to the situation where rapid growth in one industry drives up the cost of labour and other factors of production (Corden and Neary,1982, Corden,1984). Thus, the positive triggers for growth of one sector like mining is likely to create offsetting economic and social consequences as in the work of Gurbanov and Merkel (2010), which indicated that worker remittances, foreign grants and oil revenues are possible predictors of the "Dutch Syndrome" in countries like Egypt, Jordan, Lebanon Syria and other oil producing companies (Gurbanov and Merkel,2010).

However, despite many years of iron ore mining activities in Nimba County which is the "largest county" in Liberia (LISGIS,2008), there is little research about the public health impacts of the mining activities affecting its surrounding communities. Our proposed study seeks to contribute to efforts at filling the gap in knowledge to update Policy.

1.2 STATEMENT OF THE PROBLEM

Studies have showed that mining is accompanied by development, employment opportunities, road constructions, education and others in mining concession areas. However, the long term issues and challenges are paramount in determining the future health status of people living in these areas. Studies have shown that mining is associated with numerous Public Health problems that are hazardous to the health of people, animals and aquatic lives in the communities (Weber-Fahr *et al*., 2001). It is also acknowledged that lands or forests that have been tailed and deforested can remain destroyed and even cause further damages when the mine closes in the future (Kirsch, 2003).

Health assessment of the mining activities is essential in identifying the specific risk factors and health challenges facing the cluster of communities within the mining zone. Knowledge on the health impact is needed to develop appropriate interventions to improve the health status of the people to ensure sustainable quality of health for productivity and livelihood of the communities. Health effects associated with these heavy metals (Mercury, Arsenic, Lead, Cadmium) ranged from bioaccumulation in fishes that are transferred to human through food because of their (fishes) abilities to store these elements within their tissues (Afshan *et al*., 2013) and also the effect of arsenic on human include but are not limited to hyper/hypo pigmentation, skin cancer, bladder and lung cancers as compiled by WHO Background document for development of Guidelines for Drinking-water Quality (2003) (WHO, 2011). Cadmium adverse effect on human when contacted through drinking water includes kidney stones, proteinuria, and osteoporosis etc. (WHO, 2011).

1.3 RATIONALE OF THE STUDY

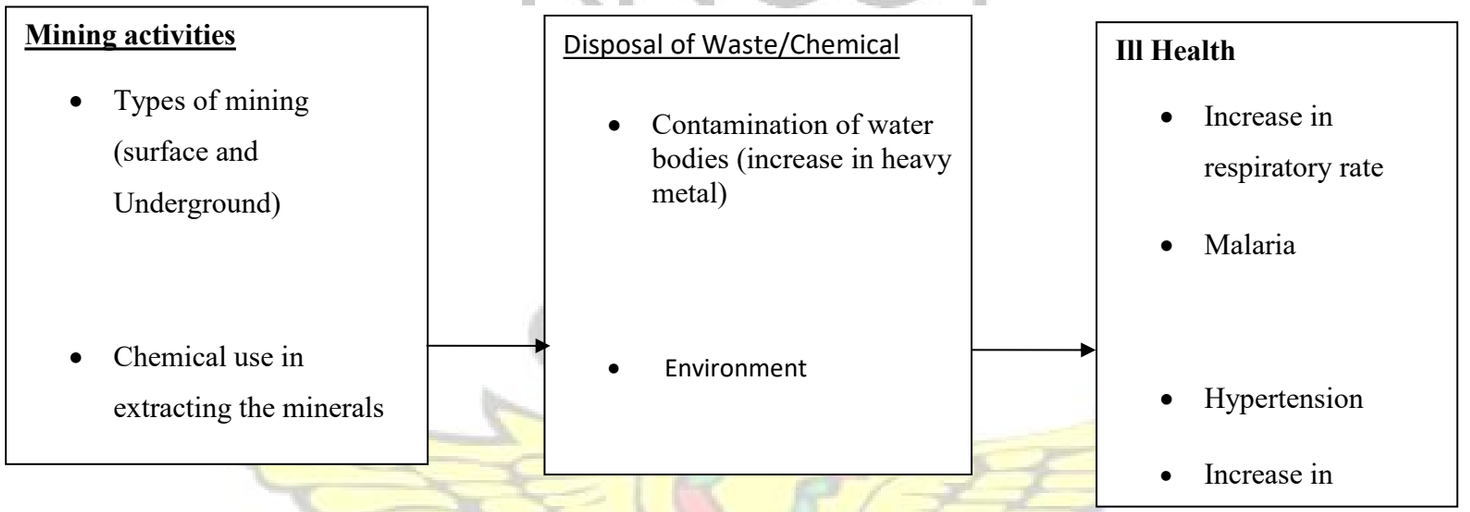
Basically, because of the numerous public health impacts that are hazardous to the health of the affected communities (Weber-Fahr *et al*., 2001 p.5), Assessment of the impacts of mining activities can be noticeable when there is a baseline data that is referred to, during the life span of the mining operation. Regrettably, the communities under study have not relatively been assessed in detail scientifically for about six decades since they get involved in mining operations. Moreover, mining in the ten communities over the past six (6) decades could have probably led to an increase level in arsenic, mercury, cadmium and lead in water bodies. Results from the study will also lay a baseline for other researches that may improve the health of people living in these mining communities. Furthermore, results that will be gathered from this research will prevent future occurrence of pollution and ill health.

Therefore, this study aims at investigating the public health impacts of mining in Nimba County; in terms of their health characteristics, level of metals in water source, population distribution and settlement. Recommendation will be made to avoid future ill health of the county and its inhabitants.

Moreover, Nimba County had a history of playing key role in the development of the Liberia through its ore mining for about six decades. Because of its long time involvement in mining operations, the researcher assumed that during the civil war, there were illegal mining activities with little concern or lack of technological know-how for mining safety. No record of any adverse health impact had been revealed over these years concerning the surrounding communities. This study therefore seeks to investigate the Public Health indicators which are likely to increase due to the activities

of mining in Nimba County. The study will also outlines the health impacts of mining activities that need to be investigated to feed into social development plan to achieve sustainable community development as well as meeting the WHO primary goal that states “all people, whatever their stage of development and their social and economic conditions, have the right to have access to an adequate supply of safe drinking water” (WHO, 2011).

1.4 CONCEPTUAL FRAMEWORK



Source: Author and Supervisor, 2014

The conceptual framework above links the relationship between mining activities and ill-health. There are several types of mining activities (surface and underground), type of chemical use in extracting the minerals (Mercury, Arsenic, etc.) as well as waste deposal technique that can lead to water and soil contamination thus leading to increase respiratory rate, Hypertension, and an increase in population size since mining boom can lead to migrant workers employment.

RESEARCH QUESTIONS

1. What are the health characteristics of people living within the mining concession?

2. What is the level of heavy metals in the water sources within the concession communities?

3. What is the population distribution and demographic of affected communities in terms of population distribution, profile of settlements and household migrants?

1.6.1 MAIN OBJECTIVE

To assess the public health effects of mining activities within the mining communities in terms of their health characteristic, levels of heavy metals in water sources, and population demographic of affected communities.

1.6.2 SPECIFIC OBJECTIVES

1. To assess the impacts of mining activities on the health characteristics of the people living in the mining concession.

2. To examine level of heavy metals in water within the mining concession

3. To assess population distribution and profile of settlement and households in mining concessions.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

This study looked at the health assessment of mining activities on concession communities in Nimba County, Republic of Liberia. Review of literature is based on the study objectives.

2.2 The impacts of mining activities on the health characteristics of people in mining concessions

According to a World Bank Report (2001), ‘‘Miners in small-scale mining as well as in large-scale mining are often migrant workers, living without their families and within disrupted social contexts. This situation can contribute to the high prevalence of human immunodeficiency virus (HIV) and other communicable diseases in mining communities.’’ (Weber-Fahr *et al*., 2001). Mining activities can also cause a permanent damage to lands, leading to an irreversible effect on, even when the mining company closes. For example, a corporate sponsored review of the OK Tedi mine Papua in New Guinea “pointed out that even if mining at Ok Tedi was to cease immediately, the problems downstream would continue to increase due to the sheer volume of tailings already in the river and ongoing erosion from waste rock dumps adjacent to the mined mountains.’’ (Kirsch S, 2003).

Even though there are environmental Laws outlined to protect the communities and the ecosystem and harms mining companies pose on communities and its workers, there are still challenges despite government efforts to ensure that her citizens are safe.

2.3 Mining and Respiratory diseases

Over the years, iron ore mining was considered a healthy occupation, which was before 1913. However, after the introduction of the pneumatic drilling, an increased in bronchitis and emphysema were noted by several researchers (Boyd *et al*.,1970).

According to Heederik and Sigsgaard (2014), respiratory tract diseases acquired in work places have a say considerably in the total weight of all respiratory diseases. Among all the respiratory diseases, pneunoconosis and lung cancers are some of the respiratory tract diseases related to mining activities. On the other hand, it was established that these activities (mining) can contribute to triggering some common respiratory tract diseases such as asthma(Heederik and Sigsgaard,2014).

Since metal degradation is "impossible", it is categorized as metalloids or metal together with semi-metallic elements such as; boron, arsenic, selenium, and tellurium. There are relatively two major ways through which metals and their compounds get emitted into the atmosphere; these are by natural and anthropogenic processes. Those compounds emitted into air by way of mineral processing, burning of objects, fuel used by motor vehicles, the wearing a way of motor vehicles tires, and brake pads that contain metals, are all sources of anthropogenic process through which particulates containing metals are transmitted into the air. Those cause by the weathering of minerals rich rocks and soil when wind blows are of natural source. Air toxics that are the large group in which trace metals form part, when breathe in or ingested, can be accountable for several ill health including cancer, neurotoxicity, immune-toxicity, cardio-toxicity, reproductive toxicity, teratogenesis and genooxicity (Goyer and Group, 2004, Järup and Åkesson, 2009, Mamtani *et al*., 2011). Scattered particles from mine waste into atmosphere had

been observed by researchers as a potential way through which human get exposed to metals in communities near active or discarded areas of mining. Zota *et al*. (2009), states, the levels to which respiratory particles from mining sites affect nearby communities depend on the distance from the mines, direction of wind blow, and concentration of rich Ca source (Zota *et al*.,2009).

2.4 The level of heavy metals in water bodies within the mining concessions

Heavy metals are defined as elements with atomic weights between 63.546 and 00.590 and have a definite magnitude greater than 4.0 i.e. at least 5 times heavier than that of water. They are found in water in colloidal, particulate and dissolved phases (Momodu and Anyakora,2010). Heavy metals occur in water bodies either by means of natural causes (e.g. eroded minerals within sediments, leaching of ore deposits and volcanism extruded products) or anthropogenic source (i.e. solid waste disposal, industrial or domestic effluents, harbour channel dredging) (Marcovecchio *et al*.,2007). Jesse (2010) revealed that the extent, to which contamination of a specified water supply system can be realized, is based on some characteristics that determine water qualities as well as the concentration levels of some constituents. These constituents have the ability to verify whether the water is fit for use by human and other living organisms. Some contaminants identified as a source that can contribute significantly to water quality determination are; Agricultural, Sanitary landfills and garbage dumps, biological contamination and heavy metal contamination (Jesse,2010).

Fundamentally, some metals are essential for promotion of health, prevention of ill health, as well as the maintenance of a particular health state. Adepoju-Bello *et al*.,

(2009) established that some metals such as calcium, magnesium, sodium, and potassium are essential for the sustainability of life. Essentially, they need to be present for normal body functions despite their potential ability to causing ill health sometimes.

Moreover, metals such as cobolt, copper, iron, manganese, molybdenum and zinc have a pivotal role (catalyst) in enzyme activities but ideally at a low level despite its demand by the body(Momodu and Anyakora,2010).

On the other hand, elements such as Aluminum, Arsenic, Cadmium, Lead and Mercury are considered the most common heavy metals that human get exposed to.

