SCHOOL OF PUBLIC HEALTH
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RESPIRATORY HEALTH AMONG SCHOOL CHILDREN AROUND AN ELECTRONIC WASTE SITE, AGBOGBLOSHIE, COMPARED WITH A CONTROL GROUP, MADINA ZONGO

BY

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DECLARATION

I hereby declare that with the exception of published studies that have been referenced and duly acknowledged, this dissertation has never been presented anywhere for the award of a degree but an original work done by me and supervised by Dr. John Arko- Mensah and Prof. Julius Fobil.

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DEDICATION

This work is dedicated to the Almighty God for His grace to complete this study. Secondly to my very supportive and dedicated husband, Mr. Archibald N. B. Okotah and my wonderful children Lemuel N. A. Okotah and Oswald N. Okotah. May God bless you guys for the great support throughout the course of my study.

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ABSTRACT

Background: Poor air quality has been associated with adverse health effects among humans, and inhaled pollutants can directly impact on cardiovascular and respiratory health, resulting in increased morbidity and mortality. Informal electronic waste recycling is often not regulated and activities could result in direct pollution of ambient air and surrounding environment with toxic chemicals such as inorganic heavy metal dust, organic bound particulate matter, toxic smoke from open burning of electrical cables among others. Although several studies have been conducted among e-waste workers to assess the effect of e-waste exposure on health, not many studies have been conducted among children who are at risk of developing respiratory symptoms.

Objective: To assess the respiratory health of children in schools around the informal e-waste site in Agbogbloshie (exposed site) and Madina (unexposed or control site).

Methods: An analytical cross-sectional study was conducted from May 2019- July 2019 among school children at Agbogbloshie and Madina. For respiratory health, a standardized questionnaire and an Easyone spirometer were used to assess self-reported respiratory symptoms and lung function respectively. Also, an Aerocette 831 was used to assess air quality inside and outside various classrooms by measuring particulate matter (PM_{1}, $_{2.5}$, and PM_{10}) concentrations. Multi-stage sampling method was used to proportionally select study participants from each school. Mean values and standard deviations were computed for lung function indices; FEV1, FVC and FEV1/FVC and PM. Pearson correlation analysis was used to test for association between $PM_{2.5}$ and lung function Indices.

Results: The most common self-reported respiratory symptoms among school children at Agbogbloshie and Madina were; sneezing (24.8% vs 17.1%), rhinorrhea (17.8%vrs 8.1%)

and cough (20.2%vs 26.1%). The mean Lung function indices for Agbogbloshie and Madina were: FEV1 (1.652±0.508 vs 1.677±0.696), FVC (2.2409±0.967 vs 2.745±1.904, $p<0.05$) and %FEV1/FVC (76.329±17.705 vs 68.74±21.135, ($p<0.05$). The average $PM_{2.5}$ concentrations of indoor and outdoor air sampled on the first day of measurement were significantly higher in Agbogbloshie compared with Madina as compared to values on the second day of air sampling.

Conclusion: The findings suggests that school children around Agbogbloshie recorded higher respiratory symptoms and reduced FVC compared with their counterparts in Madina.

Keywords: Respiratory health, Electronic waste recycling, Lung function, Particulate Matter

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LIST OF ABBREVIATIONS

BMI-	Body mass index
Co-	Carbon monoxide
EEE-	Electrical and electronic equipment
E-waste-	Electronic waste
FEV1-	Forced expiratory volume in 1second
FVC-	Forced vital Capacity
GES-	Ghana Education Service
GDP-	Gross domestic product
IAP	Indoor air pollution
JHS	Junior High School
NMIMR-	Nogouchi Memorial Institute into Medical Research
O_3	Ozone
PAH-	Polycyclic aromatic hydrocarbons
Pb	Lead
PBBE-	Polybrominated biphenyls ethers
PBDs-	Polybrominated biphenyls dibenzos
PCBs-	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzo-p-dioxins and
PCDFs	Polychlorinated dibenzofurans
PM-	Particulate matter
SDA	Seventh Day Adventist
SHS	Second-hand smoking
WHO-	World Health Organisation
$\mu g/m^3$-	Microgram per cubic meter

DEFINITION OF TERMS

Forced expiratory volume (FEV1): Volume of air expired in the first second of the blow.

Forced vital capacity (FVC): Total volume of air that can be forcibly exhaled in one breath.

FEV1FVC ratio: The fraction of air exhaled in the first second relative to the total volume exhaled.

E-waste: End of life electrical and electronic waste products.

Syncope: loss of consciousness or fainting.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Poor indoor and outdoor air quality have been associated with adverse health outcomes among humans and contributed to an increase in morbidity and mortality associated with cardiovascular and respiratory conditions (Guo et al., 2018). Globally, it is estimated that exposure to particulate matter (PM2.5) results in one million premature deaths annually (Miller & Xu, 2018). Sources of air-borne contamination stems from varied pollutants with examples such as vehicular emissions, industrialization, cooking with biomass fuel, agricultural processes and waste recycling activities. Recently, informal e-waste processing has been identified as an important source of air pollution in several developing countries engaged in informal e-waste recycling (Hoek et al., 2012).

Electronic waste generation has increased globally due to the fast advancement of technology and peoples quest to own the latest technological gadget, causing them to discard their old gadgets (Torres et al ., 2016; Oteng-Ababio, 2012). This raid and high turnover have made e-waste one of the fastest and largest growing waste streams worldwide. These end of life gadgets are quite complex in nature, hazardous in nature as it contains more than 1000 chemical compositions. Some of which are highly toxic (Noel-Brune et al., 2013) and expensive to recycle in an environmentally safe manner (Lundgren, 2012). Irrespective of these challenges posed, there are basically no stringent laws to streamline its safe disposal (Maheshwari, Rani, & Singh, 2013). An estimated 20-50 million tonnes of electrical and electronic waste items are generated annually and 80% of e-waste generated finds its way to developing countries such as India, Nigeria and Ghana to be recycled. Methods used in e-waste recycling leads to the release of organic and inorganic compounds such as Polychlorinated biphenyls PCDD/Fs Polychlorinated dibenzo-p-dioxins and Polychlorinated dibenzofurans and other heavy metal dust into the environment(Song & Li, 2014b; M. Zhang, 2017) These Contaminants have been linked to various adverse health effects such as cardiovascular, cognitive, hepatic, bone problems and reduced lung function leading to respiratory health challenges such as asthma, pneumonia, lung cancers (Amankwaa, 2014; X. Zheng et al., 2016). These have made the e-waste menace a serious global environmental concern. Electronic waste (E-waste) recycling has been a major source of ambient air pollution, leading to a rise in respiratory symptoms including sneezing, cough, chest tightness, sore throat and other chest infections among people living within the e-waste communities (Awasthi, Zeng, & Li, 2016; Bonner, 2018; G. Zheng et al., 2013) . These challenges have been linked to exposure to fine particulate matter of size 2.5 microgram and below. Particle sizes of PM 2.5 and below has the potential to penetrate the lung interstitium and cause an alteration in lung function (Babatola, 2018; Heacock et al., 2016; Pinto, 2008). The most affected population being children.

In Ghana, large amounts of e-waste are dumped in large tonnes from countries in Europe, Asia and America due to poor regulation of policies and laws. In 2009, an estimated 215,000 tonnes of e-waste was imported into the country (Dogbevi, 2011). Unfortunately, Ghana has no stringent laws that regulates the importation of these second hand electrical and electronic equipment (EEE) into the country. Agbogbloshie is the biggest site for e-waste recycling in Ghana (Asante et al., 2012; Labunska, Santillo, Johnston, & Brigden, 2008)It's regarded as the largest informal e-waste dumping site in Ghana and west

Africa(R. Grant & Oteng-Ababio, 2012) Globally, it is ranked the 10th most polluted places in the world(MacDougall, 2014; NTI, 2015). Informal collectors from Agbogbloshie move around the region to collect outdated, not useful and discarded electric appliances from homes and offices and bring them to Agbogbloshie for recycling. Informal e-waste recycling at Agbogbloshie is done using crush hammers and chisels to dismantle and open up the gadgets for sorting. This is followed by open burning of cables and wires which leads to the release of heavy metals, organic and inorganic pollutants into the environment. Common routes of exposure to these toxicants are largely by inhalation of particles in the air, ingestions through contaminated food and water and direct contact with the toxic substance through dermal routes (K. Grant et al., 2013a; Song & Li, 2015). Exposure to PM 2.5 has been linked to reduced lung functions among children found within electronic waste sites(Song & Li, 2015; Xing, Xu, Shi, & Lian, 2016). Informal E-waste recycling activities has been ongoing for decades now, hence prolonged exposures are expected to extend to the surrounding communities around the Agbogbloshie electronic waste site.

Numerous studies have also been conducted in Ghana to assess the effect of electronic waste recycling on cardio-respiratory health of adult population but similar studies are yet to be done on the respiratory health of children within the e-waste community. A study on this subject will generate more benefit to public health and establishment of policies that will protect the children within these communities

1.2 Problem statement

Electronic waste recycling has grown over the past decades in Ghana because of increased production of e-waste materials globally. Globally, an estimated 50-70 million of e-waste is generated annually and 80% of this e-waste is exported to countries in Africa and Asia to be recycled. Technology advancement and taste for newer gadgets have contributed to the increased growth of e-waste materials as people tend to quickly dump their old gadgets to get the latest electrical and electronic equipment (EEE)(Alavi, Shirmardi, Babaei, Takdastan, & Bagheri, 2015; Maheshwari et al., 2013).

