EFFECT OF AMBIENT AIR POLLUTION ON RESPIRATORY HEALTH
OF MARKET WOMEN AT AGBOGBLOSHIE FOOD MARKET IN
ACCRA, GHANA

BY

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LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE
AWARD OF MASTER OF PUBLIC HEALTH DEGREE

JULY, 2017
DECLARATION

I, Joyce Enyonam Nafrah hereby declare that with the exception of the references made to other peoples' work which I have duly acknowledged, this is my original work under the academic supervision of Dr. John Arko-Mensah and has neither in whole nor in part been presented to any University or elsewhere for another degree.

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11th October, 2017
DEDICATION

I dedicate this thesis to Almighty God who gave me this opportunity and has been my source of strength throughout my education.
ACKNOWLEDGEMENTS

I am grateful to the Lord for his abundant grace and favor that has seen me through this period. My sincere gratitude goes to my academic supervisor, Dr. John Arko-Mensah for his patience, guidance and inputs into this dissertation.

My heartfelt gratitude also goes to the staff of Accra Metropolitan Assembly (AMA) at Agbogbloshie market and to all the Queen Mothers of the market who helped me during the data collection.

I will also like to appreciate all market women in Agbogbloshie who graciously submitted themselves to be part of this study. God bless you.

To my team members, all members of the data collection team, I say thank you for being such a great team. Your support and commitment made our task easy.

Finally, I thank my family and everyone who helped me during this period, your support, encouragement and prayers has seen me through this program, God bless you.
ABSTRACT

Background: Exposure to air pollutants could lead to a variety of health effects depending on the type of pollutant, amount of the pollutant exposed to, duration, frequency of exposure, and associated toxicity of the specific pollutant. Exposure to pollutants such as particulate matter (PM), carbon dioxide (CO₂), ozone (O₃), carbon monoxide (CO) and nitrogen dioxide (NO₂) are known to impact adversely on respiratory health. Agbogbloshie market is a large open food market, which is also in the vicinity of a famous electronic recycling and dumpsite, and market women are constantly being exposed to environmental pollution.

Objective: The aim of this study was to assess the effect of ambient air pollution on the respiratory health of market women at the Agbogbloshie open food market.

Methodology: A cross-sectional study was used to assess the prevalence of symptoms of respiratory infections among market women. This was done using a structured questionnaire and spirometry. Also, the Aerocet Comet 860 and the Hobo CO₂ monitors were used to measure ambient levels of Particular Matter (PM) and Carbon dioxide (CO₂) respectively. Chi-square analysis were computed to find the relationship between ambient air pollutants and respiratory symptoms. Association between pulmonary function and independent variables were assessed using multiple linear regression analysis and Spearman’s rank correlation was used to test the strength of association between pulmonary function indices, blood pressure and age. Statistical analysis was done in STATA software version 14.1.

Results: All market women studied had high prevalence of cough, colds, sore throat and repeated sneezing (100%). Mean values of lung function test ± SD were FVC (L) = (2.40±0.69), FEV₁ (L/s) = (1.78±0.50), FEV₁/FVC = (0.75±0.11) and % Pred. (FEV₁) = (77.8±20.62). There was no significant relationship between lung function and respiratory symptoms from the p-values for...
cough, sneezing, wheezing, shortness of breath, and chest tightness when unadjusted. After adjusting for the joint effects of these variables, traders who were alcohol users had an average lung function of 0.122 (12.2%) less than those who did not, p=0.005.

**Conclusion:** This study showed that Agbogbloshie market women have a high prevalence of respiratory symptoms such as cough, colds, sore throat and repeated sneezing, reduced pulmonary function indices. There was no significant statistical relationship between respiratory symptoms and ambient air pollutants.

**Key words:** Spirometry, Respiratory symptoms, Pulmonary function, Particulate matter, Carbon dioxide, Market women, Agbogbloshie market.
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<tbody>
<tr>
<td>PM</td>
<td>Particulate Matter</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td>Particles with aerodynamic diameter ≤2.5 μm</td>
</tr>
<tr>
<td>PM$_{10}$</td>
<td>Particles with aerodynamic diameter ≤10μm</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>COPD</td>
<td>Chronic Obstructive Pulmonary Disease</td>
</tr>
<tr>
<td>FVC</td>
<td>Forced Vital Capacity</td>
</tr>
<tr>
<td>FEV$_{1}$</td>
<td>Forced Expiratory Volume in one second</td>
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<tr>
<td>E-waste</td>
<td>Electronic waste</td>
</tr>
<tr>
<td>Hazard</td>
<td>A source of exposure to danger</td>
</tr>
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<td>PPE</td>
<td>Personal Protective Equipment</td>
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DEFINITION OF TERMS