According to Ofosu-Asiedu et al., (2013), mining activities can create outsized amounts of highly exceedingly soluble inorganic matter, some of which are measured to be toxic to life and the environment entirely. Additionally, the study explained that the creation of chemical waste as a consequence of mining actions occurs globally and may seriously affect natural resources including streams, ecosystem, and vegetation widely(Ofosu-Asiedu et al.,2013). Armah et al. (2010) unveiled in their research conducted in Obuasi(Ghana) that the mining area had three of the most common heavy metal that affect human (Pb, Cd, As) in higher concentrations as compared to Ghana Environment Protection Agency (GEPA) and W.H.O acceptable level in surface water in Obuasi, Ghana (Armah *et al*.,2010).

Besides agricultural, domestic, and industrial usage of water, fishing is done from water source as well as transportation and many other important activities. Basically, water is known as the most important natural resource to mankind like air without which, life cannot exist.

Even though, mining companies have committed themselves to some social responsibilities, sustainability of environment, and their employees health and wellbeing, and also their protection for which they always have an objectives of "safety first" or "zero accidents," there are reports from Wikipedia and Human Rights Watch on their websites relating to removal of population from their land, ground water and surface water contamination cause by toxic waste from the mining sites leading to the water bodies pollution. Most often stunning issues arise from the mining are reported by international media (Vingard *et al*.,2013).

2.5 Arsenic in Water

Arsenic is one of the toxic contaminants that is colourless and tasteless and is usually found all over the earth crust and in ground water. It is a global issue mainly in countries like India and Bangladesh where 60 to 100 million people are "at risk" of consuming it (As) through drinking water (Monachese *et al*.,2012). Basically, it exists in two forms namely; organic and inorganic forms. The organic form is known to be non-toxic to lives and the environment but the inorganic form is the most toxic type according to WHO.

According to WHO (2011), As can be introduced into water bodies through several means, these include; the suspension of rocks, minerals and ores from sources including industrial effluents, mining wastes, and through atmospheric deposition. The consequence of consuming water that is contaminated with arsenic had been related to the development of cancer at several areas of the body, including; skin, bladder, lung, developmental effects, cardiovascular disease, neurotoxicity and diabetes. Moreover,

diseases associated with arsenic ingestion like cancer have become a serious Public Health problem in some parts of the world (WHO, 2011, FAO/WHO, 2011a; FAO/WHO, 2011b).

Furthermore, arsenic had been considered one of the most common heavy metals that pose health threat to human lives. It is associated relatively with iron ore mining activities and has a negative health impact when dispose in water source. This include; dermatological effects such as melanosis (pigmentation) which is believed to be the salient type and keratosis rough dry, popular skin lesions), which result from a chronic exposure to arsenic. Long-time exposure or contact with arsenic may also lead to reproductive, neurological, cardiovascular, respiratory, hepatic, haematological and diabetic effects on human. Likewise, the intake of inorganic arsenic is a well-known cause of bladder, skin, and lung cancers (Mukherjee et al.,2006). The permissible level for Arsenic in drinking water according to the World Health Organization is 0.01mg/l.

2.6 Lead in water

Lead is a commutative toxic and a potential source for human to get cancer; it can damage the connections of the nervous system especially in children as well as brain disorders (Momodu and Anyakora 2010 and Ofosu-Asiedu *et al*., 2013). Additionally, human exposure to Pb may lead to a situation where a person's immune system attacks its own cells causing a condition called "autoimmunity". This condition is capable of causing combination of diseases and ailments that affect the kidneys, and the circulatory system. In pregnant women, Pb causes miscarriages, while in males, it reduces fertility, and in young girls, it delays puberty. The delay of puberty in young girls is potent

because Pb has the ability to suppress the hormones that begin the ovulation in the reproductive system of young girls, when its level increases in blood. A prospective cohort study conducted among Russian boys concluded that blood lead levels contributed to the late pubertal commencement in peri-pubertal boys (Schoeters *et al.,* 2008, Momodu and Anyakora, 2010, Meeker, 2012, Ofosu-Asiedu *et al*., 2013).

Even though mining companies entering operation minimize the threat of exposure by to purchasing neighbouring tracts of land, in recent years, however, towns are established near a mine and residences were built on top of mine tailing (Bakewell,1984). Children found in such places in the past and even as of now, are likely to ingest huge quantities of lead, by this, they are said to have come in contact with lead through playing in contaminated soil or ingesting lead-laden dust at home (Gulson *et al*.,1994, von Lindern *et al*.,2003, Lyle *et a*l.,2006). Van Geen et al. (2012), study concluded that lead contamination through soil is possible to be widespread in Peru mining towns but the intensity of pollution is spatially far from identical (van Geen *et al*.,2012)

2.7 Cadmium in water

Cadmium is a metal with a corrosion condition of +2. It is chemically comparable to zinc and occurs naturally with zinc and lead in sulfide ores. It is used as an anticorrosive on steel; it is well known for its accumulation in tissues mainly the liver and the kidneys of terrestrial and aquatic animals. Kidney is identified as the organ that has the total burden of 50% cadmium as compared to the total body burden of the metal. The most health outcome remains as kidney renal tubular dysfunction and because of cadmium toxicity, human exposure can lead to kidneys damage and hypertension. Basically, due

to its health effects, it had been listed among the common heavy metals that humans get exposed to (World Health Organization, 2004, Momodu and Anyakora, 2010, WHO *et al*., 2011).

2.8 Mercury in water

Mercury is non-hazardous in its elemental form. However, it becomes toxic when in the inorganic species (Hg2+) after it has become chemically modified. Mercury is considered the third on the priority list of ATSDR according to its report (ATSDR, 2011) and it is among the WHO's top ten (10) chemicals of most important Public Health fear globally (WHO, 2003).

According to Momodu and Anyakora (2010), because of the toxicity of Hg, health conditions such as mental disturbance, impairment of speech, hearing and movement problems may arise (Momodu and Anyakora,2010).Other health effects may include tremor, irritability, nervousness, memory loss, excessive shyness, insomnia, hallucinations and neuromuscular changes such as muscle atrophy and muscle weakness, headaches and decreases in cognitive function (WHO,2003, ATSDR,2014). Moreover, because of its ability to eagerly cross the placental barrier, and "in-utero" exposure, its negative health outcomes include; learning disabilities reduced cognitive functions, immune suppression, and neurological disorders. (Park and Zheng, 2012, Ray *et al*.,2014). Among adults and children populations, Hg tends to cause an adverse health outcomes on the cardiovascular, respiratory, neurological systems as well as changes in the thyroid, liver, kidneys, and immune functions (Holmes *et al*.,2009).

The maximum level of mercury allowed to be present in drinking water by W.H.O is 0.001 mg/l respectively.

2.9 Population distribution, profile of settlements and households in the mining concession

Mining community is the one where the population is straightly affected by the close mining operation. It may be associated with the mining project through direct employment or through environmental, social, economic or other impacts (Veiga *et al*.,2001). Research had showed that even though mining may contribute to national and local economic, the residents of the communities in which the mining is carried on is "at risk" of not being affected with such opportunities resulting from the economic while they seem to tolerate several costs as well as risks associated with mining in "underdeveloped" areas Besides, large- scale mining companies require some levels of investment, such as infrastructure, technology, and employments. Due to the educational level of the "poor" and because participatory skills are lacking, they might not benefit. On the other hand, there are several mine-related factors that can lead to sustainable, opportunities, and livelihood reduction; 1) some natural resources such as water and land on which the poor depend for food, may be used by the company, thus causing some limitations of opportunities in terms of income generation through agriculture, fishing, or hunting; (2) the company local infrastructure services may deny the poor admittances because of increased prices of services, and otherwise due to plain capability limitations.(e.g. an unanticipated effect of construction of a new mine on an island in Papua New Guinea overwhelmingly demanded for ferry and other boat services which effectively excluded the "poor" from using them and drove up the cost of

goods because of rapid increases in ferry and boat prices); (3) employees of the company with higher incomes may cause an increase in prices of essential goods (food, fuel, land or housing) and other services within the communities at the detriment of the indigenes (Weber-Fahr *et al*.,2001). Basu et al. (2009) concluded from their study that "The fruits of mining have historically not been shared with those who occupy and mine the land, while the ill effects of mining have been disproportionate placed upon the poorest communities" (Basu *et al.*,2009).

According to Maconachie (2012), mining allows people to return to their homes after being urbanised, as in the case of Kono District, Sierra Leone. Basically, when people return to their communities because of mining, it helps to drive recovery of community-based support. Improvement of such could offer a more long-lasting foundation for sustainable and self-governing growth in years to come (Maconachie,2012).

CHAPTER THREE

3.0 METHODOLOGY

3.1 STUDY METHODS AND DESIGN

A Cross-sectional study design was used in the ten communities that are found within the "no go zone area" provided by the mining company (ArcerlorMittal mining company Liberia limited). The study was conducted for three Months from July to September.

3.2 STUDY POPULATION

Males and females in the ten communities formed the study population from the mining concession. Male and females aged eighteen (18) years and above who had lived in those clusters for at least two years were considered eligible to be included in the study. This was done in order for the researcher to avoid confounding effects due to migrants from other mining environments within the country (Liberia).

3.3 COUNTRY PROFILE

3.3.1 Location:

Liberia is located on the west coast of Africa. It is bounded on the west by Sierra Leone, Guinea to it north, La Cote D'Ivoire on the east and south by the Atlantic Ocean. Liberia gained its independence in 1847 with the total area of 111,369 kilometres (43,000sq miles) and has an estimated total population of 3.8 million (LISGIS, 2008). It is also a home to over 30 local languages despite English being its official language. The

Country is sub- divided into 15 counties (regions) and has many natural resources (Gold, Diamond, Iron ore etc.).

During its fourteen years of brutal crisis, an estimation of 270,000 people were killed while leaving basic health and socio-economic statuses of its citizens in deplorable state, people infrastructures were destroyed, citizens were impoverished, causing people to be internally displaced (IDPs) and others fled to another countries for refuge (LPRS, 2008).

Liberia, in West Africa, remains a country rich in natural resources such as gold, diamond, and iron ore and became the largest exporters of iron ore in the 1960s and 1970s, thus making the Liberia-American Mining Company (LAMCO), an iron ore mining company operating at the Mount Nimba at that time, one of the largest companies in Africa (Kraaij,1983). Even though, Liberia is rich in terms of natural resources, the wealth of the country is different when measured on other scales. Suffering from a fourteen years of civil conflict (1989 to 2003), reports from WHO (2014) shows that Liberia is one of the six "low-income" countries that have made highest improvement in life expectancy. The reports showed twenty years (20) increase in 2012 as compared to forty-two (42) in 1990 (WHO, 2014).

Throughout the period of the conflict (1989-2003), there were numerous damages and negative impacts on production and commercial activities as they ceased operation. Families were scattered, economy collapsed, and all agriculture and mining operations stopped during said period (LPRS, 2008). But before the taking over of power from His Excellency Charles Taylors in 2006 by President Ellen Johnson Sirleaf, many roads were destroyed and there were no piped water or electricity for about 15 years. Ninety-

five percent (95%) of the health facilities operating before the war was to some extent or completely damaged and was left with the total of thirty (30) physicians to provide services to the population of about 3 million people (Kruk *et al*.,2010).

3.3.2 COUNTY PROFILE

Nimba County is one of the fifteen counties (regions) in Liberia. It is found in the north-eastern part of Liberia, bordered on the northwest by Guinea and on the east by La Cote D'Ivoire. Nimba is bordered by some counties including Bong, River Cess, and Sinoe. It total geographical area (land and water) is 2,300 square kilometres; from north to south, Nimba stretches 230 kilometres, 100 kilometres from East to West. The county has a total distance of 298 kilometres from the country's capital (Monrovia) to its capital city (Sanniquellie). Its altitudes ranged from about 150 m, from which the Cestos River flows, to more than 1,300m at Mt. Nimba which is the highest point in Liberia. Its climate is at latitude 60 to 80 N respectively (Force,1983) and (NCDA, 2008-2012).