E-waste recycling is a major cause for concern, because of the harmful emissions that are released during its recycling. Rudimentary tools such as crush hammer and chisel are some of the basic tools used to dismantle the e-waste such as used computers cathode ray television sets and mobile phone devices. On the other hand, electrical cables of all sizes are openly burnt to retrieve copper wires using other waster such as foams from dismantled fridges as sources of fuel. This process of recycling causes the release of organic and inorganic compounds heavy metal dust and particulate matter into the ambient air causing air pollution. E-waste recycling doesn't only affect those engaged in the e-waste activities but also those living and working in the e-waste communities and nearby populations, thus exposing them to the hazardous emissions from the e-waste site. Previous work among e-waste workers at Agbogbloshie have associated e-waste processing with numerous adverse health outcomes such as cardiovascular conditions, reduced cognitive function in children, high prevalence of respiratory illnesses and reduced lung function among people within the e-waste site (Agbeko, 2015; Caravanos et al., 2013; Noel-Brune et al., 2013; NTI, 2015; G. Zheng et al., 2013). Other studies have also associated exposure to heavy metals with an increased in cases of type 2 diabetes and hypertension and Chronic Obstructive Pulmonary diseases among others.(Daum, Stoler, & Grant, 2017)

Agbogbloshie serves as home to numerous families who have migrated from various places including the northern parts of the country in search of work and better standard of living.

A vibrant market thrives in the heart about 200 meters from the informal e-waste site. Within the community are schools, banks, churches and other business entities (Bonner, 2018).The Ayalolo cluster of schools is located within the electronic waste (e-waste) enclave and about 500 meters from the electronic waste recycling site. The physical environment of the school, its cleanliness, and poor ventilation in classrooms significantly affect the health and well-being of children, hence adverse health conditions are likely to spread quickly in congested places with limited ventilation and at places with poor hand-washing facilities and practices. Most students from these school are from low income earning families and their parents and guardians are predominantly e-waste workers who have migrated from the northern parts of Ghana in search of greener pastures. Although there exist other background pollutants in the area, e-waste has been identified as the major source of PM pollution. Previous studies have been done on health challenges associated with e-waste activities (Noel-Brune et al., 2013; X. Zheng et al., 2016) but few data exist on the effects of e-waste on respiratory health among school children within the e-waste recycling community. This study therefore sought to assess the PM levels, respiratory symptoms and lung function among the school children within the informal e-waste recycling site in Agbogbloshie.

1.3 Conceptual framework

The conceptual framework (**fig.1.1.**), illustrates the activities involved in informal e-waste recycling that leads to the release of hazardous substances which affects human health. E-waste recycling activities such as dismantling, crushing and open-air burning could lead to the release of inorganic heavy metal dust, toxic fumes containing organic compounds such as Polychlorinated Biphenyls (PCBs)Poly Aromatic Hydrocarbons (PAH)and PM, including $PM_{2.5}$. Electronic waste (E-waste) recycling has been a major source of ambient air pollution, leading to a rise in respiratory symptoms including sneezing, cough, chest tightness, sore throat and other chest infections among people living within the e-waste communities(Awasthi et al., 2016; Bonner, 2018; G. Zheng et al., 2013), These challenges have been linked to exposure to fine particulate of size 2.5 microgram and below. Particulate sizes of PM 2.5 and below has the potential to penetrate the lung interstitium and cause an alteration in lung function (Babatola, 2018; Heacock et al., 2016; Pinto, 2008). Other background exposures include vehicular emissions, exposure to biomass fuel smoke and dust, all of which can impact on respiratory health. Irritations such as common cold, cough and sneezing are examples of symptoms suffered by these children. Variables such as age, exposure to second-hand smoking, dust particles, ventilation in the classrooms are important determinants of respiratory health.

Figure.1: Conceptual Framework

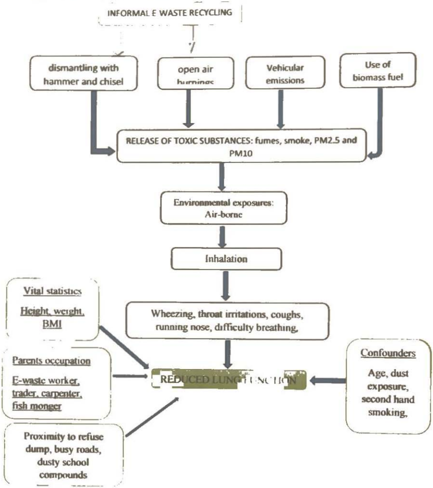

Figure 1.1 E-waste exposure pathway through inhalation and effects on lung function.

1.4. Justification of the study

Although the Parliament of Ghana has passed an act to regulate and manage the informal e-waste activities to ensure a safe environment("Parliament passes law to Control Hazardous & E-Waste - Government of Ghana," 2016), enforcing of such statutory acts have not been in full force as e-waste recyclers still engage in the use of rudimentary means to retrieve reusable part of the e-waste items.

School children spend an average of 8 hours in school (7am-3pm). These prolonged exposure to the fine particles of PM in the ambient air, within the school, predisposes them to adverse health effects. Children have higher baseline ventilation rates and are more physically active than adults, thus exposing their lungs to more air pollution(Bateson & Schwartz, 2008). In addition to the e-waste exposures, poor ventilation within the classrooms and overly congested classrooms could compound the problem of exposure to fine particulates, as contaminated air will be retained within the classroom walls.

Government and local authority need to enforce policies that regulates the activities of informal e-waste activities to help reduce the impact of e-waste exposures on health of those living within the e-waste communities especially children. Policy interventions are required to protect child health, prevent an increase in respiratory outcomes and reduce cost of healthcare(Chan & Wong, 2013). Results from this study could contribute to the passage of sound environmental policies aimed at reducing the health impacts associated with e-waste recycling.

1.5. Research Questions

1. Do school children around Agbogbloshie e-waste site have higher prevalence of respiratory symptoms compared to those in Madina?
2. Is ambient air pollution due to informal e-waste recycling activities at Agbogbloshie likely to affect negatively on lung function of school children around e-waste site compared to those in Madina?
3. Are school children around Agbogbloshie e-waste site exposed to higher levels of particulate matter compared to those in Madina?
4. Is there an association between levels of $PM_{2.5}$ and respiratory health?

1.6. Study objectives

1.6.1. General objectives.

To assess the respiratory health among school children in Agbogbloshie, an informal e-waste recycling site (exposed site) compared to those from Madina (unexposed or control site)

1.6.2. Specific objectives

1. To determine the prevalence of respiratory symptoms among school children in Agbogbloshie (exposed site) and Madina (control).
2. To assess the effects of ambient air pollution on lung function (FEV1, FVC, FEV1/FVC) among school children in Agbogbloshie and Madina.
3. To measure and compare concentrations of $PM_{2.5}$ and PM_{10} in indoor and outdoor air in schools at Agbogbloshie and Madina.
4. To determine whether there is an association between $PM_{2.5}$ levels and respiratory health

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Scope of the Review

This literature review focuses on the effects of E- waste recycling activities and ambient air pollution (section 2.2), comparing what other studies have come out with, the impact of E-waste recycling on respiratory health (section 2.3), the role of indoor air pollution and respiratory health (section 2.4), outdoor air pollution and respiratory health (2.5) and the particulate matter (PM) and lung function (section2.6)

2.2. E-waste recycling and ambient air pollution

Ambient air pollution occurs when the composition of normal outdoor air gets contaminated by smoke, dust and pollutants. Mortality often associated with ambient air pollution is mostly attributed to exposure to particulate of size 2.5microns or less as they are noted to cause respiratory conditions, cardiovascular disease and some cancers although sizes above 2.5 also result in other adverse health outcomes(Babatola, 2018; Heacock et al., 2016; Mannucci & Franchini, 2017). The World Health Organisation (WHO) guideline for air quality are: $PM_{2.5}$ =10ug/m^3 for annual mean and 25ug/m for a daily mean of 24hours, PM_{10}= 20ug/m^3 for annual mean and 50ug/m^3 for daily mean. Contamination of ambient air can occur through industrial activities, vehicular emissions, household activities and e-waste recycling (WHO, 2017). According to reports in the Global Burden of Disease, about 3.7million people died globally from harmful effects of atmospheric air pollution in 2012 and 88% of these deaths were recorded in developing countries alone(Zhang, 2017). Its noted that air particles of size $PM_{2.5}$ are very fine and can reduce visibility and also enter human lung, cause irritations, lead to reduced respiratory functions and cause asthma, lung cancer and heart problems. In recent times e-waste recycling has gained much attention due to the complex pollutants released from such activities. Informal E-waste recycling using chisels and crush hammer to dismantle electronic gadgets, acid bathing and leaching to melt the cables and expose the copper and aluminum wires and open-air burning. This results in the release of toxic fumes, particulate matter and dust that are often heavily concentrated in the air, food, water and soil samples around e-waste site. Inorganic and organic pollutants have also been detected in biological samples of e-workers and inhabitants of e-waste communities(Heacock et al., 2016; Song & Li, 2014a). Studies have shown that heavy metals enters the human body to the lung ,blood stream and target organs through inhalation, ingestion of contaminated food and water and dermal contact through direct exposure to the toxic substance leading to life threatening conditions like kidney damage, impaired lung functions and reduced intellectual capacity in children, lung cancers among others(NTI, 2014; Zhang, 2017).

2.3. Impact of E-waste recycling on respiratory health

Harmful substances that occur from e-waste recycling is due to processes such as dismantling or shredding open-air burning, acid bathing and leaching of the electronic gadgets. Tiny dust particles bound with heavy metals released through e-waste recycling has been associated with reduced lung functions among e- waste workers and people engaged in other works on the field (NTI, 2015). Another study also reported that exposure to chromate dust and fumes cause asthma and other respiratory symptoms (Kargar Shouroki et al., 2018).

A comparative study conducted by Zheng et al (2012), among school children living in an e- waste community of Guiyu and a control group Liangying in China revealed that spirometry readings (FVC) were lower in school children in Guiyu than those in the control group, likewise the serum Chromium levels. The presence of chromium in the lungs accounts for the reduced lung function and this predisposes subjects to respiratory conditions such as asthma and bronchitis (Zeng, Xu, Boezen, & Huo, 2016). Another study by Zheng et al (2013) also recorded low FVC among school children and this was attributed to the chronic exposure to the toxic substances in the atmosphere. It was concluded that these exposures are likely to affect their growth and development and further destroy the lung tissues and lower FVC readings. A qualitative survey done among E-waste workers in Agbogbloshie, Ghana, brought to light a number of health challenges experienced by workers. This includes throat irritations, chest pains and chronic respiratory tract infections attributed to frequent exposure to smoke and fumes of metals from burning of cables, and dust from crushing of the electronic gadgets. It was evident that most of the workers had little knowledge on the use of personal protective equipment (Asampong et al., 2015).