Occupational hazard

A working condition that leads to illness or death

Spirometry

A test used to assess how well the lungs work by measuring how much air you inhale, how much you exhale and how quickly you exhale. It is used to diagnose Asthma, Chronic Obstructive Pulmonary Disease (COPD) and diseases that affect breathing.
CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Air pollution has become one of the most important global concerns in the 21st century, especially in developing countries. Exposure to air pollutants could lead to a variety of health effects depending on the type of pollutant, amount of the pollutant exposed to, duration or frequency of exposure, and associated toxicity of the specific pollutant. These exposures are associated with a broad range of acute and chronic health effects varying from sub-clinical effects to premature mortality. According to the latest urban air quality database, 98% of cities in low- and middle income countries with more than 100,000 inhabitants do not meet the World Health Organization’s (WHO) air quality guidelines (WHO, 2016). However, in high-income countries, the percentage air quality decreases to 56%. As urban air quality declines, the risk of stroke, heart disease, lung cancer, and chronic and acute respiratory diseases, including asthma, increases for the people who live in them (Nandasena, Y. L. S., Wickremasinghe, A. R., & Sathiakumar, N., 2010). Outdoor air pollutants including particulate matter (PM), carbon monoxide (CO), ozone (O₃) and nitrogen dioxide (NO₂) have been reported to be associated with short-term adverse effects on lung function in healthy adults, children, or patients with Chronic Obstructive Pulmonary Disease (COPD) or asthma, this means everyone is at risk (Nandasena et al., 2010).

Agbogbloshie is a vibrant informal settlement with considerable overlap between industrial, commercial, and residential zones. The location of the market makes market women prone to exposure to a myriad of pollutants, ranging from particulate matter, exhaust fumes from vehicles, metals, especially heavy metals, from the nearby e-waste recycling and dumpsite, all with the potential to impact negatively on respiratory health.
Motor vehicles are commonly viewed as one of the major causes of serious air pollution in the urban area. High concentration of traffic-related air pollution; carbon monoxide (CO), sulphur dioxide (SO₂), may cause adverse health effects, such as exacerbating asthma, impairing lung function, increasing cardiovascular morbidity and mortality, aggravating adverse birth outcomes, and declining cognitive ability (Harrop Owen, 2017).

The United Nations Environmental Program (UNEP) estimates that 50 million metric tons of e-waste is produced per year globally, of which 15% is estimated to enter Ghana through the Tema port, with much of it finding its way to the Agbogbloshie recycling site. Recycling of e-waste ranges from mechanical dismantling of electronic and electrical equipment, to open air burning to retrieve oxidized copper and other metals. Recycling activities could release inorganic heavy metals into the ambient environment. Open air burning of e-waste is connected to health risks which may result from direct contact with harmful materials such as lead, cadmium, chromium, brominated flame retardants or Polychlorinated biphenyls (PCBs). A vast array of waste electronic and electrical equipment’s are manufactured with these products which could easily migrate into homes, food, markets and other places (Townsend, 2011).

All these materials (lead, cadmium, chromium, brominated flame retardants or Polychlorinated biphenyls (PCBs) could have adverse health effects on those in the vicinity of the market or e-waste dumpsite and surrounding areas (Loftus-Farren, 2013). Market women in Ghana, often work from the early hours of the morning till evening in a sedentary manner and therefore are prone to exposure of several pollutants, thus, putting them at risk of occupational health conditions such as long term respiratory health problems and harsh weather conditions. It is important for these market women to enjoy good health by putting measures in place to help control their health risk
(Harrison & Yin, 2000). This study explored the prevalence of respiratory symptoms and lung function among market women in Agbogbloshie market.

1.2 Problem Statement

Few studies have examined the short-term to medium term (acute to sub-chronic) effects of relatively high outdoor air pollution on pulmonary function and respiratory health. For instance studies conducted at Agbogbloshie focused on individuals, all males, involved in electronic waste (e-waste) recycling activities; collection, sorting, dismantling and open air burning and therefore are in direct contact with toxic chemicals and smoke (Asante, Agusa, Biney, Agyekum, Bello, Otsuka, 2012). Others have studied hawkers in direct contact with these activities on the scrapyard (Akormedi, M., Asampong, E., J.N & Fobil, 2013).