The estimated total population of the Nimba County from the 2008 Population and Housing Census is 462,026 with the proportion of male to female almost as 1:1(males=230,113, female=231,913) (LISGIS, 2008). Records from the 2005 voter statistic in the County information pack shows that 64% (121,844) of the total registered voters of 190,284 were between the ages of 18-39. A little over ninety-eighty per cent (98.2%) of its population is made of locals, 0.31 %(IDPs and refugees) returnees and 0.49% refuges" while females of child bearing ages are often found within the ages of 14 to 49 giving rise to the high fertility rates in the county (NCDA, 2008- 2012). Even-though, all the sixteen tribes spoken in Liberia can be found in the Nimba County, there

are two major ethnic groups (Gio and Mano), who predominant the others. The County is currently having 41 functioning clinics for the population of 462,026.

3.3.3 Ethnicity

The Mano and the Gio ethnic groups pre-dominantly live within the county with fewer tribes from other parts of the Country who are business people, employees, student etc.

3.4 SAMPLING TECHNIQUE OF HOUSEHOLD DATA AND ANALYSIS

The number of respondents from each community was selected by probability proportion to population size (PPS). Random sampling was used in households' selection. An instance where more than one household was in a house, a systematic random sampling strategy was employed with a sampling interval by 15,000/653=23 for interview.

Table 1 **Distribution of sampling strategy**

Deleted[Eddie Miaway Farngalo]:

Name of mining area	**Total population (N)**	**Proportion to sample**	**Estimated Sample size from Each Cluster(community)**
Bonlah	857	6%	39
Lugbeyee	1258	9%	58
Konlah	500	4%	23
Yekepa	5149	37%	239
Camp 4	729	5%	34
Liabala	428	3%	20
Gpapa	1432	10%	66
Zolowee	1353	9%	64
Makinto	700	5%	32
Sehygeh	1692	12%	78

Total	14,098	100%	653

3.5 DATA COLLECTION METHOD

A quantitative technique was employed to collect data:

Structured questionnaire was used to gather data on health characteristics of the people living in the mining concessions, population distribution and demographic.

Water samples were collected randomly from those communities' surface and underground water sources. Those samples collected were representative of the main water sources used by the respondents for domestic and drinking purposes.

3.6 STUDY VARIABLES

Two main classes of variables are involved in this study. These are dependent and independent variables.

Table 2 Study variables

STUDY VARIABLES	OPERATIONAL DEFINITION	MEASUREMENT LEVELS OF VARIABLE
Metals level	Measures in mg/l	Continuous
Age	Age at last birthday	Categorical
Gender	Female or Male	Binary
Ethnicity	Gio, Mano, other	Categorical
Education level	No formal, Pre-school, Primary, JHS, Secondary/SHS/Tech/Voc/,	Categorical

	Tertiary	
Occupation	Unemployed, Farmer, Civil/Public servant, Artisan, Petty trader, other	Categorical
Marital status	Single, Married/cohabitation, Divorce/separated, Widowed, Don't know	Categorical
Household size	Number of people in household	Discrete

3.5 SAMPLE SIZE

The study assumes the prevalence of the impacts of mining activities among the ten communities is 50%, with a 95% confidence level and a standard error of 5%. However, with the estimated population of the mining concessions was calculated at 15,000(Krishnamurthy and Jalnawalla,2011).

The formula used for the estimated sample size for each community was calculated as;

$n= [z2 (p0.q0)] \div d^2$.

n= sample size

q0: (1-p) =0.5; Where z: coefficient of reliability at 95% CI=1.96

P0: estimated proportion of the prevalence of the mining externalities is=0.5

d: deviation= 0.047

Design effect= 1.5

$n= [1.96^2 (0.5x\ 0.5)] \div 0.047^2$

n=3.8416x0.25÷0.002209

n=0.9604÷0.002209

n= 435*1.5=653

Therefore, the sample size estimated is 718 participants adding the non-respondents rates of 10%.

3.5.1 Water samples collection

Plate 3.1

Fourteen (14) water samples were collected in 1000mL (1L) well washed amber polypropylene bottles from the communities' boreholes and other water sources including hand pumps, streams and river that are used for drinking and other activities. Water sources used during the study were classified as surface (spring, river, dam, and pond) and groundwater (boreholes, dug well).

The samples were kept under the recommended temperature of 4 ^{0}c by W.H.O after collection. Moreover, during the samples transport from Liberia to Ghana, they were placed in a cool box with icepack to have it kept under the WHO recommended temperature for travelling.

An identification numbers were written on those samples as well as the community's name. All water samples for heavy metal analysis were acidified (pH<2) by adding 1mL conc.HNO3. All samples were taken to the laboratory for analysis. All sample containers collected from the ten (10) communities (Camp 4, Yekepa, Zolowee, Lugbegee, Gbapa, Konlah, Liabala, Mankinto, and Sehyigeh), were ensured by the researcher they were chemically cleansed, by washing them with chromic solution and rinsed with deionized water before taking it to Ghana where they were analysed.

3.5.2 Water Sample Preparation

Analysis to determine the level of heavy metals in water samples was performed at the Nuclear Chemistry and Environmental Research Centre, Ghana Atomic Energy Commission in Accra.

3.5.3 Digestion Protocol for Water Sample Using Milestone Acid Digestion Microwave ETHOS 900.

Five millilitres (5.0ml) of water sample was measured into a previously acid washed labelled 100ml polytetraflouroethylene (PTFE) Teflon bombs. Six millilitres (6ml) of concentrated nitric acid (HNO3, 65%), 3ml of concentrated hydrochloric acid (HCL,35%) and 0.25ml of hydrogen peroxide (H2O2,30%) was added to each sample in a fume chamber. The samples were then loaded on the microwave carousel. The vessel caps were secured tightly using a wrench. The complete assembly was microwave irradiated for 26minutes using milestone microwave lab station ETHOS 900, INSTR: MLS-1200 MEGA using the below microwave programme.

Table 3 **presents the report code for the instrumentation**

Table 3: Report Code: CD 1194A

Step	Time	Power Pressure	Temp 0C 1	Temp 0C 2
1	00:05:00	250	400	500
2	00:01:00	0	400	500
3	00:10:00	250	400	500
4	00:05:00	450	400	500

Ref: Milestone Acid Digestion Cookbook update 1st January 1996

3.5.4 QUALITY CONTROL

The following Quality Control and Quality Assurance techniques were used during the analysis:

Blanks: They were to check contamination during sample preparation.

Duplicates: used to check the reproducibility of the method used.

Standards: To check the efficiency of the equipment being used.

3.5.5 Recommended instrument parameters

Table 4: Atomic Absorption: Working Conditions

ELEMENT	WAVELENGTH (nm)	LAMP CURRENT (mA)	SLIT WIDTH (nm)	FUEL	SUPPORT
Pb	217.0	5	1.0	ACETYLENE	AIR
Cd	228.0	4	0.5	ACETYLENE	AIR
As(BY HYDRIDE)	248.3	5	0.2	ACETYLENE	ARGON
Hg(BY HYDRIDE)	253.7	4	0.5	ACETYLENE	ARGON

Ref: VARIAN. Publication No 85-100009-00 Revised March 1989

Calculation: Concentration (C) (mo/l) = $\frac{conc.(d.f)x\ Nominal\ Vol}{Sample\ weight\ in\ grams}$

This formula was used because the test solution was already diluted.

3.5.6 Determination of Water pH

Heavy metals were assessed in the Laboratory (ref 1.9.8).The pH of the water samples were measured in the laboratory with a Suntex® SP-707 (Taipei, Taiwan) portable pH meter

3.6 PRE-TESTING

The questionnaires and data summary sheets were pre-tested at the Putu mine which was not part of the selected communities in the Nimba county concession area prior to the research. Fourteen people participated during the pre-testing of the questionnaire. After the pre-testing of the questionnaire, the views of the respondents to the questionnaire were deemed appropriate. No change was made to the questionnaire but questions were re-arranged for easy understanding.

3.7 DATA HANDLING AND ANALYSIS

Thirty research assistants and five supervisors were trained for 4 days (1 day for presenting of tools) prior to data collection and guidelines as well as translation of questionnaires in respondent's respective local languages, the Nimba Gio and Mano to ensure consistency.

Data collected from field were entered into Microsoft access. Data was cleansed by researcher to correct any mistakes that were made during the data entry. Thereafter, data

was inputted into STATA version 11 for analysis. The micro level analysis involved assessing the influence of mining related public health externalities on the individual respondent while macro level analysis based on households and the community. Generally, data were presented with descriptive statistics and inferential statistics to test for association between the outcome variable and the independent variables. The heavy metals analysis was compared to the international thresholds as defined by WHO (Cadmium 0.003mg/l, Arsenic 0.01mg/l, Mercury 0.001mg/l and Lead 0.01mg/l respectively).

3.8 CONSENT

Written consents were obtained from respondents. The intent, procedure, expected risks and benefits were explained and those who agreed to participate were enrolled into the study. Permissions were soughed from communities' leaders. Household heads or participants above eighteen years who have lived in the communities for over two years were asked to consent to the study protocol.

3.9. ETHICAL CONSIDERATION

All the study protocols were reviewed and cleared by the Committee for Human Research Publication and Ethics of Kwame Nkrumah University of Science and Technology and the Institutional Review Board (IRB) of the ArcerlorMittal mining company Liberia limited in whose mining concession, the study was conducted. Privacy and confidentiality were ensured by assigning codes to participants' questionnaire. Respondents were told that their participation in the study was absolutely voluntary; they had the right to refuse or not to participate without being affected in anyway.

Information gathered from the study participants were used for the intended purposes. In accordance with the Archives law of Liberia and Ghana, results gathered from the study will be discarded after five (5) years.

3.10 LIMITATIONS OF THE STUDY

1 For the translation of the questionnaire to local dialects, the meanings may have changed even though research assistants were trained to translate the questionnaire back and forth.

2. There was disturbance between the locals and the mining company during the week of the data collection. Subsequently, the commotion between the company and the respondents might have influenced their responses.

3. The water samples were collected during the rainy season. It might had caused dilution of heavy metals in those samples thus leading to the under or over estimation of some heavy metals levels in water samples analysed.

3.11 ASSUMPTIONS

The following assumptions were made while carrying out the research.

1. The sample size chosen representative of the study population

2. Responses from the participants represented the true situation on ground.

3. The water samples were analysed by a renowned chemical analysis laboratory in Ghana. Therefore the level of heavy metals detected is dependable and gave the clear picture of the state of those water bodies selected during the research

CHAPTER FOUR

4.0 RESULTS AND ANALYSIS

This chapter shows the results and analysis of the study. It is presented according to the specific objectives of the study. The results are showed in tables, figures and charts. Seven hundred four (704) participants responded to the questionnaire. Heavy metals analysed were Cadmium, Arsenic, Mercury, and Lead.

4.1 Household survey on Perceived Health Impacts of Mining Activities

4.1.1 Demographic characteristics of Respondents

From the demographic characteristics of respondents sampled, sixteen per cent of the respondents were less than 30 years with those in 41- 50 age group constituting the majority (29.7%).

Table 4.1: Demographic characteristics of respondents

Variables	Frequency, n=704	Percentage
Age groups		
≤30	118	16.8
31-40	174	24.7
41-50	209	29.7
51-60	88	12.5
≥61	115	16.3
Gender		
Male	489	69.5
Female	215	30.5
Primary occupation		
Unemployed	132	18.8
Farmer	325	46.2
Civil/Public Servant	42	5.9
Artisan	10	1.4
Petty Trading	79	11.2
Other	116	16.5
Ethnicity		

Gio	101	14.3
Mano	502	71.3
Others	101	14.3
Education of Respondents		
No formal education	289	41.1
Pre-school	27	3.8
Pre-Primary/Primary	62	8.8
JHS/Middle	133	18.9
SHS/Secondary	183	25.9
Tertiary	10	1.4
Average number of household (SD)	6.68(2.76)	
Average adults above 18yrs (SD	3.26(1.46)	
Average children below 18yrs(SD)	3.51(1.79)	

Source: Field data, 2014

There were more males (69.5%) than females. The main occupation for the respondents was farming (46.2%), while petty trading was the least (11.2%).