E- waste recycling at a specific location does not only affect those directly engaging in the recycling but the entire population within the area and nearby communities. School children residing within the area and in nearby communities, workers and people going about their daily activities are equally affected by this socioeconomic activity generating dust and smoke.(Robinson, 2009)

2.4. Indoor air pollution and respiratory health

Indoor air pollution (IAP) is a major environmental health issue in developing countries causing high morbidity and mortality rates due to acute lower respiratory illnesses(Nandasena, Wickremasinghe, & Sathiakumar, 2013b). Indoor air pollution could occur when polluted air from outside gets trapped inside and in the absence of good ventilation. This contamination may stay trapped for long hours exposing occupants of such rooms to respiratory tract illnesses. Rooms that are poorly designed with insufficient windows for through ventilation, mostly observed in urban slums, may lead to occupants having a feeling of stuffiness and suffocation(Nandasena, Wickremasinghe, & Sathiakumar, 2013a; Shrestha & Shrestha, 2005). A comparative study was conducted to analyse particulate (PM2.5, PM10) concentrations of room air, in an urban slum and a control site in India. Sampled houses were selected from three (3) types of home categorized as low, middle- and high-income homes and also based on their proximity to a commercial area, either a railway station or the lorry road. The homes selected from the control site were quite far from commercial activities. Findings revealed that PM2.5 and PM_{10} were higher during winter among the lower- and middle-income homes. This finding was attributed to type of fuel used, high occupancy in homes, poor ventilation and the entry of outdoor air indoor. Mean FEV1 and FVC scores were lower in the exposed site than in the control site which indicates high levels of lung impairment mostly among people from low- and middle-income homes. Women and children were identified in the study as the most affected because they mostly spend more time at home and in the rooms, hence may have daily continuous exposure to indoor pollutants from molds and dumpiness, smoke and fumes from cooking fuels (biomass), strong liquids and detergents. Study showed a negative association between exposure to indoor pollutants and level of household income (Franklin, 2007; Rinne et al., 2006; Kulshreshtha & Khare, 2010).

Smoking tobacco indoor is another source of IAP and exposes non- smokers to tobacco smoke. Secondhand smoke (SHS) comprises of a main-stream smoke (smoke first inhaled by an active smoker and then exhaled) and side-stream smoke (smoke emitted between puffs). The later smoke accounts for about 85% of total second-hand smoke. Second hand smoke is a mixture of more than 4000 chemicals, of which over 40 are identified carcinogens in vapor and particle phases. The vapor-phase compounds include benzene, vinyl chloride, acrolein *etc*. The particulate-phase chemicals include alkaloids, nicotine and its derivatives, aromatic amines, polycyclic aromatic hydrocarbons. 40% of children globally are exposed to SHS and an estimated 165,000 children under 5 die annually from lower respiratory infections associated with SHS. Two-thirds of these deaths occur in developing countries of Africa and South Asia. In these same studies, exposure to environmental tobacco smoke has been linked to reduced lung function and abnormally developed lung in prenatal life(Agrawal, 2012; Cheraghi & Salvi, 2009; Nandasena et al., 2013b). Rinne et al (2006) also identified that fetal or early postnatal exposure to maternal smoke was associated with significant deficits in lung function that persisted into young adult life. Childhood exposure also resulted in reduced lung function (FEV1) when results are compared to a non-exposed child(Rinne et al., 2006).

2.5. Outdoor Air Pollution and Respiratory Health

Outdoor air pollution is the presence of one or more substances in the atmosphere with a concentration that exceeds the normal limits. These include substances like Ozone (O_3), airborne lead (Pb) and carbon monoxide (CO)and many more (Song & Li, 2014a). Recent studies on air pollution have focused more attention on particulate matter (PM 2.5), because of their ability to bypass the muco-ciliary defenses in the airway into the lung to cause a disruption in normal lung function leading to either local or systemic effect (Zheng et al., 2013). A review done by Nandasena, et al. (2013) found out that 32% of the world's population lived in areas that far exceeded the WHO level one threshold of $35\mu g/m^3$.

Ozone is one of the outdoor pollutants and exposure to high levels in the air causes severe symptoms such as breathing problems, irritations and trigger asthmatic attacks. It can also cause a reduced lung function and severe lung diseases (Fiotakis, 2016). A comparative cross-sectional study was conducted in India, Chandrapur district (an industrial area) revealed that respiratory symptoms were prevalent in villages with multiple industries than villages with only one industry. This indicates that ambient air pollution impact on respiratory health are evident with symptoms of respiratory illnesses. They observed that the probable cause of morbidity and mortality associated with air-borne pollutants may be as a result of inflammation and haemostasis effects that these pollutants possess (Gawande, Khanvilkar, Kadam, & Salvitthal, 2016).

An assessment conducted in Europe on the impact of outdoor and traffic related air pollution revealed road traffic as the primary source of PM emissions, and it plays an important role in the effects of outdoor air pollution and these are higher in densely populated areas(Jagla, 2016).

Another study conducted on e- waste workers in Agbogbloshie Ghana, showed that their outdoor exposure to pollutants released in the recycling area led to high complained mostly of tiredness and sore throat common cold and phlegm (NTI, 2015).

2.6 Particulate matter and lung function

Particulate matter (PM) is a complex mixture of solids and liquid droplets in the atmosphere. They are so minute and can't be seen with the naked eye. The smaller the size, the more likely they are to induce an adverse health effect. It ranges from size 10µm (PM_{10}), 4µm (PM_4), 2.5µm ($PM_{2.5}$) and below. $PM_{2.5}$ and below have been linked in several studies as the most hazardous in causing an alteration in lung function(Jiang, Mei, & Feng, 2016; Miller & Xu, 2018). Combustion of fuel, electronic waste recycling, dust generated from an untarred road and industrialisation are all sources of PM emissions. World health Organisation recommends an average annual PM_{10} of $<20 \mu g/m^3$ and $<50 \mu g/m^3$ for the daily average. The recommended $PM_{2.5}$ daily mean is also $<25 \mu g/m^3$ and $<10 \mu g/m^3$ for annual mean figures. Increased morbidity and mortality has been linked to exposure to $PM_{2.5}$ and below(Guo et al., 2018; WHO, 2013). Epidemiologists have revealed a significant association between $PM_{2.5}<$ and respiratory morbidity and mortality. They found that an increased PM concentration in the air may directly lead to an increased morbidity and mortality within a population. In European countries, $PM_{2.5}$ decreased the average life span by 8.6 months.

A systematic study found a relation between PM concentrations and reduced lung function. It was observed that a consistent increase in the PM concentrations in ambient air was associated with reduced lung function in children who had no known respiratory conditions. Although these findings exists, another longitudinal study conducted in California found no consistent relationship between high PM concentrations in ambient air and reduced lung function(Paulin & Hansel, 2016).

A study in Beijing found that mortality associated with respiratory and cardiovascular illnesses had significantly increased by 10µg/m^3 in PM2.5 annual concentration between 2007 and 2008 and a mean PM2.5 concentration of 122µg/m^3(Miller & Xu, 2018). They also observed that the type of weather could contribute to an increase in the effects of PM2.5 on the general health of humans.

A study conducted in Agbogbloshie among market women revealed a high prevalence of respiratory symptoms and reduced lung function indices. They also reported daily PM2.5 and PM10 concentration ranging from 72.09-168.84µg/m^3 and 492.41-1690.62 µg/m^3. They reported high cases of cough, cold, sore throat and repeated sneezing as the common symptoms suffered by the market women within the Agbogbloshie market.

2.7 Respiratory symptoms and children's health

Studies have found a consistent associations between outdoor particulate matter concentrations and various adverse health effects, such as an increase in asthma, other respiratory tract diseases, and decrease in lung function among humans especially children(Langkulsen, Jinsart, Karita, & Yano, 2006) The high concentration of respirable particulate matter (PM_{10}) in ambient air is one of the serious environmental problems in Bangkok city, particularly in the traffic-congested areas. PM_{10} levels were monitored systematically at 32 Pollution Control Department (PCD) monitoring stations. In many areas, annual average PM_{10} concentrations were found to be higher than the National Ambient Air Quality Standard. In 2004, annual average concentrations of total suspended particulate matter (TSP) and PM_{10} at roadside monitoring stations were ~0.18 mg/m^3 and 78.50 µg/m^3, exceeding the standard[13] by ~8.3 and 8.4% days, respectively. There is a potential increase in the concentration of pollutants each year. Furthermore, PM_{10} in

Bangkok has been associated with serious health effects, such as increased hospital admissions and mortality. The associations were also reported between air pollution and respiratory health among traffic policemen and their wives. These studies have mainly been conducted in healthy adult groups. It is not clear to what extent such associations could be revealed in children, who might be more susceptible to air pollution than adults. A few researchers have reported that there is an increase in respiratory symptoms and impaired lung function among asthmatic children near Maemoh Power Plant, Thailand. However, chronic health effects for the children remain uncertain, particularly for Bangkok children. Therefore, with the help of a cross-sectional design, possible chronic effects of exposure to air pollution in Bangkok school children were investigated (Langkulsen et al., 2006). Children living in highly polluted areas would possibly indicate higher prevalence of respiratory symptoms and impaired lung function than those living in moderately and less-polluted areas(Budhiraja, Singh, Pooni, & Dhooria, 2010; Paulin & Hansel, 2016; Zeng et al., 2015)

CHAPTER THREE

3.0 METHODS

3.1. Study site

The main study area Agbogbloshie, covers a total surface area of 15 acres of land and is located on the west border of the Odaw river. Within the Agbogbloshie community are banks, a large and vibrant open food market, schools, a pharmaceutical company, a soft drink bottling plant, shops, mosques and churches and also a community where the migrants and electronic waste workers stay. The densely populated community has few social amenities that is shared by approximately 40,000 members of the community. (Amankwaa, 2014; Asampong et al., 2015). The study was conducted in two schools from the Ayalolo cluster of school (Agbogbloshie) namely Central Mosque primary and Akoto Lantey Junior high school (**Fig. 3.1**). These schools' share the same compound with the Amamomo JHS, Richard Akwei memorial JHS, the Ayalolo 1 and 2 JHS and the Ussher Polyclinic. The school is located on latitude 5.54507 and longitude -0.2167 with a GPS address of GA-181-7429. On its right border is the SDA church and Schools. The schools are about 500meters from the E-waste recycling site and about 300metres from the Agbogbloshie Market. The school compound is untarred with the buildings scattered all over the compound with inadequate ventilation in the classroom. The windows are closed due to the dusty nature of the school compound. Dust is mostly observed during play breaks and when there is an activity within the compound. Dark smoke can be observed from the e-waste recycling site while in the school premises.