The Agbogbloshie food market in Accra is located behind a large open electronic waste (e-waste) recycling/dumpsite which is the largest in Ghana and the 2nd largest in West Africa (Loftus-Farren, 2013). The market is famously known for the selling and buying of yams and onions, although all other foodstuffs are also sold there. Market women, conduct daily business activities here for their income while being exposed to health hazards from several sources including dust from untarred roads, exhaust fumes from motorbikes, cars and heavy duty trucks that transport goods to the market, and ambient exposure to pollutants from e-waste processing, thus presenting unique occupational and ecological health risks.

A study conducted on the short term effect of outdoor air pollution in China reported that particulate matter (PM) can penetrate and be retained in the walls of small airways leading to generation of free radicals and triggering intracellular oxidative stress. Individuals may experience
adverse effects on the respiratory system and higher level may lead to continuous damage to the lung (Zhou, Y., Liu, Song, Xie, Cui, et al., 2016).

Continuous exposure to toxic air pollutants and higher levels may lead to continuous damage in lung functions. There is however very little information on the scope towards exposure of market women to ambient air pollutants and its respiratory health effect in Ghana. There is therefore the need to investigate how ambient air pollutants in the Agbogbloshie market affects the respiratory health of market women.

1.3 Conceptual Framework

Figure 1.0 represents the sources and type of air pollution at Agbogbloshie market and the possible health effects. Individuals are exposed to air pollutants such as dust, PM, CO, CO₂ and other toxic gases from vehicle fumes. Toxic smoke from inorganic compounds released from burning of metals at the e-waste dumpsite, are also released into the environment. These pollutants when inhaled into the lungs may generate inflammatory reactions resulting in respiratory symptoms and prolonged exposure results in respiratory health disease such as COPD, lung cancer and asthma. Also, variables such as duration of exposure, smoking status and past medical history of respiratory disease can account for respiratory health. A conceptual framework of the study is presented in Figure 1.0;
Figure 1.0: Sources and type of ambient pollution and the possible health effects

M A R K E T A C T I V I T I E S

Vehicle traffic

Trash burning

Open pit burning

Dust
PM2.5, PM10

Toxic smoke

Ambient air pollution pollutants
Inorganic metal, heavy metals, PCBs,
dioxin (CO2, NOx), CO, fumes

Direct inhalation

Respiratory symptoms
Cough, wheezing, breath

Prolonged exposure

Other variables
Duration of stay in the work environment.
Medical history of respiratory health.
Smoking status

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1.4 Justification

This study was to determine the prevalence of respiratory symptoms and lung function among market women in Agbogbloshie market. These individuals are people with low socio-economic status who work hard daily in the market for their livelihood. The nature of their daily activities expose them to several occupational and health hazards, due to direct inhalation of air pollutants from several sources, which could have an impact on their respiratory health and lower quality of life in the long term. Besides the direct impact of market activities, the market is in proximity to a notorious open e-waste recycling dumpsite, not to mention exposure to hazardous fumes from vehicular pollution.

Although few studies have looked at the health conditions of electronic waste (e-waste) workers, there is a general lack of data on respiratory health conditions among market women in Ghana.

Findings in this research will reposition the Environmental Protection Agency (EPA), Ghana to work more on effective preventive health policies to address environmental causes of respiratory diseases and injury.

1.5 Research questions

- Are sedentary market women at Agbogbloshie exposed to high levels of air pollutants (PM or CO₂) and therefore at a high risk of respiratory symptoms?
- What is the prevalence of respiratory symptoms among market women?
- Do market women have reduced pulmonary function due to exposure to ambient pollution?
- What is the relationship between respiratory symptoms and pulmonary function measurements?
1.6 Study objectives

1.6.1 General objective

To assess the effect of ambient air pollution on the respiratory health of market women at the Agbogbloshie open food market.

1.6.2 Specific objectives

- To determine the knowledge of market women on common environmental hazards.
- To determine the prevalence of self-reported respiratory symptoms among market women.
- To assess the lung function of market women by spirometry.
- To determine the daily ambient air concentrations of carbon dioxide and particulate matter at the market.
- To determine the association between respiratory symptoms and pulmonary function measurements.
CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Ambient air pollution and respiratory health

According to the World Health Organization (WHO) air pollution is the contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution. Pollutants of major public health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide (WHO, 2016).

It is well known that exposure to high levels of air pollution can adversely affect human health (Ren & Tong, 2008). Most studies conducted in populations of developed countries, where air pollutant levels were lower than developing countries (e.g. China) examined the short-term effects of relatively high outdoor air pollutant level on lung function alteration among school children or college students, the effects of high air pollution level exposure reported that it is still unclear among adults, also the association between air pollution and lung function is inconsistent (Wei, Goa, Wang, Zhou, H. & Lu, et al., 2015).