Most of the respondents had no formal education 289 (41.1%) as compared to one hundred eighty three183 (25.9%) with earlier secondary education. The average household size was 6.7(SD 2.76) persons and averagely, there were 4 children below 18 years in each household. Most of the respondents were from the Mano tribe 502(71.3%).

4.1.2 General Health status and Health seeking Behaviour of Respondents

General health status and health seeking behaviour of participants is presented in (table 4.2).

The orthodox medical service comprising of hospitals and clinics were the primary source of health care for most of the respondents 580(84.4%). However, 71(10.3%) use herbal medicine as their primary source of treatment when they are ill.

Table 4.2: General Health Status and Health seeking Behaviour

Variables	Frequency	Percentage
Primary health care		
Herbal medicine	71	10.3
Hospital/Clinic	580	84.4
Faith healing centre	36	5.2
Others	0	0.0
Total	687	100
Ever used Herbal Medicine		
Yes	453	66.3
No	233	33.7
Total	686	100
Do you have health facility in this community		
Yes	347	50.7
No	338	49.3
Total	685	100
Attended Hospital over the past one year		
Yes	473	70.7
No	196	29.3
Total	669	100
Mode of payment of Medical bills		
Myself	608	88.6
Relatives	35	5.1
Others	43	6.3
Total	686	100
Do you get all prescribed medications		
Yes	246	36.0
No	437	63.9
Total	683	100
Assessment of your Health		
Excellent	81	11.8
Very good	92	13.4
Good	191	27.8
Fair	116	16.8
Poor	208	30.2
Total	688	100

Source: Field data, 2014

Over the period of one year, 70.7% had attended hospitals/clinics for various ill conditions. In terms of their ability to pay medical bills, self-payment was most common with a proportion of 88.6% as compared to 11.4% who paid medical bills by the help of relatives. A little over fifty per cent (50.7%) reported of having a health facility in the community as compared to forty nine per cent (49.3%) who admitted that, they have to travel to nearby towns for health care services. Regrettably, among all the respondents who go to the health facilities, sixty three per cent (63.9%) were unable to obtain their prescribed drugs. The general perceived health status of the people disclosed that 11.8% was experiencing excellent health, 208(30.2%) had poor health status, and 191 (27.8%) admitted to have had good health.

Table 4.1.3: Below shows the relationship between demographic characteristics

Variables	Ever diseased over the past 3 months		P-value
	None	Disease	
Age group			0.273
≤30	20(16.9)	98(83.1)	
31-40	32(18.4)	142(81.6)	
41-50	39(18.7)	170 (81.3)	
51-60	10(11.4)	78(88.6)	
≥61	13(11.3)	102(88.7)	
Ethnicity			0.04
Gio	15(14.9)	86(85.1)	
Mano	74(14.7)	428(85.3)	
Others	25(24.7)	76(75.3)	
Primary occupation			0.78
Unemployed	25(18.9)	107(81.1)	
Farmer	46(14.2)	279(85.9)	
Civil/Public servant	8(19.1)	34(80.9)	
Artisan	1(10.0)	9(90.0)	
Petty trader	14(17.7)	65(82.3)	
Others	20(17.2)	96(82.8)	
Educational status			0.79
No formal education	42(14.5)	247(85.5)	
Primary	15(16.9)	74(83.1)	
Junior High	23(17.3)	110(82.7)	
Secondary/Tertiary	34(17.6)	159(82.4)	
Household size			0.003
≤3	26(26.8)	71(73.2)	
4-6	40(17.3)	191(82.7)	
≥7	48(12.8)	328(87.2)	
Primary health care			0.03
Herbal medicine	3 (4.2)	68(95.8)	
Hospital/clinic	89(15.3)	491(84.7)	
Faith healing center	7(19.4)	29(80.1)	
Herbal medicine use			<0.001
No	48(20.6)	185(79.4)	
Yes	51(11.3)	402(88.7)	

and the risk of becoming ever diseased over the past 3 months (table 4.3)

Source: Field data, 2014

Reports from the study shows that respondents who used herbal medicine over the past three months (83.8%) had experienced diseases as compared to 16.2% who did not experience disease. Among people who used Hospital/clinic as their primary source of health care, 15% was reported to have experienced no disease with relative to 84.7% who have had diseases. House hold with more than three members reported to have experienced diseases (73.9%) as compared to house with ≤3 members (27.1%).

4.3 Availability of Water and Mechanism for Purifying Water for Domestic Use

Table 4.8 shows the availability of water and mechanism used for water purification intended for consumption and other domestic purposes. Dug well was the most common water source used for drinking and domestic activities in the mining concession. Three hundred and sixty eight 368(52.7%) respondents reportedly used it for drinking, 362(51.7%) cooking, and hand cleaning 337 (48.1%) and laundering purposes 337 (48.1%).

Table 4.4: Indicates the responses to differences between water sources and mechanisms used for water purification.

Water Sources and Uses	Frequency, n=704	Percentage
Main drinking water Source		
Piped into dwelling	24	3.5
Public tap, standpipe	127	18.2
Tube well or borehole	8	1.1
Dug well	368	52.6
Spring water	32	4.6
Rainwater	26	3.7
Surface water (river, dam, stream, pond)	113	16.2
Bottled water	1	0.1
Cooking Water Source		
Piped into dwelling	24	3.4
Public tap, standpipe	73	10.4

Tube well or borehole	10	1.4
Dug well	362	51.7
Spring water	32	4.6
Rainwater	31	4.4
Surface water (river, dam, stream, pond)	167	23.9
Bottled water	1	0.1
Hand Cleaning Water Source		
Piped into dwelling	24	3.4
Public tap, standpipe	51	7.3
Tube well or borehole	8	1.1
Dug well	337	48.1
Spring water	29	4.1
Rainwater	32	4.6
Surface water (river, dam, stream, pond)	218	31.1
Bottled water	1	0.1
Laundering Water Source		
Piped into dwelling	24	3.4
Public tap, standpipe	26	3.7
Tube well or borehole	7	1.0
Dug well	332	47.4
Spring water	29	4.1
Rainwater	34	4.9
Surface water (river, dam, stream, pond)	247	35.3
Bottled water	1	0.1
Availability of main water source		
Yes	329	52.4
No	299	47.6
Mechanism for water purification		
Boil	99	16.2
Add bleach, chlorine, alloy	310	50.8
strain through cloth	0	0.0
Use water filter (ceramic, sand, composite, etc.)	16	2.6
solar disinfection	0	0.0
let it stand and settled	185	30.3

Source: Field data, 2014

It was reported that the main source of water is always available for 329 (52.4%) participants who used it for both domestic and consumption purposes. However, a little over forty seven per cent (47.6%) complained that their main source of water is not always available. Fifty per cent of the respondents (50.8%) reported that bleach (Clorox)

was used for the purification of their drinking water while thirty per cent (30.3%) always let the water to settle naturally before domestic use and drinking.

4.3.1 Water Sources, Adequacy, and Quality

More than half of the respondents (65.9%) reported that their main source of water for domestic and drinking purposes was not always clean.

Table 4.5: Responses relating to water quality and adequacy in the ten communities

Variables	Frequency	Percentage
Water Source always clean		
Yes	238	34.1
No	461	65.9
Noticed change in water colour		
Yes	510	75.2
No	168	24.8
Frequency water colour changes		
Frequent	296	54.8
Occasional	180	33.3
Rare	64	11.9
****Causes of water colour change**		
Mining activities	296	54.8
Natural	180	33.3
Construction	64	11.9
Others	0	0.0

****among those who noticed change in water colour**

Seventy five per cent of respondents reported that they have noticed a change in water colour. Out of those respondents who complained that their water colour changes, 54.8% reported a frequent changed in water colour while 33.3% reported that the condition was occasional. A significant portion (54.8%) of respondents who had noticed change in water colour attributed it to the mining activities while 33.3% said it was due to some natural phenomenon.

4.4 Stressors of Community Members

Perceived stressors in the ten communities (table 4.6). This study unveiled that 55.1% of the respondents sometimes worry about not having clean air to breathe as compared to 24.7% who had never worried about having clean air to breathe. Among those who had worried about clean air to breathe, 71.3% attributed it to mining activities. Nevertheless, a relatively insignificant portion (28.7%) reported that the mining operations were not the cause of said conditions. Considering environmental cleanliness, 63.7% sometimes worried about not having a clean environment while 16.9% had never worried about their environment becoming clean. Forty six per cent of the respondents sometimes worried about not having safe drinking water relative to 16.3% who had never worried about having clean water to drink.

Table 4.6: Perceived sources of stressors among the ten communities' members

Variables	Frequency	Percentage
Worried about clean air to breathe		
Never	169	24.7
Sometimes	377	55.1
Often/Usually	44	6.4
All of the time	94	13.8
Perceived causes (Mining)		
Strongly agree	250	38.1
Agree	218	33.2
Don't agree	188	28.7
Worried about clean environment		
Never	116	16.9
Sometimes	437	63.7
Often/Usually	23	3.4
All of the time	110	16.0
Perceived cause (mining)		
Strongly agree	130	19.58
Agree	320	48.19
Don't agree	214	32.23
Worried about safe water to drink		
Never	112	16.33
Sometimes	321	46.79
Often/Usually	64	9.33
All of the time	189	27.55
Perceived cause (Mining)		
Strongly agree	262	39.70
Agree	197	29.85
Don't agree	201	30.45
Worried about becoming ill		
Never	78	11.37
Sometimes	480	69.97
Often/Usually	30	4.37
All of the time	98	14.29
Perceived cause (Mining)		

Strongly agree	205	30.8
Agree	222	33.3
Don't agree	239	35.9
Worried about your children becoming ill		
Never	77	11.22
Sometimes	496	72.30
Often/Usually	34	4.96
All of the time	79	11.52
Perceived cause (Mining)		
Strongly agree	202	30.5
Agree	225	33.9
Don't agree	236	35.6

Source: Field data, 2014

With respect to the perceived cause of worrying about safe water to drink, 262(39.7%) strongly agreed that it was due to the mining activities while 201(30.5%) did not agree. The investigations of the occurrence of disease disclosed that 480(69.9%) worried about them becoming ill while 72.3% sometimes worry about their children becoming ill. On the other hand, 35.6% of the respondents who worried about their children becoming ill did not attribute it to the mining activities while 33.9% pointed to the mining activities as a perceived cause.

4.5.1 Disease experienced by Respondents (Multiple Responses)

Table 4.7 Differences in percentage of prevalence of diseases among respondents

Variables	Frequency	Percentage
Malaria	562	81.6
Diarrhea	301	43.7
Skin diseases	210	30.5
Staining of teeth	151	21.9
TB	19	2.8
Cough	298	42.3
Asthma	25	3.6
Joints pain	311	45.1

Source: Field data, 2014

The above table indicates the disease experienced by household members in the communities. A great proportion (81.6%) of the people reported to have had malaria over the past three months. About 45.1% have experienced joints pain as compared to 43.7% who admitted to have experienced diarrhea within the communities under study. Moreover, notable percentage of the study population had experienced cold and cough 298(42.3) and skin diseases 210(30.5%). Staining of teeth was the least disease reported in those communities.

4.5.2 Disease experienced by Household Members (Multiple Responses)

Diseases experienced by household members in the communities under study (table 11). An alarming percentage (80.9%) of household members had experienced malaria disease over the past one year.