The control group on the other hand is from two schools within the LaNkwantanang cluster of schools (Madina) namely, the LaNkwantanang "5" basic school and LaNkwantanang

"7" basic school (**Fig.3.2**). It's within another heavily populated community in the Accra metropolis within the LaNkwantanang municipality. The schools are located on Latitude 5.68290, Longitude -0.1697 with a GPS address GM-014-2194. The community is quite unstructured and serves as home to many businesses such as banks, telecommunication companies, schools, churches and mosques. A vibrant market thrives in the heart of the community. It covers a total area of 166acres of land. Madina is a fast-growing community with small rural settlements fast developing and catching up with the urban communities. The school is approximately 200metres from the Madina market. It is about 200metres from the main Accra- Aburi road and directly opposite the Elim preparatory school and 200metres from the Republic Bank of Africa. The compound is untarred and dust can be seen in the environment during play times and during closing time. There is a major construction site right on the left border of the school. The School buildings are quite unstructured and poorly constructed with inadequate ventilation into the classrooms. The classrooms are also congested and classroom window have all been shut due to the dust within the school compound. The control site, LaNkwantanang '7' Basic school is similar in characteristics with the Ayalolo cluster of school. Both schools have similar environmental exposures to vehicular emission, dust and particulate from the school compounds, overcrowding in the class rooms and have similar socioeconomic and cultural characteristics

Figure 3.1 Map showing a section of Agbogbloshie and sites.
Source: Adapted from (Agbeko, 2015)

Figure 3.2 Map of Madina showing LaNkwantanang cluster of schools.
Source: Adapted from Google maps

.2 Study Design

ιn analytical cross-sectional study was conducted from May 2019- June 2019, among 240 chool children from the Central Mosque primary and Akoto Lantey Junior high school vithin the Ayalolo cluster of school (Agbogbloshie) and the LaNkwantanang "5" basic chool and LaNkwantanang "7" basic school also within the LaNkwantanang cluster of chools (Madina). Multi stage sampling and systematic random sampling were used to andomly select the participant; At each site, schools were grouped into clusters and the equired clusters selected, after which each class were put into subgroups to determine the ιppropriate number to select at each stage. Systematic random sampling was used to select ɔarticipants within each class. The target population were children from primary 4 to Junior ligh School 3, whose ages are between 9-14years. This age was selected because of their ιbility to express themselves and perform the study procedures. Four schools were enrolled n this study; two within the informal e-waste recycling community and the other two from he control site Madina within the LaNkwantanang municipality. School selected from Madina had similar characteristics such as school setting (both are public schools), similar ethnic and socio- economic characteristics and similar sources of exposures to school in Agbogbloshie but the difference lies in the E-waste recycling activities at Agbogbloshie. A structured questionnaire was used to take demographic data and also record self-reported respiratory signs and symptoms among the school children at both study sites. Lung function was compared among the two study sites and PM concentration also compared among the two study areas.

3. Study Variables

3.1. Dependent Variables

ie outcome (dependent) variables of interest were measures of lung function forced :piratory volume in one second (FEV1), forced vital capacity (FVC) and the ratio :V1/FVC and prevalence of respiratory symptoms including sore throat, common cold, heezing, chest pain and shortness of breath.

3.2 Independent Variables

he explanatory (independent) variable of interest were, $PM_{2.5}$ and PM_{10} measured in ırrounding ambient air, weight, height and Body Mass Index (BMI).

.3.3. Confounding factors

.ge, sex, biomass fuel use, proximity of home and school from the main road, proximity f home from market place, second hand smoking exposures.

.4. Study Population

ource population was the Ayalolo cluster of schools in Agbogbloshie and the aNkwantanang cluster of schools from Madina. A total of 240 school children were :cruited from these two cluster of schools. One hundred and twenty-nine (129) school hildren were selected from Ayalolo cluster of Schools (98 from central mosque primary nd 31 from Akoto Lantey Junior high school) and 111 school children from .aNkwantanang "5" and "7" basic schools were recruited (56 school children from .aNkwantanang "5" and 55 school children from LaNkwantanang "7' Basic schools). All articipants were between the ages of 9-14years and selected from primary 4- JHS 3. chool children were recruited based on voluntary participation as described in section 3.6 or sample size calculation.

.4.1. **Inclusion criteria**

chool children were included if they were within the age range of 9-14years. Study articipants were also recruited if they had been in the school for not less than an academic ear as at the time of the study.

.4.2. **Exclusion criteria**

ecent thoracic, abdominal or eye surgery (due to pressure from hard blowing) or refusal f consent, mental illness with inability to follow procedure or history of recurrent syncope

.5. **Sample size Determination**

'sing an estimated prevalence of 18.2% from a results of pre-test conducted among school hildren at Abokobi landfill site with a 5% margin of error in the formula $Z(1-\alpha/2)^2P(1-P)/d^2$, a sample size of 229 was arrived at, where z=is for the z-score of 95% is 1.96, P is roportion from previous study=18.2%, and d is for margin of error =0.05. This is the ninimum sample size required for this study.

$$N = (1.96)^2(0.182(1-0.182) / (0.05)^2$$

$$N = (1.96)^2(0.182*0.818) / 0.0025$$

$$= (3.8416)(0.148876) / 0.0025$$

$$= 0.57192 / 0.0025$$

$$= 228.7$$

Estimated population for Central Mosque primary and Akoto Lantey JHS = 200 students

Estimated population for LaNkwantanang "5" and "7" basic school = 154

Total: 200+154= 354

00/354 x 229 = **129.37.**

linimum sample required from schools in Agbogbloshie = **130**

54/354x229= **99.62**

linimum sample required from selected schools in Madina = **100**

.6. Recruitment/ Sampling Method

lulti stage sampling and systematic random sampling were used to recruit the study articipants. Schools in Agbogbloshie and Madina were put into three clusters each and ne cluster selected randomly from each of the study locations. Two schools were andomly selected from each cluster and included in the study. The next stage of the ampling method involves the determination of study participants from each school. At the chool level, Classes 4 to JHS 3 classes were considered for inclusion based on the age riteria (9 - 14 years) provided for the study design. The total student population between ie class category (Class 4 to JHS 3) and the overall study sample guided in estimating the rget sample for each class.

t the class level (Class 4 to JHS 3), each class contributed a certain number of students roportional to size of that class. Systematic random sampling technique was used to select articipants within each class. A total sample of 240 respondents participated in this study sample in excess of 10 respondents purposively selected and included). Parent's informed onsent was obtained on behalf of the students from all 240 respondents after which the chool children assented to partake in the study. All study Procedures and protocols were learly stated in the consent form and appropriately explained to school children and their eachers prior to data collection.

ll school children who had been in school for at least one academic year and also met the ge criteria of 9-14 years were enrolled in the study.

chool children were assembled in an empty classroom that was allocated for the study. ll study procedures and objectives were carefully explained to the school children and eir teachers in English, Twi, Ewe and Hausa. Demonstration sections on how to perform e blowouts was done prior to commencement of the data collection. A Spirette was used demonstrate on how to take in deep breaths and how well to blowout continuously. ections of deep breathing exercise was conducted to help expand the lungs. They were en taken through filling of the questionnaires by trained research assistants. They were terviewed in English, Akan, Ewe and Hausa for easy understanding. Participants were uided in performing the maneuvers required to perform the spirometry. The Forced xpiratory volume in one second (FEV1), the Forced Vital Capacity (FVC) and the EV1/FVC ratio was measured and documented.

he Met One Aerocet units were also set at various locations within the school premises to ample air quality. Both indoor and outdoor air quality were sampled simultaneously. M2.5 ≤, PM4 and PM10 were recorded. Air quality sampling was done throughout the eriod the children were in school only. This was to measure the on-site exposures during chool hours. Observations were noted at certain times of the day, when school children vere on breaks and when certain activities that could affect the PM concentration in the tmosphere were being carried out. This was to help identify the cause of any spurious epresentation on the graphs during data analysis. School children were refreshed with fruit uice to replenish them after performing the Spirometry.

3.7. Data collection tools and procedures

Tools for data collection included a standardised questionnaire, a spirometer for lung function measurement, an Aerocet 831 for indoor and outdoor air sampling, a stadiometer was used for standing heights and weight measurement.

3.7.1. Questionnaire

The questionnaire was sectioned into four parts. The first part asked questions on their personal data (age, sex), the second section asked questions about the home situation (the number of people at home, how many rooms shared by the members of the house, work of parents, whether a parent smokes, where cooking is done, and the type of cooking fuel used, whether child helps in the kitchen, whether child works at the e-waste site and whether they use a personal protective equipment and whether the child was exposed to certain determinant of respiratory health such as smoke, dust, fumes and irritating liquids at home). The third part was focused of identifying the current respiratory health situation of the child and how often they have respiratory infections. It sought to identify where the child had most respiratory health triggers; whether home or school. The last part had recordings of the child's weight, height and values of FEV1, FVC an FEV1/ FVC, being values produced during spirometry. There was space provided for any other comment or observation during the performance of spirometry.