Table 4.8: Disease experiences by Household Members (Multiple Response)

Variables	Frequency	Percentage
Malaria	276	80.9
Diarrhoea	113	33.1
Skin diseases	210	30.5
Straining of teeth	53	15.5
TB	9	2.6
Cough	169	49.9
Asthma	18	2.6
Joints pain	117	34.3

Source: Field data, 2014

Roughly 49.9% reported to have had cold and cough while 33.5% admitted to have had diarrhoea. On the average, malaria was most common among the respondents and other household members in the communities. Malaria accounted for 562(81.6%) among

respondents and 276(80.9%) among other household members. Diarrhoea, joints pain, skin diseases were on an increase among both the respondents as well as other household members. Staining of teeth, TB, and asthma were rare among the two groups.

4.6 Having a history of hypertension and smoking

Table 4.9: Respondents who had their BP checked and those who smoked

Variables	Frequency	Percentage
Blood pressure checked		
Yes	182	29.9
No	427	70.1
How long since you checked		
< six (6) months	121	66.5
>six months but < 1 year	25	13.7
>1 year	36	19.8
Does anyone here smoke		
Yes	17	
No	398	95.9
Have ever smoked		4.1
Yes	19	4.7
No	382	95.3

<Less than, >greater than

Source: Field data, 2014

Over the past one (1) year, one hundred eighty two 182 (29.9%) of respondents have had their blood pressure checked as compared to four hundred twenty seven (427) respondents of (70.1%) who have not checked their blood pressure. Accordingly, 121(66.5%) have had their blood pressure checked in less than six months, 25(13.7%) have it checked after six months but was less than a year, while 36(19.8) have it checked over one year.

Table 4.10: Univariate logistic regression analysis of demographic characteristics and becoming ill over the last three months

Variable	OR	95% CI	P –value
Age group			
≤30	1.00		
31-40	0.96	.49 - 1.85	0.90
41-50	0.89	.47 - 1.71	0.75
51-60	1.51	.62 - 3.69	0.37
≥61	1.59	.66 - 3.81	0.30
Gender			
Male	1.00		
Female	1.04	.67 - 1.61	0.86
Occupation			
Unemployed	1.00		
Farmer	1.42	.83 - 2.42	0.20
Civil/public servant	0.99	.40 - 2.41	0.99
Artisan	2.10	.25 - 17.37	0.49
Petty trader	1.08	.53 - 2.24	0.83
Others	1.12	.59 -2.15	0.73
Ethnicity			
Gio	1.00		
Mano	1.01	.55 - 1.84	0.98
Others	0.53	. 26 - 1.08	0.08
Education			
No formal education	1.00		
Primary	1.19	.57 - 2.50	0.63
Junior High	0.98	.52 - 1.80	0.94
Secondary/tertiary	0.94	.54 -1.65	0.83
House hold size			
≤3	1.00		
4-6	1.74	.99 - 3.07	0.05
≥7	2.50	1.46 -4.30	0.001
Primary health care			
Herbal medicine	1.00		
Hospital/clinic	0.24	.075 - .79	0.02
Faith healing centre	0.18	.04 - .76	0.02

Herbal medicine use			
Yes	1.00		
No	2.04	1.33 - 3.15	0.001

Source: Field data, 2014

Ages above 61 years as well as 51-60 years have a risk of 59% and 51% of experiencing diseases respectfully, relative to those less than 31 years. However, this was not statistical significant. Among all occupations, farmers were 42% and Artisan 110% more likely to had developed disease as compared to those who were unemployed. With respect to house hold size, house with 4 to 6 members' risk of disease was increased by 74% and those with 7 or more members, risk of becoming diseased was 1.5 times more likely as compared to household size of less than 4. Respondents who used herbal medicine are 1.4 times more likely to getting ill relative to those who did not. The latter is likely to be relapsed probably because the symptoms were not properly cleared from the body system.

Table 4.11 Multivariate logistic regression showing an adjusted odds ratio between studied variables

Variable	Adjusted OR(95% CI)	P-value
Ethnicity		
Gio		
Mano	0.84(.44 - 1.59)	0.59
Others	0.51(.24 - 1.06)	0.07
Household size		
≤3		
4-6	1.73(.95 -3.15)	0.07
≥7	2.40(1.34 -4.32)	0.003
Primary health care		
Herbal Medicine		
Hospital/Clinic	0.26(.08 -.84)	0.03
Faith healing centre	0.26(.06 - 1.01)	0.07
Used herbal medicine		
Yes		

No	1.67(1.05-2.64)	0.03

Source: Field data, 2014

There was no statistical significant difference between all tribes and the risk of becoming diseased over the past 3 months. With respect to the number of people in each house, seven or more members, as well as those with four to six members were 1.4 times and 73% more likely to becoming disease respectively, as compared to house hold size with less than or three members while respondents who used hospital/clinic as their primary health care had a protective effect. Respondents who used herbal medicine were 67% more likely to have developed ill health relative to those who did not

4.7 Heavy Metal in ground water as per community.

Table 4.12: Analysis of Heavy Metals in Water Samples (Ground Water)

Heavy Metals/ Community	Mean (SD)	W.H.O Permissible Limit (mg/l) in drinking water
Camp 4		
Arsenic (As)	0.001	0.01
Cadmium (Cd)	0.002	0.003
Lead (Pb)	0.001	0.01
Mercury (Mg)	0.001	0.001
Gbapa		
Arsenic (As)	0.001	0.01
Cadmium (Cd)	0.002	0.003
Lead(Pb)	0.001	0.01
Mercury (Mg)	0.001	0.001
Konlah		
Arsenic (As)	0.001	0.01
Cadmium (Cd)	0.002	0.003
Lead (Pb)	0.001	0.01
Mercury (Mg)	0.001	0.001
Liabala		
Arsenic (As)	0.001	0.01
Cadmium (Cd)	0.002	0.003

Lead (Pb)	0.064	0.01
Mercury (Mg)	0.001	0.001
Lugbegee		
Arsenic (As)	0.001	0.01
Cadmium (Cd)	0.002	0.003
Lead (Pb)	0.001	0.01
Mercury (Mg)	0.001	0.001
Makinto		
Arsenic(As)	0.001	0.01
Cadmium(Cd)	0.002	0.003
Lead(Pb)	0.001	0.01
Mercury (Hg)	0.001	0.001
Yekepa		
Arsenic(As)	0.001	0.01
Cadmium(Cd)	0.002	0.003
Lead (Pb)	0.001	0.01
Mercury (Hg)	0.001	0.001
Zolowee		
Arsenic(As)	0.0065	0.01
Cadmium (Cd)	0.002	0.003
Lead (Pb)	0.001	0.01
Mercury (Hg)	0.0285	0.001

Source: Field data, 2014

Out of the fourteen water samples collected from the ten (10) communities, Liabala reported the highest lead concentration of 0.064mg/l which was above the WHO permissible level of 0.01mg/l. Zolowee had the highest mean concentrations of Arsenic (0.0065) and Mercury (0.0285) relative to WHO permissible level 0.001mg/l and 0.001mg/l respectively. Water samples that takes it sources from uphill where the mining takes place had a higher level of As and Hg (0.100mg/l vs 0.144mg/l respectively) that was above the WHO permissible level. Sehigeh stream had an As level of 0.016 mg/l. The mean water samples tested from Zolowee, had an Hg level of 0.0395mg/l and 0.0455mg/l. These results are all above the W.H.O acceptable metals concentration level in water bodies.

4.7.1Heavy Metals per community in surface water.

Table 4.13: Analysis of Heavy Metals in Water Samples (Surface Water)

Heavy Metals/ Communities	Mean (SD)	W.H.O Permissible Limit Drinking Water
Gbapa		
Arsenic (As)	0.08	0.01
Cadmium (Cd)	0.002	0.003
Lead (Pb)	0.001	0.01
Mercury(Hg)	0.04	0.001
Sehyigeh		
Arsenic (As)	0.001	0.01
Cadmium (Cd)	0.002	0.003
Lead (Pb)	0.001	0.01
Mercury (Hg)	0.001	0.001
Yekepa		
Arsenic	0.016	0.01
Cadmium	0.002	0.003
Lead (Pb)	0.001	0.01
Mercury (Hg)	0.001	0.001
Zolowee		
Arsenic (As)	0.0805	0.01
Cadmium (Cd)	0.002	0.003
Lead (Pb)	0.001	0.01
Mercury (Hg)	0.0505	0.001

Source: Field data, 2014

From the surface water samples analysed, Arsenic (0.08mg/l) and Mercury (0.04mg/l) levels were higher compared to WHO permissible limits. Zolowee and Gbapa recorded the mean Arsenic value of 0.0805mg/l while Zolowee Mercury value was 0.04mg/l. These values when compared with the WHO approved levels were higher.

4.7.2 Overall mean levels of chemicals compared with WHO guidelines for drinking water.

Table 4.14 Mean heavy metals analysis in underground and Surface water sources

Over all mean Metals	Mean levels	Drinking water WHO
Underground		
Cadmium	0.002	0.003
Arsenic	0.00222	0.01
Lead	0.008	0.01
Mercury	0.00711	0.001
Surface water		
Cadmium	0.002	0.003
Arsenic	0.0514	0.01
Lead	0.001	0.01
Mercury	0.001	0.001

Source: Field data, 2014

The mean heavy metal concentration of Arsenic (As) 0.00222mg/l, and

Mercury (mg) 0.00711mg/l in underground water in the communities were higher than the W.H.O approved level (0.001mg/l)while the mean surface water level of As (0.0514) was also higher than the WHO standard (0.01mg/l).

4.7.3 PH levels of water samples

Table 4.15: Mean levels of pH in the communities

pH Levels of Water Samples / Community	Mean
Sehigeh Stream	6.17
Makinto borehole	5.13
Zolowee borehole	6.24
Zolowee stream	6.24
Zolowee stream	6.14
Zolowee borehole	7.05
Gbapa borehole	6.93
Gbapa stream	6.49
Liabala borehole	6.90
Camp 4 borehole	6.15
Lubegee borehole	6.21
Konlah borehole	6.90
Yekepa stream	7.32
Yekepa borehole	6.53
W.H.O pH level*	6.5-8.5

*(WHO,2011)WHO Guidelines for drinking-water quality

The pH values of the water samples ranged from 5.13 to 6.90. PH levels were lower for Sehigeh, Zolowee streams, Gbapa stream, Camp 4, Lubegee and Makinto as per the WHO optimum limits of between 6.5 and 8.5.

Fig 4.1: Results of TDS in water samples per community

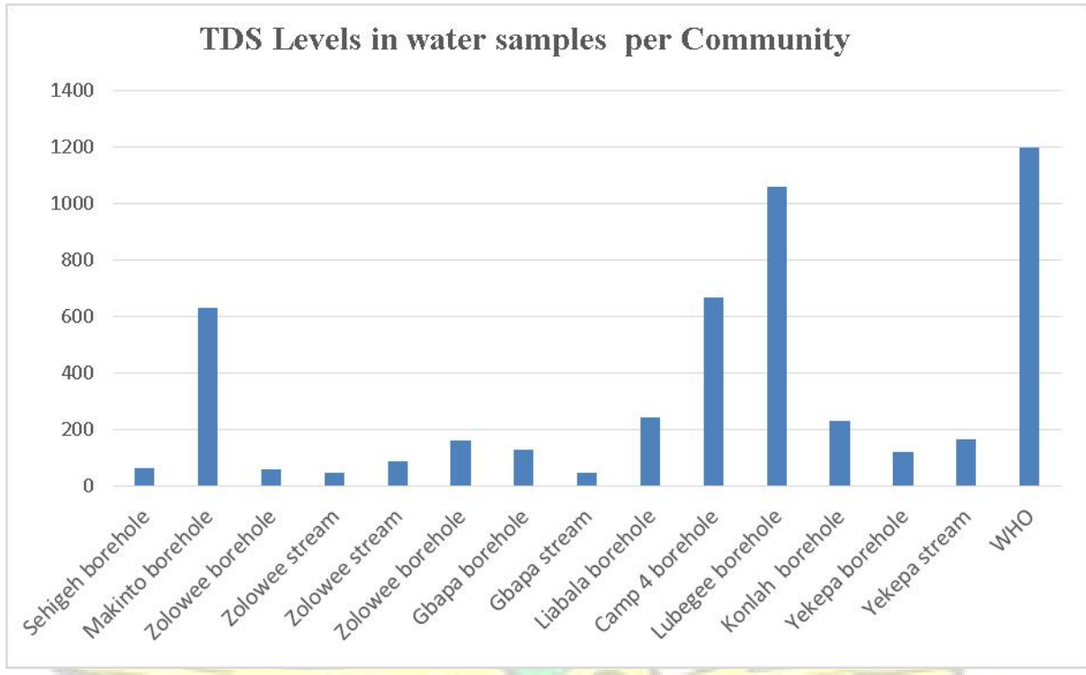


Figure 4.1 Results of TDS in water samples per community
Source: Field data, 2014

The total dissolved solid (TDS) from the fourteen (14) water samples ranged from 47.9 to 1059. Levels of TDS were within the WHO guidelines for drinking water quality (1200mg/l).