3.7.2. Spirometry

An EasyOne spirometer (NDD, USA) was used to measure the lung function (FEV1, FVC, FEV1/FVC) of the school children. The portable spirometer is an easy to use, battery powered machine with a disposable mouthpiece (Spirette). It has the advantage of storing over 6,000 data of spirometry values. The machine is designed to allow for 6 blow outs

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and the best three values were recorded and the quality of the test graded from A-F. Weight and standing height of the school children were recorded as a standard requirement for performing spirometry. A GLC/ 2017 mechanical personal weighing scale was used to check the weight and a stadiometer was used to check their standing height measurement. Spirometry test was conducted by Principal investigator and assisted by a trained clinician. The spirometry procedure was demonstrated to the school children. The right position to assume (stand up, take in deep breaths and blast out), how to blow the air and when to stop blowing. They were encouraged to take deep breaths prior to performing the procedure. Each student spent approximately 5minutes performing the spirometry. Values of lung volume was computed based on the height, weight, sex and ethnicity of respondents. The Spirometer was disinfected with mild soapy solution and one Spirette each was given to an individual student and discarded after use.

3.7.3. Particulate matter (PM) measurement with Aerocet 831

Indoor and outdoor air samples were collected from the selected schools. First from those located adjacent the Agbogbloshie e-waste recycling site and those in the Madina Zongo community, using a light weighted, battery powered and hand-held Met One Aerocet 831 (2.8 L/min) (Met One Instruments INC) sampling pump. This sampler simultaneously measures PM_1, $_{2.5}$ and PM_{10} levels at each minute. Prior to sampling each pump was calibrated and flow rate checked. Indoor (in classroom) and outdoor (within school compound) sampling within school premises were done concurrently. Sampling at both sites was done within four days and continuously for 6 hours each day. Retrieval of Met One Aerocet 831 stored data was done using "Comet" software package onto a computer.

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3.8. Training of research assistants

Research assistants were trained on what the questions in the survey entailed and how to explain the questions to the children so that they could understand. This was to prevent interviewer biases. They were trained to conform to the ethics guiding the study. Trained nurses from the University Hospital were recruited and taking through the use of the spirometer and how to guide the children to perform the spirometry. This was facilitated by an occupational health physician from the University of Ghana Hospital.

3.9. Data Processing and Statistical analysis

Data was entered into a computer database using SPSS Statistics Data Editor and analysed with IBM SPSS version 21 and Microsoft excel 2010. Data was crosschecked and missing values and inconsistencies addressed. Descriptive analysis was conducted on all the study variables. Students t-test was used to mean of lung function indices and PM concentrations of indoor and outdoor air for Agbogbloshie and Madina. A 95% confidence interval (p-value <0.05) was used to test for significance. Pearson correlation analysis was used to find the relationship between the indoor and outdoor PM2.5 and lung function indices, normality was tested and a One -way ANOVA used to test for association between lung function indices and PM2.5. Confounders such as parent's occupation, type of fuel used for cooking at home, proximity of home to school were controlled for during analysis

3.10 Ethical considerations

Ethical clearance was sought from the Institutional Review Board of the Nogouchi Memorial Institute of Medical Research (NMIMR), University of Ghana. Permission was taken from the Director of Accra Metropolitan office of the Ghana Education Service (GES), the Director of LaNkwantanang District Education Office, Madina and heads of the schools under study. Written consent was sought from parents and teachers of the students and a written assent from school children who were participating in the study. Participants were taken through the purpose of the research, the risk, benefits and questioned answered to allay all fears. Participants were informed about their right to stop at any point in the study. They were reassured of their anonymity and privacy and that whatever was discussed will be protected from unlawful asses by anybody. All data collected were kept under lock and key to prevent unlawful access to unauthorized persons.

3.11 Pre-test of Questionnaires

Questionnaire was pre-tested at the Pantang Presby Basic school. A school located at the Abokobi Landfill site.

3.12. Quality Control

The following was done to ensure data collected was of superior quality and validity. Research assistants recruited were nurses who were fluent in Ga, Hausa, and Twi to help interpret questionnaire as and when required. Principal investigator was actively involved to ensure the accuracy and validity of data collected and to ensure that research assistants adhered to all protocols in data collection. Batteries for Spirometers were changed and new ones fixed on a daily basis to ensure accuracy of data collected. Aerocettes were charged and calibrated on daily basis to ensure its sharpness in air sampling. Research participants were informed of the risks of dizziness during spirometry. School children who were found to have respiratory symptoms were given referral notes to be given to their parents to asses the right medical care at the health facilities.

CHAPTER FOUR

4.0 RESULTS

4.1. Socio-demographic characteristic of participants.

Two hundred and forty (240) school children were involved in the study, with 129 and 111 from Agbogbloshie and Madina respectively. The mean ages of school children were 12.27(±0.75) and 12.18(1.65) years for Agbogbloshie and Madina respectively. The sex distribution was 56 males (43.4%) and 73 females (56.6%) for Agbogbloshie, and 42 (37.8%) males and 69 (62.2%) females for Madina.

The age distribution for Agbogbloshie and Madina were as follows; 9-10 years: 20 (15.5%) vs 21(18.9%), 11-12 years: 43 (33.3%) vs 32(28.8%), and 13-14 years: 66(51.2%) vs 38(52.3%) respectively. The mean height for Agbogbloshie was 143.9cm±10.92 while Madina was 148.28cm±11.7%). Mean weights of school children in Agbogbloshie and Madina were 38.5kg±8.8 and 43.3kg±10.7. The overall mean weight and height for Agbogbloshie and Madina were 40.91kg±9.79 and 146.1kg±11.32 respectively. The mean Body Mass Index (BMI) was 18.36(±2.66) for Agbogbloshie and 19.43(±2.97 for Madina. The mean (standard deviation) BMI for both study area was18.9(±2.81). Based on similarities in demographic characteristics of the Exposed and control group, there is enough reason to compare data from the two sites. A total of 29.5% school children in Agbogbloshie reported of having respiratory symptoms as at the time of visit in compared with those in Madina 27%. **(tab.4.1)**.

Table 4.1: Demographic characteristics of schools in Agbogbloshie and Madina.

Characteristics of study Participants	Agbogbloshie (N=129)	Madina (N=111)	Total N= 2
Sex	N (%)	N (%)	N(
Male	56 (43.4)	42 (37.8)	98(40.
Female	73 (56.6)	69 (62.20	142(59.
Total	129 (100)	111 (100)	240(10
Age group			
9-10yrs	20 (15.5)	21 (18.9)	41(17.
11-12yrs	43 (33.3)	32 (28.8)	75(39.
13-14yrs	66 (51.2)	38 (52.3)	104(43.
Total	111 (100)	129 (100)	240(10
Mean age	12.27±0.75	12.18±1.65	12.22±1.
Mean height (cm)	143.9±10.92	148.3±11.72	146.1±11.3
Mean weight (kg)	38.512±8.84	43.31±10.74	40.911±9.7
BMI (kg/m^2)	18.36±2.66	19.43±2.96	18.90±2.8
Child has respiratory symptoms at time of Visit			
Yes	38(29.5)	30 (27.0)	68(28.3
No	91 (70.5)	81 (73.3)	172(71.7
Total	129 (100)	111 (100)	240(100
Ever had respiratory illness (within past 1 month)			
Yes	123(95.3)	104 (93.7)	227(94.6
No	6 (4.7)	7 (6.3)	13(5.4
Total	129 (100)	111 (100)	240(100

4.2. Prevalence of respiratory symptoms among exposed and control groups.

The graph below (fig.4.1) shows self-reported respiratory symptoms by school children from Agbogbloshie and Madina. It was observed that colds, cough and sneezing were the most recorded cases. Agbogbloshie had most cases for almost all symptoms with the highest recorded in cold (24%) as against Madina (23.4%), sneezing, Agbogbloshie (24.8%) as against Madina (17.1%) except for cough where Madina recorded 26.1% against Agbogbloshie's 20.2%. The least recorded symptoms were wheezing (Agbogbloshie, 3.1%: Madina, 3.6%) and shortness of breath (Agbogbloshie 3.1%: Madina 1.8%). In all the symptoms recorded, the exposed group had higher rates in most of the reported symptoms than the control group (fig. 4.1)

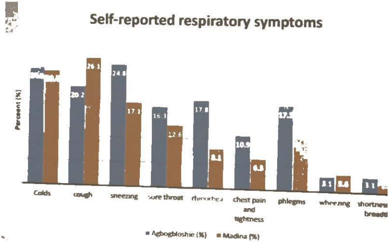

Figure 4.1 Prevalence of respiratory symptoms among the schools in Agbogbloshie and Madina

4.3. Indoor and outdoor airborne concentrations of PM in schools at Agbogbloshie and Madina

The average indoor and outdoor PM 2.5,and PM10 values over the two days (day1 and day 2) at Agbogbloshie and Madina were as follows; Day1 indoor, Agbogbloshie vrs Madina $PM_{2.5}$- 54.77µg/m³vrs41.46µg/m³ PM_{10}- 161.07µg/m³ vrs 86.88µg/m³ respectively and day 2 indoor values were $PM_{2.5}$- 50.56µg/m³ vrs 51.43µg/m³ and PM_{10}- 109.23µg/m³ vrs 153.10µg/m³ For outdoor air concentration $PM_{2.5}$ and PM_{10} for Agbogbloshie and Madina were; day1 $PM_{2.5}$- 56.81µg/m³vrs38.45µg/m³ and PM_{10}- 761.63µg/m³vrs260.50µg/m³. Day 2 values were; $PM_{2.5}$- 63.88 µg/m³vrs39.91 µg/m³ and PM_{10}- 732.41 µg/m³vrs239.41 µg/m³.

There was statistically significant difference of PM 2.5 values between Agbogbloshie and Madina (P-value = 0.019), (**Table4.2**).

Table 4.2 Particulate Matter concentrations inside and outside classrooms in schools at Agbogbloshie and Madina.

Days	PM	AGBOGBLOSHIE		MADINA		t-test
		Indoor	Outdoor	Indoor	Outdoor	Power
Day one	PM2.5 (µg)	54.77	56.81	41.46	38.45	0.019
Day one	PM10 (µg)	161.07	761.63	86.88	260.50	0.454
Day two	PM2.5 (µg)	50.56	63.88	51.43	39.91	0.316
Day two	PM10 (µg)	109.23	732.41	153.10	239.41	0.549

*$p<0.05$ significance level (t-test)

4.4 Indoor and outdoor mean PM values (Day 1 and 2) at Agbogbloshie and Madina.

The mean PM concentration of outdoor and indoor air monitored for the two days, compared between Agbogbloshie and Madina showed a significant difference in outdoor PM2.5 concentrations between Agbogbloshie and Madina (fig.4.2)

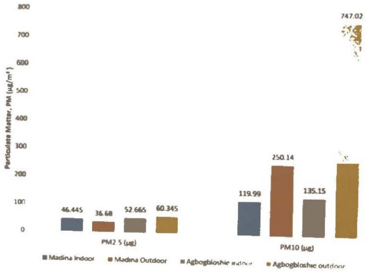

Figure 4.2 Graphical representation of Mean indoor and outdoor PM concentration in schools at Agbogbloshie and Madina.

4.5. Lung function for school children in Agbogbloshie and Madina

In the table (4.3) below, the Mean (standard deviation) values of FEV1 among the exposed and control group was 1.652±0.505) and 1.677±0.696) respectively (P-value 0.814). FVC was 2.2409±0.967) and 2.745±1.904) respectively (P-value of 0.004). the % FEV1/FVC was 76.329±17.705) and 68.74±21.135) respectively with a p-value of 0.010 (**Table. 4.3**).

Table 4.3 Lung function indices for school children in Agbogbloshie and Madina

	AGBOGBLOSHIE		MADINA		t-test
Characteristic	Mean	St. deviation	Mean	St. deviation	p-value
FEV1	1.652	0.508	1.677	0.696	0.814
FVC	2.2409	0.967	2.745	1.904	0.004
Mean % FEV1/FVC	76.329	17.705	68.74	21.135	0.010

*$p<0.05$ significance level (students t-test)

4.6 Pearson correlation between $PM_{2.5}$ indoor and outdoor, lung function indices and other determinants of respiratory health.

Pearson's correlation was done to determine the relationship between $PM_{2.5}$ concentrations (indoor and outdoor) and lung function indices. It was observed that a weak negative correlation existed between $PM_{2.5}$ (indoor and outdoor) and FVC (-0.163, $P<0.05$). A unit rise in $PM_{2.5}$ will reduce FVC by 0.163. There was a weak positive correlation between $PM_{2.5}$ (indoor and outdoor) and FEV1/FVC (0.167 and 0.169, $P<0.01$) (**Table.4.4**)

Table 4.4 Correlation between $PM_{2.5}$ (indoor and outdoor) lung function indices and determinant of respiratory health.

	FEV1	FVC	%FEV1/FVC	$PM_{2.5}$ indoor	$PM_{2.5}$ outdoor	Person days in school
FEV1	1	0.540**	0.05	-0.034	-0.033	-0.020
FVC		1	-0.620**	**-0.163***	**-0.163***	**-0.169****
%FEV1/FVC			1	0.167**	0.169**	0.191**
$PM_{2.5}$ indoor				1	0.997**	0.928**
$PM_{2.5}$ outdoor					1	0.929**
Person days at school						1

4.7. Association between $PM_{2.5}$ (indoor and outdoor) and lung function

Analysis of Variance (ANOVA) was used to determine the relationship between exposure to $PM_{2.5}$ and its effects on lung function. The table (4.5) showed a statistically significant relationship between the difference in the mean indoor $PM_{2.5}$ measurement between groups (Madina and Agbogbloshie) and the lung function test of the individual school children on different days. This significant relationship was also observed for outdoor $PM_{2.5}$ exposure and the effect on lung function tests (P-value = 0.13, 0.02, 0.32 for FEV1, FVC, and FEV/FVC respectively) (**Table 4.5**)

Table 4.5 Association between Indoor and outdoor $PM_{2.5}$ concentration and Lung function indices

ANOVA											
		Indoor PM2.5					Outdoor PM2.5				
		Sum of Squares	df	Mean Square	F statistics	P-value	Sum of Squares	Df	Mean Square	F statistics	p-value
FEV1	Between Groups	3.876	3	1.292	3.693	.013	3.953	3	1.318	3.771	.011
	Within Groups	82.557	236	.350			82.480	236	.349		
	Total	86.433	239				86.433	239			
FVC	Between Groups	22.287	3	7.429	3.427	.018	22.237	3	7.412	3.419	.018
	Within Groups	511.608	236	2.168			511.659	236	2.168		
	Total	533.895	239				533.895	239			
FEV1_FVC percentage	Between Groups	3588.829	3	1196.276	3.253	.022	3603.672	3	1201.224	3.267	.022
	Within Groups	86789.977	236	367.754			86775.135	236	367.691		
	Total	90378.807	239				90378.807	239			

4.8. Comparison of mean FVC values across ages for Agbogbloshie and Madina.

Mean FVC values for age 9-10 was 1.17 and 1.82 for Agbogbloshie and Madina with a p-value of 0.842. this shows that the difference between these groups was not statistically significant. The mean FVC for 11-12 years was 1.57 and 2.14 for Agbogbloshie and Madina respectively (P-value =0.136). This denotes that the difference in values of FVC of this age category between the Agbogbloshie and Madina is not statistically significance but due to chance. the mean FVC values of the age 13-14 read 1.82 and 3.88 for Agbogbloshie and Madina respectively, with a P-value of 0.002. Meaning the difference in the value for the different group is statistically significant at a 95% confidence interval and not due to chance. (Table.4.6)

Table 4.6 Mean FVC value across age categories for Agbogbloshie and Madina.

Age(years)	No. (Agb./ Mad)	Agbogbloshie	Madina	p-value
9-10	20/21	1.17	1.82	0.842
11-12	43/32	1.57	2.14	0.136
13-14	66/58	1.82	3.88	0.002

*p<0.05 significance level (student's t-test)

CHAPTER FIVE

5.0 DISCUSSION

5.1 Summary of findings

From the findings of this study, it was observed that most of the school children from Agbogbloshie had more self-reported respiratory symptoms than Madina. Children in Agbogbloshie reported more cases of sneezing (24.7% vrs 17.1%) and rhinorrhea (17.8% vrs8.1%) although Madina recorded more cases in cough (26.1%vrs20.2%) than Agbogbloshie. For PM (PM_1, $PM_{2.5}$ and PM_{10}) concentrations, higher values were recorded in Agbogbloshie than Madina for both indoor and outdoor air. There was statistically significant difference between FVC values among school children in Agbogbloshie and those Madina($P<0.05$).

5.2 Method validity

Several studies have been conducted in this area among adult populations, but this study is the first among school children in the enclave of Agbogbloshie. The questionnaire was administered in English and other local languages; Twi, Hausa and Ewe when and where necessary for clear understanding of the questions. Spirometry was conducted by two trained clinicians to ensure that spirometry was performed according to the American Thoracic Society (ATS) guidelines. The major limitations of the study were the study design, The cross-sectional nature of the study made it difficult to establish causality. A longitudinal study will be required to detect a causal relationship. The sample size was also too small, so lacked the power to detect an effect.

5.3 Comparison of results to previous findings.

Inhalation is the major route of exposure to airborne pollutants. Open air burning of e-waste, especially burning of electrical cables of all sizes to retrieve copper wire release toxic smoke/fumes containing polychlorinated biphenyls (PCBs), poly aromatic hydrocarbons (PHAs), and particulate matter (PM) among others. These airborne pollutants have been linked to respiratory symptoms such as common cold, sneezing and rhinorrhea (NTI, 2015). School children in Agbogbloshie reported increased cases of respiratory symptoms than their counterparts in Madina

The main aim of the study was to assess respiratory health among school children at Agbogbloshie (an informal electronic waste site) compared to those in Madina (control site). Studies have observed high rates of respiratory tract symptoms and reduced lung functions among children found within electronic waste recycling sites (Grant et al., 2013b; Xing et al., 2016; Zheng et al., 2013). In this study, the prevalence of respiratory symptoms was slightly higher among the children in Agbogbloshie (29.5%) as compared to their counterparts in Madina (27%). School children in Agbogbloshie reported high cases of sneezing (24.8% vs 17.1%) and rhinorrhea (17.8% vs 8.1%) than Madina. Higher PM concentrations were measured inside and outside the classrooms in Agbogbloshie. The landscapes of the school is such that depending on the direction of the wind, school children almost always come into contact with residual smoke and dust particles. It was also observed that the schools in Agbogbloshie and Madina had poor ventilation in the classrooms and the few windows were always closed during the course of the visit to the schools. Poor ventilation causes stale air and high concentration of pollutants within an enclosed space and can encourage the spread of respiratory symptoms. The schools in

Agbogbloshie were just about 500metres from the informal e-waste site and 16.3% of these children live within 200-400metres from the informal e-waste site, whiles 48.8% live within 100-200metres from the informal e-waste recycling site. The nature of housing in Agbogbloshie, with less ventilation and often crowded may have contributed to the higher prevalence of some respiratory symptoms compared to children in Madina.