CHAPTER FIVE

5.0 DISCUSSION

This chapter looks at the various findings that have been established from the ten communities under study. The findings are different and similar to phenomena that have been unveiled through several researches around the globe.

5.1 Educational level of the respondents

The survey report showed that, 41% of the respondents were not formally educated. Basically, viewing the educational level of the community members, most employment opportunities within the concession is less likely to benefit them. The results is consistent with a study conducted by Weber-Fahr (2001) suggested that even-though mining companies may have some levels of infrastructure, technology and employments opportunities, the educational level of community inhabitants, may not permit them to be employed.

5.2 Population distribution within the communities

People living within mining concessions are migrant workers living without their families and within disrupted social contexts. This situation can contribute to a high prevalence of human immunodeficiency virus (HIV) and other communicable diseases in mining communities (Weber-Fahr *et al.,* 2001). Report from the surveyed areas showed that most people living in the mining concession area 603 (85.7%) are indigenes while 101 (14.3%) are from different tribes. This report does not support the research by Weber-Fahr et al., (2001) but is in line with the research by Maconachie (2012), who

concluded that mining allows people to return to their homes after being urbanised, thus helping to drive recovery of community-based support.

5.3 Perceived mining impact

Mining of natural resources such as iron ores is a significant activity which benefits and on the hand contributes to the ill health of the community and its inhabitants doing and even after the mining company shut down. Consequently, the mining operation are often associated with short and long-term adverse effects on the environment and its people (Weber-Fahr *et al*.,2001).

Results from the water samples analysed indicated that Arsenic was above the W.H.O permissible level in Gbapa (sediment), Yekepa (Stream), and Zolowee (Up mines, stream, and workshop). These results confirmed the study of Armah et al. (2012) that mining can produce high levels of soluble inorganic matters, some of which are measured to be toxic to life and the environment as a whole. The result from Armah et al. (2012) also showed that As, Pb, and Hg are potential heavy metals that are likely to affects people and aquatic lives in mining communities. The above WHO permissible level of heavy metals detected was perhaps due to other potential contaminants like car batteries, geological compositions, weathering of rocks, mine tailings, agricultural activities, water drainage, rain water run-off from general mining site, ores possessing plants as well as from ammunitions used doing the fourteen years civil war in the county and country at large.

Therefore, the results are of concern because As consumption is a major public health hazard worldwide. Consequently, the consumption and other use of As over a period of

time may lead to skin, kidney, and lung cancers. Reproductive, neurological, cardiovascular, respiratory, hepatic, haematological, and diabetic effects on human are additional health effects of As (Mukherjee *et al*., 2006, World Health Organization 2010, WHO *et al.*, 2011, Monachese *et al.,* 2012). Hence, because of the communities' extensive involvement in both small and large scales mining of diamonds and other minerals over the years, chemicals used in the extraction might had led to the high levels of some heavy metals in the study area.

5.4 Reported malaria prevalence in the communities

Malaria kills 627,000 people worldwide out of the reported cases of 207 million in 2012 according to the latest WHO's estimates released in December 2013. Given the estimates, the WHO further estimates that every minute a child dies in Africa of malaria thus accounting for the mortality rate of 54% since 2000. In Liberia as of 2010, 11% of under-five (<5yrs) deaths were attributed to malaria and 726.91 cases in thousands population were diagnosed with malaria in the Country (Liberia Factsheets of Health Statistics, 2010). The surveyed data showed that malaria was the most common disease experienced by the respondents 562(81.6%) while 276(80.9%) occurred among other household members. The finding is consistent with the work of Knoblauch et al.(2014) that communities affected by mining activities are likely to have high prevalence of malaria (Knoblauch *et al*.,2014). Malaria with a known host (Anopheles mosquitoes) transmission can be caused by several unhygienic practices. Prevalence of malaria in dwelling places are subjective to various factors including the existence of the parasite, the vector, the human host, and the environment. Additionally, the vector with the parasite can breed during the rainy season, in ponds. Moreover, the disease is

transmitted to humans in areas where people are the only animal it bites, as well as when people with low immunity go in search for jobs. The relatively high prevalence recorded in the survey is more likely due to the environmental practices of the inhabitants such as not cleaning around communities, keeping stagnant water in homes as well as the mean household size of 7 recorded during the study. The household size of seven or more shows statistical significant association (p=0.003) for experiencing diseases. As statistically proven, increase household size might have contributed to the relatively high prevalence of malaria reported. This research result is in line with the work of Huldén, McKitrick et al. (2014) with the conclusion that the prevalence of malaria disease will reduce when household size in community become small (≤ 4). Basically, when many people are in household and are sharing the same bed room is more likely prevention of the malaria disease is unlikely. Consequently, when one person becomes infected with the disease, the vector (mosquitoes) spread the disease by biting those who did not have the sickness initially thus leading to an upward prevalence rate among household members.

Furthermore, with 41.1% of the total respondents having no formal education, it is most likely that knowledge levels about the disease occurrence and prevention among respondents is relatively low.

5.5 Physico-chemical analysis of the water samples

The pH of water is an important parameter in measuring water quality, even-though it has no negative health effects according to WHO. Acid-base reactions are important in ground water because of their influence on pH and the ion chemistry. The pH levels in the study area ranged from 5.13 to 7.32. The lowest pH (5.13) was recorded in Makinto and it shows slight acidity. Basically, low pH of water may be attributed to expulsion of acidic water by agricultural and small scale mining activities and also its geological considerations. The average pH (6.47) recorded during the survey was slightly acidic when compared to the WHO permissible level (6.5-8.5). Acidity which gives an idea of natural salt in drinking water is influenced by several factors including mineral run-off from soil, bicarbonates, hydroxides, phosphates borates and organic acids (ionic types). Other factors responsible for drinking water acidity are industrial pollution, sewage, and drain water. Generally, activities including sedimentation, runoff, erosion, dissolved oxygen temperature and decayed organic materials are some of the factors that can influence the alkalinity and acidity of water. Perhaps, the acidity of drinking water in the study area is as a result of the sewage system problem such as toilets built around water sources (underground and surface water), some boreholes were reported to have been used by community members for over one decade without being repaired as well as drain water in close proximity to drinking water sources located in the studied communities.

Moreover, the results showed that all the individuals in this community depend on both underground and surface water sources for drinking and domestic use. The level of pH reported is of Public health importance because individuals who may have an unpleasant

taste of the water due to its acidity, may easily substitute the present drinking water source that seem acidic for other water sources that are probably not save for drinking. This may increase water borne diseases among the community dwellers.

The TDS of drinking water has no direct effects on human according to W.H.O. Its concentration levels in water bodies vary according to the geographical locations, and natural sources. The TDS levels within the surveyed areas ranged from 47.5ppm to 1059ppm with a mean value of 265ppm. TDS level less than 1000mg/l is acceptable for human consumption, though circumstances may influence its level of acceptability. Moreover, a high level of TDS makes water unpleasant for drinking purposes because of its taste and its ability to cause unnecessary scaling in water pipes, heaters, boilers, and household appliances.

The highest TDS was recorded in the sample collected from Lubegee hand pump (1059ppm) and all other TDS levels detected were within the WHO recommended level for peoples' consumption (WHO, 2010).

Even-though these TDS levels were within the WHO permissible limit, studies have showed that TDS values less than 300mg/L as recorded in both underground and underground water samples from Khanlah (230mg/L), Yekepa workshop (122mg/L), Liabala (243mg/L), Gbapa (130mg/L), are necessary for dyeing of cloths and the manufacture of plastics, pulp paper and may limit the growth of aquatic lives (Rao,2013) and (Joseph, 2005) while the lowest levels recorded in samples collected from Sehigeh (62.5ppm), Zolowee (58.3 ppm), and 88.8ppm of Zolowee mines may cause unattractive taste, flatness, and are often acidic to water-supply systems, making them unacceptable

to users. Therefore, the relatively high and extremely low TDS concentrations in those towns need serious public health attention.

5.6 Respiratory tract diseases

Worldwide, non-communicable diseases (Asthma, Chronic Obstructive Pulmonary Diseases) are the leading causes of death. They cause more deaths, compared to all other causes of deaths. The burden is mainly on the world's "low and middle income Countries". In Liberia, W.H.O estimates that 6% of all deaths were attributed to chronic respiratory disease alone. The risk factors for these NCDs are occupational hazards, tobacco smoke, exposure to allergens, and hereditary susceptibility (W.H.O, 2014).

In the Nimba county mining concession, two hundred twenty eight (298) people (42.3%) have experienced cough, nineteen (19) people (2.8%) of TB and twenty five (25) people of (3.6%) have also experienced Asthma for the past three months. However, with the highest proportion of respondents (46.2%) being farmers when compared to all other occupations, the respiratory diseases reported in the study is perhaps due to the risk factors outlined by WHO (2014) for non-communicable diseases, especially in relation to farming activities reported in the mining concession.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSIONS

The results gathered from the study showed that some of the heavy metals (As, Hg and Pb) were above the WHO's permissible levels in some of the mining communities. These reported high levels of some of the heavy metals in the water bodies, surface and underground water poses some risk to the general population.

Malaria prevalence was common among both the household head and other members of the household. Diarrhoea was also observed to by very high in the concession communities.

However, this study is a cross-sectional survey that cannot give substantive evidence that the mining activities were the cause of the high level of heavy metal detected.

Therefore, more research (cohort, case study) study is needed to establish the sources of heavy metals (As, Pb, Hg) and the relatively high prevalence of malaria and diarrhoea revealed in the study.

6.2 RECOMMENDATIONS

District Representative

- Should involve the health team in the county in dealing with the transmission and prevention of diseases in the mining concession communities

Household heads

- Household heads and other members, who are knowledgeable of these diseases, should organize community for meetings (durbars) and discuss the mode of transmission, prevention, and how to seek prompt treatment whenever there are signs of ill health.

- Household heads should also encourage community dwellers to drink water sources that are approved for drinking and other domestic uses by the County Health Team (CHT).

- Water sources within the mining concession should be thoroughly investigated for physico-chemicals (Heavy metal, TDS, PH, flatness,)

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APPENDIX

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY/DEPARTMENT OF COMMUNITY HEALTH, SCHOOL OF MEDICAL SCIENCES, COLLABORATIVE CENTRE FOR RESEARCH (KCCR).

Title: The health assessment of mining activities on concession communities in Nimba County, Liberia from July to August 2014.

Household Questionnaire #

Introduction

Good morning/afternoon. I am a student at School of Medical Sciences, KNUST. I will be conducting several meetings with people like you in Yekepa mining concession to find out your views and ideas about: The health assessment of mining activities on concession communities in Nimba**.** Your opinions are highly essential at the same time vital as they will help us find out what is happening in our communities and find means to how we can prevent them for going further. Whatever you say will be treated confidential (secret), so feel free to answer the questions we are giving you. Be assured that your responses will not in any way be linked to your identity. You are kindly requested to answer the questions below by indicating a tick or writing the appropriate answer when needed. Thank you very much.