Although there is no e-waste activity in Madina, the Zongo community is similarly unstructured and congested with majority of the population relying on use of biomass fuel for cooking and heating purposes as well as the close proximity to an open market with heavy vehicular traffic. Like Agbogbloshie, Madina Zongo is close to a major road and an open market. The rate of respiratory symptoms among the school children in Madina could also be associated with the presence of other background pollutants such as dust from construction site, and dust from untarred school compounds. This is similar to findings by Xing et al.(2016) where they identified dust from other sources and vehicular emissions as causes for cold, cough and sneezing. Therefore, it is not surprising that respiratory symptom like cold was even slightly high among school children in Madina than Agbogbloshie. These are all sources for particulate matter (PM) exposures. Children are at more risk to any form of environmental pollution because they are still growing and their body is vulnerable to these pollutants in the ambient air. Their intake of air is more than the adults, they require more air to perform normal functions in the boy. Because of the high intake of air, high intake of pollutants is also inhaled into the lung to cause morbid conditions in their lungs.

Average concentrations of particulate matter in the ultra-fine range $PM_{2.5}$ and PM1 for both indoor and outdoor air were on the high side for Agbogbloshie compared to Madina. The average indoor and outdoor concentrations of PM2.5 in Agbogbloshie were higher ($54.77\mu g/m^3$, $56.81\mu g/m^3$ respectively) than Madina ($41.46\mu g/m^3$, $38.45\mu g/m^3$) ($P<0.02$). $PM_{2.5}$ levels on Day 1 ($54.77\mu g/m^3$) was slightly higher than that of Day 2 ($50.56\ \mu g/m^3$). This could largely be due to increased e-waste burning activities, which was visible on day 1 of data collection. Change in wind direction could also be a contributory factor. Madina on the other hand recorded high values for indoor air monitored on Day 2 ($51.43\ \mu g/m^3$), compared to Day 1($41.46\ \mu g/m^3$). This could be as a result of the dust from a nearby construction site that engulfed the school environment on the day 2 of data collection. This finding is similar to a study done on particulate air pollution and impaired lung function by Paulin and Hansel where higher $PM_{2.5}$ concentration was associated with reduced lung function among 112 healthy Dutch children (Paulin & Hansel, 2016). Both Agbogbloshie and Madina exceeded the WHO's daily guidelines for $PM_{2.5}$ ($25\mu g/m^3$) and PM_{10} ($50\mu g/m^3$) (WHO, 2018). Kulshrestha et al (2009) in their study realized that urban areas have high concentrations of $PM_{2.5}$ and PM_{10} due to heavy vehicular emissions, construction work, emissions from industries and informal e-waste recycling.

A normal lung can empty 80% of its volume in 60seconds. FVC is the most important spirometry maneuver because it's the total volume of air that can be exhaled in a maximal forced expiratory effort. The normal FEV1 should be >80% of the predicted value[(observed/predicted) x100] and the normal FEV1/FVC ratio should be >0.7(Global Intiative for Chronic Lung Diseases, 2010.; Stanojevic, Wade, & Stocks, 2010). The mean FEV1 for both Agbogbloshie and Madina were less than 80% FEV1(1.652L vs 1.677L) (predicted value of FEV1 is 4L). A statistically significant difference was observed for mean FVC scores for school children in Agbogbloshie compared to those in Madina (p-value=0.04). This shows that school children in Agbogbloshie have some level of reduced lung capacity to exhale air compared to those in Madina. These findings are similar to another analysis by Paulin and Hansel (2016) who reported lower FEV1 and FVC values in 163 healthy Australian children after they sampled outdoor air for 8-hours and recorded high PM2.5 and PM10 values. In a study among children in California, those exposed to low levels of PM had better lung function than those exposed to higher PM concentrations (Paulin & Hansel, 2016). FVC among the various age categories, showed an increase in FVC values as the age progressed, with statistically significant increase recorded for 13-14years category($P<0.05$). This finding is similar to a study conducted by Budhiraja et al.,(2010), where they observed a strong positive correlation between age and FVC($P<0.01$)(Budhiraja et al., 2010).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions.

Study identified higher prevalence of some respiratory symptoms; sneezing, rhinorrhea (running nose) among school children in Agbogbloshie than Madina. PM concentrations in indoor and outdoor air sampled were higher in Agbogbloshie with a significant difference in $PM_{2.5}$ (day 1) and PM_1 (day 2) due to the persistent informal e-waste recycling activities. Overall, school children in Agbogbloshie had reduced lung function than those in Madina. There was an association between $PM_{2.5}$ and FEV1, FVC and FEV1/FVC ratio.

6.2. Recommendations.

1. School authorities, parents and school children must be educated on the potential adverse health effects of ambient air pollution.
2. Good ventilation should be provided in classrooms and windows should always be kept open to allow free movement of fresh air..
3. A longitudinal study needs to be done to establish the relationship between e-waste recycling activities and respiratory health among younger people in Agbogbloshie, and perhaps, schools in general.

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APPENDICES

Appendix I: Parental Consent Form

Title: Respiratory health among school children around an Electronic waste site and a control site at Madina Zongo junction

Principal Investigator: Gifty Enyonam Okotah

Address: School of Public Health, University of Ghana, Legon

General Information about Research:

The Objective of the Research is to find out how often respiratory symptom occurs among school children near Agbogbloshie e-waste recycling site and a control site at Madina and factors that expose the children. Data will be collected on your ward and it will be collected in a day. Your Ward will be asked series of questions to which he may provide answers to. He will also be required to blow air into a device which will record how his/ her lung is functioning.

Possible Risks and Discomforts

There is no associated risk to this project and the processes of Data collection. Means of Data collection is non-invasive; hence no harm will be done to participants. However, signs such as slight dizziness may occur among some participant in the process of checking for their lung function.

Possible Benefits

School children with reduced lung function will be encouraged to seek medical treatment and the information gathered will be given to the stakeholders which could influence future planning and siting of schools within E-waste sites.

Confidentiality

All data collected and field notes will be kept in confidentiality by the principal investigator. The field note will be developed and saved in files on the computer with security codes that will only be known by the principal investigator. Data will not be labelled to any study participant but with an identification number known only to the principal investigator in the person of Gifty Enyonam Okotah (student), school of Public Health, University of Ghana. Mobile Number: 0242553095

Compensation

No compensation will be given for participation in this research.

Additional Cost

No cost will be incurred by the participants as every cost has been covered by the Principal investigator.

Voluntary Participation and Right to Leave the Research

School children will participate in this study by their own free will and that, refusing to enter the study, or answer a particular question or even partake in the Spirometry will have no negative consequence.

Contacts for Additional Information

Please contact Gifty Enyonam Okotah on 0242553095 if you have any question about the study.

Your Child's Rights as a Participant

This research has been reviewed and approved by the Noguchi Memorial Institute for Medical Research Institutional Review Board (NMIMR-IRB). If you have any questions about your child's rights as a research participant you can contact the IRB Office between the hours of 8am-5pm through the landline 0302916438 or email addresses: nirb@noguchi.ug.edu.gh

VOLUNTEER AGREEMENT

The above document describing the benefits, risks and procedures for the research title (Respiratory health among school children around an Electronic waste site and a control site at Madina Zongo junction)

has been read and explained to me. I have been given an opportunity to have any questions about the research answered to my satisfaction. I agree that my child should participate as a volunteer.

__________________ ____

Date Name and signature or mark of parent or guardian

If volunteers cannot read the form themselves, a witness must sign here:

I was present while the benefits, risks and procedures were read to the child's parent or guardian. All questions were answered and the child's parent has agreed that his or her child should take part in the research.

__________ ____________ ____________________________________

Date Name and signature of witness

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

____________________ _________________________________

Date Name Signature of Person Who Obtained Consent

Appendix II: Child Assent Form

General Information

My name is Gifty Enyonam Okotah and I am from the Department of Behavioural, Environmental and Occupational Health and at the University of Ghana. I am conducting a research study entitled **RESPIRATORY HEALTH AMONG SCHOOL CHILDREN AROUND AN ELECTRONIC WASTE SITE (AGBOGBLOSHIE) AND A CONTROL GROUP (MADINA ZONGO JUNCTION).**

I am asking you to take part in this research study because I am trying to learn more about how often you get respiratory symptoms and the factors associated with it. This will take 40 minutes of your time

If you agree to be in this study, you will be asked to answer some questions and blow air into a tube.

Possible Benefits

Your participation in this study will help you know how well your lung is, and if you have any health problems with your lungs you will be directed to the appropriate health facility for health care.

Possible Risks and Discomforts

However, the risks associated is you may feel some slight dizziness because of the force that will be used to blow air into the tube.

Voluntary Participation and Right to Leave the Research

You can stop participating at any time if you feel uncomfortable. No one will be angry with you if you do not want to participate.

Confidentiality

Your information will be kept confidential. No one will be able to know how you responded to the questions and your information will be anonymous.

Contacts for Additional Information

You may ask me any questions about this study. You can call me at any time on 0242553095 or talk to me the next time you see me.

Please talk about this study with your parents before you decide whether or not to participate. I will also ask permission from your parents before you are enrolled into the study. Even if your parents say "yes" you can still decide not to participate.

Your rights as a Participant

This research has been reviewed and approved by the Institutional Review Board of Noguchi Memorial Institute for Medical Research (NMIMR-IRB). If you have any questions about your rights as a research participant you can contact the IRB Office between the hours of 8am-5pm through the landline 0302916438 or email addresses: nirb@noguchi.ug.edu.gh

VOLUNTARY AGREEMENT

By making a mark or thumb printing below, it means that you understand and know the issues concerning this research study. If you do not want to participate in this study, please do not sign this assent form. You and your parents will be given a copy of this form after you have signed it.

This assent form which describes the benefits, risks and procedures for the research titled **RESPIRATORY HEALTH AMONG SCHOOL CHILDREN AROUND AN ELECTRONIC WASTE SITE (AGBOGBLOSHIE) AND A CONTROL GROUP (MADINA ZONGO)** has been read and or explained to me. I have been given an opportunity to have any questions about the research answered to my satisfaction. I agree to participate.

Child's Name:.................... **Researcher's Name:................................**

Child's Mark/Thumbprint........... **Researcher's Signature:...........**

Date: ...... **Date:** ....

Appendix III: Questionnaire for Respiratory Assessment.

Section A. Socio-Demographic data (please tick where applicable)

1. Age: 9-11yrs [ ] 12-14yrs [ ]

2. Sex: male [ ] female [ ]

Section B. The next set of questions are about the home

3. How many are you at home? 3-5 [ ] 6- 8 [ ]

4. How many living rooms do you have at home? [ ]

5. Where is cooking done? Inside [ ] outside [ ]

6. In which room is cooking done? kitchen [ ] living room [ ]

7. What work does father do? E-waste worker [ ] welder [ ] trader [ ]

Others specify ....

8. what work does mother do? Trader [ ] E-waste worker [ ] Unemployed [ ]

Other specify ....

9. What does your mother use to cook at home? Firewood [ ] charcoal [ ]

gas stove [ ] other [ ]

10. Do you help in the kitchen? Yes [ ] No [ ]

11. Does any parent smoke? Yes [ ] No [ ]

12. Do you work at the E- waste site? Yes [ ] No [ ]

If yes, do you use protective clothing? Yes [ ] No [ ]

Section C. Other factors

13. Are u exposed to any of this at home?

Pollutant	Yes	No
Smoke		
Fumes		
Dust		

Molds/ Dumpiness		
Irritating liquids		

14. How far is the home from e- waste site? 100 -200metres [ ] 300- 400metres [ ]

500metres – 1000metres [ ]

15. how far is the home from the market? 100-200metres [ ] 300- 400metres [ ]

500metres – 1000metres [ ]

Section D. Current health status

15. Do you have any respiratory health condition? Yes [ ] No [ ]

16. Have you ever had any respiratory illness? Yes [ ] No [ ]

If yes how often do you have it? Daily [ ] weekly [ ] Monthly [ ]

17. Do u currently have any of this?

Symptom	Yes	No
cold		
cough		
sneezing		
Sore throat		
Rhinorrhoea		
Chest pain and tightness		
phlegm		
wheezing		
Shortness of breath		
Itchy nose and throat		
Itchy and watery eyes		
Easy tiredness		

Others (specify)		

18. Do you have any respiratory symptoms when you come to school? Yes [ ] No [ ]
19. When are symptoms severe? At home [ ] At school [ ]
20. how many years in current school ? [ ]
21. how many days do u come to school? [ ]
22. how many hours do u spend in school? [ ]

SPIROMETRY DATA ENTRY SECTION

WEIGHT	HEIGHT	FEV-1	FVC	FEV-1/FVC	TEST GRADE

Additional Test Comments

....

....

....

Thank you for being a part of this project

Appendix IV: Introduction Letters

UNIVERSITY OF GHANA
DEPARTMENT OF BIOLOGICAL, ENVIRONMENTAL AND OCCUPATIONAL HEALTH
SCHOOL OF PUBLIC HEALTH

Ref. No.

June 17, 2019

The Headmistress
La Nkwantanang 5 Basic School
Madina

Dear Sir,

LETTER OF INTRODUCTION
GIFTY ENYONAM OKOTAH (10700990)

I am pleased to introduce to you the above-named Master of Science (MSc) student in the Department of Biological, Occupational and Environmental Health Sciences in the School of Public Health, University of Ghana, Legon.

As part of the requirement for the award of MSc Occupational Hygiene Degree, she is conducting a research on "**Respiratory Health among School Children around an Electronic Waste Site (Agbogbloshie) and a Control Site (Madina Zongo Junction.**"

The general objective of this study is to determine the prevalence and risk factors of respiratory symptoms among school children.

It is my hope that you will give her the necessary assistance to enable her carry out the research work.

I count on your support and assistance.

Yours faithfully,

Prof. Julius Fobil
(Head of Department)

COLLEGE OF HEALTH SCIENCES

• Telephone • Email • Website

UNIVERSITY OF GHANA
DEPARTMENT OF BIOLOGICAL, ENVIRONMENTAL AND OCCUPATIONAL HEALTH
SCHOOL OF PUBLIC HEALTH

January 24, 2019

The Headmaster
Ayalolo Cluster of Schools
Accra

Dear Sir,

LETTER OF INTRODUCTION
Gifty Enyonam Okotah (10700990)

I am pleased to introduce to you the above-named Master of Science (MSc) student in the Department of Biological, Occupational and Environmental Health Sciences in the School of Public Health, University of Ghana, Legon.

As part of the requirement for the award of MSc Occupational Hygiene Degree, she is conducting a research on **"Respiratory Health among School Children around an Electronic Waste Site (Agbogbloshie) and a Control Site (Madina Zongo Junction."**

The general objective of this study is to determine the prevelence and risk factors of respiratory symptoms among school children.

It is my hope that you will give her the necessary assistance to enable her carry out the research work.

I count on your support and assistance.

Yours faithfully,

Prof. Julius Fobil
(Head of Department)

COLLEGE OF HEALTH SCIENCES
P. O. Box LG 13, [illegible] Accra, Ghana
Telephone: +233 (0)30 [illegible]
Email: [illegible]@ug.edu.gh
Website: www.publichealth.ug.edu.gh

Appendix V: Approval Letter from La-Nkwantanang

GHANA EDUCATION SERV.CE

In case of reply the number and date of this letter should be quoted

My Ref: GES/LaNMA/34/Vol.3/83

Your Ref. No. ....

REPUBLIC OF GHANA

MUNICIPAL EDUCATION OFFICE
LA-NKWANTANANG MADINA
P. O. BOX MD 515
MADINA

6th FEBRUARY 201

DISTRIBUTION

THE HEADTEACHER OF NKWANTANANG '7' BASIC

RE: LETTER OF INTRODUCTION OF
MS. GIFTY ENYONAM OKOTAH

With reference to a letter dated on the 31st January 2019, I write to introduce to you **Ms. Gifty Enyonam Okotah with Index number 10700990** a Master of Science **(MSc) Student at the Department of Biological, Environmental and Occupational Health at the University of Ghana**
She is conducting a research on "**Respiratory Health among School Children around an Electronic Waste Site (Agbogbloshie) and a Control Site (Madina Zongo Junction.**"

Permission is hereby given to her to carry out the exercise in your school, Nkwantanang '7' Basic.

By copy of this letter, the Circuit Supervisor and Headteacher are requested to give her the assistance needed to have a successful exercise.

For further clarification, please contact **Mr. Peter N. Ngala the Head of Supervision and Monitoring (S&M)** on telephone numbers **0244968881/0208251167**

Thank you

(Signed)

FRANCES MABEL WILLIAMS (MS)
AG. MUNICIPAL DIRECTOR OF EDUCATION
LA NKWANTANANG-MADINA

CC: THE CIRCUIT SUPERVISOR

E-MAIL: gesgarlanmmao13@gmail.com [illegible]

Appendix VI: Approval Letter from Accra Metro

GHANA EDUCATION SERVICE

In case of reply the number and date of this letter should be quoted

My Ref. No. GES/ACD/PG 46/VOL.12

Your Ref. No.

METRO EDUCATION OFFICE
POST OFFICE BOX [illegible]
ACCRA

Tel. No. [illegible]

20th February, 20

CIRCUIT SUPERVISORS
ASHIEDU KETEKE SUB-METRO
ACCRA

LETTER OF INTRODUCTION TO CONDUCT A RESEARCH
MRS. GIFTY ENYONAM OKOTAH
UNIVERSITY OF GHANA - LEGON

I write to introduce Mrs. Gifty Enyonam Okotah who is a Master of Science student in the School of Public Health, University of Ghana, Legon, Accra.

As part of her requirements for the award of MSc Occupational Hygiene Degree, she is expected to conduct a research on a project entitled **"Respiratory Health Among School Children Around an Electronic Waste Site (Agbogbloshie)** in the Ayalolo Cluster of schools.

It is expected that all ethical standards and measures to preserve the confidentiality of respondents identities would be observed.

Permission has therefore been granted to Mrs. Gifty Enyonam Okotah to conduct the research in the Ashiedu Keteke Sub Metro

The researcher is directed to contact you for further discussions and directives

Kindly ensure that she is assisted to fulfil this academic requirement. You are entreated to ensure that contact hours are not compromised.

MARGARET FREMPONG-KORE (MRS.)
DIRECTOR OF EDUCATION
ACCRA METRO

Cc DD Sup, AMEO, Accra
The Basic Schools Coordinator, AMEO, Accra
Prof. Julius Fobil, Head of Dept. School of Public Health, UG, Legon

Appendix VII: Ethical Clearance

NOGUCHI MEMORIAL INSTITUTE FOR MEDICAL RESEARCH

Established 1979A Constituent of the College of Health Sciences

University of Ghana

INSTITUTIONAL REVIEW BOARD

Phone: +233-302-916438 (Direct)
+233-289-522571
Fax: +233-302-502182/513202
E-mail: nirb@noguchi.ug.edu.gh
Telex No: 2556 UGL GH

Post Office Box LG 581
Legon, Accra
Ghana

My Ref. No: 10/ ::
Your Ref. No

8th May, 2019

ETHICAL CLEARANCE

FEDERALWIDE ASSURANCE FWA 00001824 | **IRB 00001276**

NMIMR-IRB CPN 062/18-19 | **IORG 0000908**

On 8th May, 2019, the Noguchi Memorial Institute for Medical Research (NMIMR) Institutional Review Board (IRB) at a full board meeting reviewed and approved your protocol titled:

TITLE OF PROTOCOL : **Respiratory health among school children around an electronic waste site (Agbogbloshie) and a control group (Madina zongo Junction)**

PRINCIPAL INVESTIGATOR : **Gifty Enyonam Okotah, MSc Cand.**

Please note that a final review report must be submitted to the Board at the completion of the study. Your research records may be audited at any time during or after the implementation.

Any modification of this research project must be submitted to the IRB for review and approval prior to implementation.

Please report all serious adverse events related to this study to NMIMR-IRB within seven days verbally and fourteen days in writing.

This certificate is valid till 7th May, 2020. You are to submit annual reports for continuing review.

Signature of Chair: ....

Mrs. Chris Dadzie
(NMIMR - IRB, Chair)