INTRODUCTION

Name of Community _____ Interviewer's Code _____

Community Status Rural

Time Started _____:_____Time Ended ____:_____ Duration _____:____

SECTION A: DEMOGRAPHICS / BACKGROUND INFORMATION

1. Age at last birthday: _____ (Estimated ☐
2. Gender: 1. Male [ ] 2. Female [ ]
3. Primary Occupation: _____1. Unemployed 2. Farmer [ ] 3. Civil/ Public Servant [ ] 4. Artisan [ ] 5. Petty Trader [ ] 6. Other _____
4. Ethnicity_____1.Gio 2.Mano 3.Other_____
5. Education _____1 No formal education 2.Pre-School 3.Primary 4.JHS 5. Secondary, /SHS, /Tech/ Voc; 6.Tertiary

6. Total persons in household (Household Size): _____
7a. Total number of adult above 18 years in the household: _____
7b. Number of household members 18 yrs & above

Relationship to Household Head	Sex	Age (years completed)	Highest Level of Education Attained	Marital Status	Occupation

2.=Wife or Husband;
3. = Son or Daughter;
4. = Son-in-law or daughter-in-law;
5 = grandchild;
6 = Parent;
7 = Sibling;
8 = Unrelated;
777= Other (Indicate below),
888 = Don't know
	M=1
	F=2
		# YRS
		888= Don't know
			0 = No school;
			1=Nursery,Pre-Sch
			2= Primary;
			3= Middle, JHS;
			4 = Secondary, SHS, Tech, Voc;
			5 = Higher than Secondary education,
			888 = Don't know
				1 = Single
				2=Married or cohabitation
				3= Divorced or Separated;
				4 = Widowed;
				888 = Don't know	

7c Total number of children (under 18) in the household: _____
7d: Children of the Household (under age 18)

ID	Age	Sex	Education Level	

8. **What is the main type of fuel used for cooking in the household**?

No.	Fuel	No = 0; Yes = 1; Don't Know = 888	Main Fuel Source (chose ONE only)
a.	Electricity		
b.	Kerosene		
c.	Charcoal		
d.	Wood/firewood		
e.	LPG		
f.	Natural gas		
g.	Biogas		
h.	Straw/shrub/grass		
i.	Agricultural crop residue		

9a. Main material of the <u>WALLS</u> in the Dwelling (INTERVIEWER RECORD OBSERVATION):_____ (earth/sand ( ); cane/palm ( ); dirt ( ); bamboo+mud ( ); stone+mud ( ); plywood ( ); cardboard ( ); cement ( ); stone ( ); brick ( ); wood ( ); other ( )

9b. Household amenities

14. What kind of toilet facility do members of your household usually use?	No Toilet Facility/Free Range (bush, field) [IF YES, SKIP TO 16]	1☐
	Flush or Pour Toilet	2☐
	Pit Latrine - ventilated improved, with slab	3☐
	Bucket or Pan	4☐
	Other Public (Specify):_____	777☐

9c. does your household have:

No.	Service/Appliance	No = 0; Yes = 1; Don't Know = 888	If Yes, how many functioning units? 789= Not Applicable
a.	Electricity		
c.	Television		
d.	Refrigerator		
e.	Freezer		
f.	Farm Animals (cow, chicken, goat, sheep, pig, donkey, etc		
			N/A

SECTION B: WATER SOURCES, ADEQAUCY AND QUALITY

1a. is your source of water always clean? Yes [ ] No [ ]

1b. If No, what usually make it unclean?

_____

2a. Have you noticed a change in colour of your source of water Yes [ ], No [ ]

2b. If yes How often? Frequent [ ] Occasional [ ] Rare/hardly [ ]

3. What do you think is the cause of water colour changing? 1. Mining activities [ ], 2. Natural [ ], 3. Construction [ ], 4. Other_____

4. Sources of Domestic/ Home Water

	Drinking Water Source	Cooking Water Source	Hand Cleaning Water Source	Laundering Water Source
Piped into dwelling/ indoor = 1				
Piped into yard = 2				
Public tap, standpipe = 3				
Tube well or borehole = 4				
Dug well = 5				
Spring water = 6				
Rainwater =7				
Tanker truck, cart truck = 8				
Surface water (river, dam, stream, pond) = 9				
Bottled water = 10				
Sachet/ sac water = 11				
Other (specify) =777				
Which of the above water sources is your MAIN water source for each of these activities? (enter number)				

12. Who usually goes to fetch/ draw the water for your household? (check all that apply) Explain _____ _____ _____	[ ]$_1$ Adult Women [ ]$_2$ Adult Man [ ]$_3$ Female Child under 18 years [ ]$_4$ Male Child under 18 years [ ]$_5$ Water isn't fetched; is bought from vendor/ seller [ ]$_{777}$ Other: Explain _____ [ ]$_{888}$ Don't know
13. How long does it take to go there, get water and come back?	Minutes: _____ N/A$_{789}$ [ ] Don't Know$_{888}$ [ ]

14. How many times per day or week do you obtain/buy water?	_____ times per Day _____ times per Week
15. Each time water is obtained for your household, about how much is obtained/ get?	____ Liters _____ Basins _____888 Don't know
16. How much does the water cost each time it is purchased?	_____ LD [ ]$_{789}$ Not Applicable
17. At your main source of water, is the water always available?	[ ]$_{0}$ No [ ]$_{1}$ Yes [ ]$_{888}$ Don't know
17a. If not, how often (# of days per month or year, carefully record units) is the water not available?	_____ days per month (note: dry season is 4-5 months long) _____ month per year [ ]$_{789}$ Not Applicable
18. Do you do anything to the water to make it clean?	[ ]$_{0}$ No [ ]$_{1}$ Yes [ ]$_{888}$ Don't know
19. What do you usually do to make the water clean? Anything Else: (RECORD ALL MENTIONED)	[ ]$_{1}$ Boil [ ]$_{2}$ Add bleach, chlorine, alloy [ ]$_{3}$ strain through cloth [ ]$_{4}$ use water filter (ceramic, sand, composite, etc) [ ]$_{5}$ solar disinfection [ ]$_{6}$ let it stand and settled [ ]$_{777}$ Other (Specify: _____) [ ]$_{888}$ Don't know [ ]$_{789}$ Not Applicable

5. Have you ever experienced any of the under listed conditions?

		Possible Cause
5b. Not having clean air to breathe	[ ]$_{1}$ Never [ ]$_{2}$ Sometimes [ ]$_{3}$ Often/Usually [ ]$_{4}$ All of the time	Mining Activities 1.Stongly Agree [ ] 2. Agree [ ] 3. Don't Agree [ ]
5c. Not having a clean environment	[ ]$_{1}$ Never [ ]$_{2}$ Sometimes [ ]$_{3}$ Often/Usually [ ]$_{4}$ All of the time	Mining Activities 1.Stongly Agree [ ] 2. Agree [ ] 3. Don't Agree [ ]
5d. Not having safe water to drink	[ ]$_{1}$ Never [ ]$_{2}$ Sometimes [ ]$_{3}$ Often/Usually [ ]$_{4}$ All of the time	Mining Activities 1.Stongly Agree [ ] 2. Agree [ ] 3. Don't Agree [ ]
5e. Yourself becoming ill	[ ]$_{1}$ Never [ ]$_{2}$ Sometimes [ ]$_{3}$ Often/Usually [ ]$_{4}$ All of the time	Mining Activities 1.Stongly Agree[ ] 2. Agree [ ] 3. Don't Agree [ ]

5f. Your children becoming ill	[ ]1 Never [ ]2 Sometimes [ ]3 Often/Usually [ ]4 All of the time [ ]789 Not applicable - have no children	Mining Activities 1.Stongly Agree [ ] 2. Agree [ ] 3. Don't Agree [ ]

SECTION C: GENERAL HEALTH

1a. What is your primary source of health care?

1b. Herbal Medicine [ ] 2. Faith healing center [ ] 3.Hospital [ ] 4. Clinic [ ] 5.Other_____

2a. What is your secondary source of health care?

2b1. Herbal Medicine [ ] 2. Faith healing [ ] 3. Hospital / Clinic 4. Other_____

3a. Have you ever used herbal medicine before? Yes [ ] No [ ]

3b. If Yes, for what disease/sickness _____

4a.Have you attended hospital over the past one year Yes [ ] No [ ]

4b. If yes how many times _____

Complaints _____

5a. Is there a health facility in this community Yes [ ] No [ ]

5b. Estimated distance to the health facility (in km) _____

6. Who pay for medical bills, myself [ ], Relatives [ ], others _____

7a. Do you get all prescribed drugs Yes [ ] No [ ]

7b. If no, by what means? Buy [ ] credit [ ] Ignore [ ] Barter/exchange [ ] other_____

7c. Effectiveness of treatment: 1.Very effective [ ] 2. Effective [ ] 3.Some-how effective [ ] 4. Not effective [ ]

8a. Have you ever found it difficult/ hard to breathe? Yes [ ] No [ ]

8b. If yes what was the cause? _____

9. Have you experienced any of the under listed disease over the past three months?

Disease	Yes No	Occurrence (Very often, Often, Rare)
Malaria		
Diarrhoea		
Skin diseases		
Staining of teeth,		
TB		
Cough and cold		
Asthma		
Joints pain		
Other		

10 Has any of your family members experienced any of the under listed disease over the past three months?

Disease	Yes No	Occurrence (Very often, Often, Rare)
Malaria		
Diarrhoea		
Skin diseases		
Staining of teeth,		
TB		
Cough and cold		
Asthma		
Joints pain		
Other		

11. Would you say your health in general is:	[ ]$_1$ excellent [ ]$_2$ very good [ ]$_3$ good [ ]$_4$ fair [ ]$_5$ poor
12. Is there a particular clinic, health centre, doctor's office, or other place that you usually go if you are sick, need advice about your health, or for routine care?	[ ]$_0$ No [GO TO 23] [ ]$_1$ Yes, please specify a name for the place _____ ___
13. Where do you usually go to see a doctor?	[ ]$_1$ = Public hospital [Specify name of hospital] [ ]$_2$ = Public clinic/Community Health Centre [ ]$_3$ = Private General Practitioner/nurse [ ]$_4$ = Private hospital [ ]$_5$ = Private pharmacy shop [ ]$_6$ = Chemical seller with prescription [ ]$_7$ = Chemical seller without prescription [ ]$_8$ = Community health worker [ ]$_9$ = Private Midwife [ ]$_{10}$ = Traditional birth attendant [ ]$_{11}$ = Traditional Healer/herbalist [ ]$_{12}$ = Spiritualist [ ]$_{13}$ =Drug Peddlers

	[ ]14 = Treat self with herbs or left over drugs at home. [ ]777 = Other [Specify] _____ [ ]888 = Don't Know [ ]999 =Refuse to answer [ ]789=N/A
14. Is there one particular doctor or health professional you usually see?	[ ]0 No [ ]1 Yes
15. In the past 12 months, how many times did you see or talk to a medical doctor or health professional (do not count the times while overnight in the hospital)?	[ ]0 None _____times
16. In the past 12 months, how many times did you stay in the hospital overnight or longer?	0 None _____ times
17. How long has it been since you last saw or talked to a medical doctor or other health professional about your health? Include health professionals seen while a patient in a hospital.	0 never _____ months 888 Don't know
HEALTH SYMPTOMS	
18.Do you think you've lost weight recently? [Do you think that your clothes are too large for you due to a loss of weight?]	[ ]0 No [ ]1 Yes [ ]888 Don't know
19. In the last three months, have you had diarrhea that lasted for more than three days?	[ ]0 No [ ]1 Yes
20a. In the last three months did you have fever?	[ ]0 No [GO TO 29] [ ]1 Yes
20b. If yes, did it last for more than one month?	[ ]0 No [ ]1 Yes
21. Have you had white sores in your mouth over the last three months?	[ ]0 No [ ]1 Yes
22. Have you had swollen lymph nodes in your neck, under your arms or in your groin over the last three months?	[ ]0 No [ ]1 Yes
23. Have you had shingles (painful blisters or sores usually in a narrow band on one side of the head or body) over the last 12 months?	[ ]0 No [ ]1 Yes

BLOOD PRESSURE, CHOLESTEROL, SMOKING

Part I. High Blood Pressure/Cholesterol

24. Have you ever had your blood pressure taken by a healthcare professional?	[ ]0 No [GO TO 32b] [ ]1 Yes

25a. About how long has it been since you last had your blood pressure taken by a doctor or other health professional?	[ ]$_1$ less than 6 months [ ]$_2$ more than 6 months, but less than 1 year [ ]$_3$ more than 1 year, but less than 5 years [ ]$_4$ more than 5 years [ ]$_{789}$ not applicable [ ]$_{888}$ don't know
25b. Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?	[ ]$_0$ No [GO TO 34] [ ]$_1$ Yes
25c. Were you told on 2 or more different visits to a doctor or health professional that you had hypertension, also called high blood pressure?	[ ]$_0$ No [ ]$_1$ Yes [ ]$_{789}$ Not applicable
26. Because of your high blood pressure, have you ever been told by a doctor or health professional to…	
27a.Take prescribed medication:	[ ]$_0$ No [GO TO 33c] [ ]$_1$ Yes [ ]$_{789}$ Not applicable
27b. If yes, are you now taking it?	[ ]$_0$ No [ ]$_1$ Yes [ ]$_{789}$ Not applicable[ ]
27c. Control your weight or lose weight?	[ ]$_0$ No [GO TO 33e] [ ]$_1$ Yes
27d. If yes, are you now controlling or losing weight?	[ ]$_0$ No [ ]$_1$ Yes [ ]$_{789}$ Not applicable
27e. Cut down on salt or sodium in your diet?	[ ]$_0$ No [GO TO 34] [ ]$_1$ Yes [ ]$_{789}$ Not applicable
27f. If yes, are you using less salt or sodium in your diet?	[ ]$_0$ No [ ]$_1$ Yes [ ]$_{789}$ Not applicable
28. In the past week, how many alcoholic drinks have you consumed? [A drink= 1 beer, 1 shot of liquor, 1 glass of wine, 2 glasses of palm wine, stout	_____ drinks [ ]$_{888}$ Don't Know
29. Over the last six (6) months, how often in days per week did you drink alcoholic beverages?	_____ per week [ ]$_{888}$ Don't Know

Part II. Smoking

30. Does anyone who lives here smoke cigarettes or pipes anywhere inside this home?	[ ]$_0$ No [ ]$_1$ Yes
31. Have you ever smoked (cigarettes, pipe tobacco)?	[ ]$_0$ No [GO TO 47]

	[ ]1 Yes
32. How old were you when you first started smoking cigarettes fairly regularly?	_____ age in years
33. Do you smoke cigarettes now?	[ ]0 No [GO TO 44] [ ]1 Yes
34. About how many sticks of cigarettes do you smoke per day? [20 sticks/pack]	number of sticks _____
35. For approximately how many years have you smoked this amount?	_____ years
36. Have you smoked at least 100 cigarettes during your entire life (equivalent to about 5 packs)?	[ ]0 No [ ]1 Yes
37. About how old were you when you last smoked cigarettes (fairly regularly)?	_____age [ ]1 currently smoking [ ]888 don't know
38. Did you quit smoking because you had a health problem that was caused or made worse by smoking?	[ ]0 No [ ]1 Yes [ ]789 Not applicable [ ]888 Don't know

Part III. Other Tobacco Use

39. Have you ever smoked a pipe regularly? YES means more than 350grams of tobacco in a lifetime	[ ]0 No [GO TO 49] [ ]1 Yes
40. How much pipe tobacco are you smoking now? [On the average over the entire time you smoked pipes, how many grams did you smoke per week?]	_____grams per week

RESPIRATORY SURVEY

I am going to ask you some questions about your health. At first these will be mostly about your breathing. Wherever possible, I would like you to answer 'YES' or 'NO'.
Part I. Wheezing and tightness in the chest

41. Have you had wheezing or whistling (noise in your chest when you breathe) in your chest at any time in the last 12 months?	[ ]0 No [GO TO 48] [ ]1 Yes
42a. Have you been short of breath when the wheezing noise was present?	[ ]0 No [ ]1 Yes [ ]789 Not applicable
42b. Have you had this wheezing or whistling when you did not have a cold or flu?	[ ]0 No [ ]1 Yes [ ]789 Not applicable
43. Have you been woken up with a feeling of tightness in your chest at any time in the last 6 months?	[ ]0 No [ ]1 Yes

Part II Shortness of breath

44. Have you had an attack of shortness of breath that came on during the daytime when you were at rest at any time in the last 6 months?	[ ]$_0$ No [ ]$_1$ Yes
45. Have you had an attack of shortness of breath that came on following running or exercise at any time in the last 6 months?	[ ]$_0$ No [ ]$_1$ Yes
46. Have you been woken by an attack of shortness of breath at any time in the last 6 months?	[ ]$_0$ No [ ]$_1$ Yes

Part III. Cough and phlegm from the chest

47. Have you been woken by an attack of coughing at any time in the last 6 months?	[ ]$_0$ No [ ]$_1$ Yes
48. Do you usually cough first thing in the morning?	[ ]$_0$ No [ ]$_1$ Yes
49. Do you usually cough during the rest of the day, or at night?	[ ]$_0$ No [ ]$_1$ Yes
50. Do you cough like this on most days/nights for as much as three or more months in each of the last two years?	[ ]$_0$ No [ ]$_1$ Yes [ ]$_{789}$ Not applicable
51. Do you usually bring up any phlegm from your chest first thing in the morning?	[ ]$_0$ No [ ]$_1$ Yes
52. Do you usually bring up any phlegm from your chest during the day, or at night?	[ ]$_0$ No [ ]$_1$ Yes
53. Do you bring up phlegm like this on most days/nights for as much as three or more months in each of the last two years?	[ ]$_0$ No [ ]$_1$ Yes [ ]$_{789}$ Not applicable

Part IV. Breathing

54. Do you ever have trouble with your breathing?	[ ]$_0$ No [GO TO 58a] [ ]$_1$ Yes
55a. Do you have this trouble: 55b.Give all options at once, and insert cross (X) next to ONE answer only	[ ]$_1$ continuously so that your breathing is never quite right? ____ [ ]$_2$ repeatedly, but it goes away completely between the times when it troubles you? ____ [ ]$_3$ only rarely? [ ]$_{789}$ Not applicable ____
56. Do you have a condition other than heart or lung disease that hinders your walking ability? [Do you have problems walking with a condition other than heart or lung disease?	[ ]$_0$ No [ ]$_1$ Yes → STATE CONDITION:
57. Are you troubled by shortness of breath	[ ]$_0$ No

when walking fast on level ground?	[ ]$_1$ Yes
58a. Do you get short of breath walking with other people of your own age on level ground?	[ ]$_0$ No [ ]$_1$ Yes [ ]$_{789}$ Not applicable
58b. Do you have to stop for breath when walking at your own pace on level ground?	[ ]$_0$ No [ ]$_1$ Yes [ ]$_{789}$ Not applicable

Part V. Asthma

62. Have you ever had or been told that you have asthma?	[ ]$_0$ No [ ]$_1$ Yes
62a. If yes, was this confirmed by a doctor?	[ ]$_0$ No [ ]$_1$ Yes
62b. How old were you when you were told you have asthma? Give all options at once, and insert cross (X) next to ONE answer only	[ ]$_1$ Only before you were 18 years old ____ [ ]$_2$ Only at the age of 18 years or older ____ [ ]$_3$ Both [ ]$_{789}$ Not applicable ____
The following references to "attack" of asthma refers to episodes of wheezing, shortness of breath, chest tightness or cough attributed to asthma	
63. How old were you when you had your first attack of asthma?	_____ years old
64. How old were you when you had your most recent attack of asthma?	_____years old
65. Which months of the year do you usually have attacks of asthma?	January/February$_1$ [ ] March/April$_2$ [ ] May/June$_3$[ ] July/August$_4$ [ ] September/October$_5$[ ] November/December$_6$ [ ]
66. Have you had an attack of asthma in the last 6 months?	[ ]$_0$ No [ ]$_1$ Yes
66. How often have you had an attack of asthma in the last 6 ÿ 61	[ ]$_1$ Every day ____ [ ]$_2$ More than 2 times a week ____

months? Give all options at once, and insert cross (X) next to ONE answer only	[ ]3 More than 1 time per month _____ [ ]4 3 to 12 times in the whole year _____ [ ]5 1 to 2 times in the whole year _____
67. Are your chest symptoms caused by, or made worse by any of the following: [ANSWER ALL QUESTIONS]	
68a. Contact with animals/pets	[ ]0 No [ ]1 Yes
68b. Grass or flowers	[ ]0 No [ ]1 Yes
68c. During exercise	[ ]0 No [ ]1 Yes
68d. Breathing cold air	[ ]0 No [ ]1 Yes
68e. Dusts or sprays at work/ home	[ ]0 No [ ]1 Yes
68f. Tobacco smoke	[ ]0 No [ ]1 Yes
68g. Change in the weather	[ ]0 No [ ]1 Yes
69. Do your chest symptoms seem better or worse when you are away from work (for example, on weekends, off-shift and vacations)? ÿ69	[ ]1 Stay the same [ ]2 Get better [ ]3 Get worse
69. Does being at work ever make your chest tight or wheezy?	[ ]0 No [ ]1 Yes
70a. When did you first notice having problems with chest tightness or wheeze at work?	Date: Month _____ Year _____
70b. Is there anything that you work with that causes you to have these chest symptoms?	[ ]0 No [ ]1 Yes
70c. What do you think is causing these symptoms? _____ _____	WRITE ANSWER:

Part VI. TB Questions

71. Have you ever been told by a doctor that you had chest tuberculosis or TB?	[ ]0 No[SKIP TO Sec. E] [ ]1 Yes
72. How old were you when you were first told that you had TB?	_____ years [ ]888 Don't know
72. How long did you take medication for TB? (First) episode of TB?	_____months [ ]0 Did not take any medication
73. Have you ever been told by a doctor that you had a second episode of TB?	[ ]0 No [ ]1 Yes
74. How old were you when you were told that	_____ years

you had a second episode?	[ ]888 Don't know
75. For how long did you take medication for this second episode?	_____ months [ ]0 Did not take any medication
76. Do you still have TB?	[ ]0 No [ ]1 Yes [ ]888 Don't know

SECTION E STRESSORS

In this section, I'm going to read a list of things that people sometimes worry about.
1. Thinking back over the last 6 months, for each one, please tell me whether you worry about it never, sometimes, often, all of the time.
2. How often do you worry about…?

2a. Not having enough money to raise your children	[ ]1 Never [ ]2 Sometimes [ ]3 Often/Usually [ ]4 All of the time [ ]789 Not applicable - have no children
2b. Not having clean air to breathe	[ ]1 Never [ ]2 Sometimes [ ]3 Often/Usually [ ]4 All of the time
2c. Not having a clean environment	[ ]1 Never [ ]2 Sometimes [ ]3 Often/Usually [ ]4 All of the time
2d. Not having safe water to drink	[ ]1 Never [ ]2 Sometimes [ ]3 Often/Usually [ ]4 All of the time
2e. Having your food ran out before you have money to buy more?	[ ]1 Never [ ]2 Sometimes [ ]3 Often/Usually [ ]4 All of the time
2f. Yourself becoming ill	[ ]1 Never [ ]2 Sometimes [ ]3 Often/Usually [ ]4 All of the time
2g. Your children becoming ill	[ ]1 Never [ ]2 Sometimes [ ]3 Often/Usually [ ]4 All of the time [ ]789 Not applicable - have no children

THANK YOU FOR YOUR CONTRIBUTION!!!