Most studies reported that the negative association could be weak or absent, a study in Brazil reported that a cumulative adverse effects on lung function, whether the effects of different pollutant levels on lung function are different is still unknown (Zhou et al., 2016). Respiratory diseases such as chronic Obstructive Pulmonary Diseases (COPDs), however, still remain one of the leading causes of mortality and disease burden globally and the role of air pollution is irrefutable (Naddafi et al., 2012).
2.2 Health risk of E-waste management and recycling activities

Electrical and electronic waste (e-waste), is a fast growing solid waste stream. According to the World Health Organization, about 40 million tons of e-waste are created globally each year. E-waste is a source of a variety of materials that can be recovered and brought back into the production cycle. Over 1,000 different chemicals are identified in the e-waste streams due to heavy metals and a number of plastics components that are burnt openly to extract valuable metals, because of the heterogeneous composition of these materials, recycling them safely is complex and can require a high level of skill. Particulate matter (coarse and fine particles) from dismantling activities ashes from burning activities, fumes from “cooking”, DE soldering, and other burning activities leads to evaporation of toxic substances (WHO, 2013), other pollutants released into the air that may affect the health of children and adults in the environment, including lead, mercury, benzene and nickel can be harmful to children's development. Others, like nickel and benzene, are associated with cancer (Fung, K. Y. K. Y., Luginaah, I. N. I. N., Gorey, K. M. K. M., 2007).

One of the primary activity of concern from a public health perspective is the burning of sheathed cables to recover the copper material inside and Styrofoam packaging being used as a fuel to burn the material in the open (Pure Earth, 2015). According to the New African Journal, not many residents of Ghana’s capital, Accra go to the Agbogbloshie market but their health is sure to suffer from the toxic – laden smoke that spew into the atmosphere every day from the Agbogbloshie dump.

2.3 Respiratory health risk of dust

Market activities produce dust which has harmful effects on respiratory health of traders. Dust is any solid matter that is produced during processes such as rock disintegrations and any construction activities which is borne by air. Exposure to dust is an occupational hazard, especially
in the market where variety of trading activities take place. Dust particles have been associated with the development of occupational asthma and chronic obstructive pulmonary diseases (Brunekreef, 2005).

A hospital-based case-control study of 300 subjects in Sri Lanka found that the presence of dust at home was a significant risk factor for asthma also episodes of bronchitis, emphysema and other chronic obstructive pulmonary diseases had a strong association with PM10. Nearly 20% of Asthma patients who visited the Lady Ridgeway Hospital for Children in Colombo in 2005 could be attributed to exposure to PM10 based on the health impact assessment software developed by WHO (Nandasena et al., 2010).

When dust is inhaled, the amount that is retained in the lungs depends on the chemical and physical properties of the dust particle, size, and where the particles are deposited in the respiratory tract (Schwarze, Ørvik, Hetland, Becher, Cassee, Refsnes et al., 2008). This suggests that market women are at risk of developing dust induced respiratory problems since they inhale these particulate matter as they go about their daily trading activities.

2.4 Vehicular emissions (Carbon monoxide)

In Ghana, several reports have been published linking environmental pollution to adverse population health in various cities. Reports from the EPA have consistently shown that vehicle exhaust fumes forms a major source, forming 72 percent of all carbon monoxide (CO) emissions in terms of environmental exposure and its potential effects. Agbogbloshie market women are exposed to repeated episodes of short-term and long-range transport of air pollutants due to constant vehicle activities, and the closeness of the market to a major road.
Being in proximity to heavy traffic is increasingly being linked to adverse health outcomes, such as asthma, reduced respiratory function, adverse birth outcomes, and cardiovascular disease (Quintana, Dumbauld, Garnica, Chowdhury, Velascosoltero, P.J.E., et al., 2014). Individuals who live, work, attend school or commute in areas with high traffic density may be exposed to elevated levels of several of traffic-related pollutants, though exposure at any location is a function of multiple external factors, of which one of the most important is distance from major roads. Meteorological factors including wind speed and direction, humidity, solar radiation, and temperature are also important determinants of localized concentrations of air pollutants (Quintana et al., 2014).

Transported air pollution is characterized by gaseous pollutants (CO) and concentrations of particles. Many environmental pollutants such as particulate pollutants resulting from the heavy traffic on highways can be carried a long way by winds, affecting areas even far removed from the source of the pollution (Fung et al., 2007).

2.5 Respiratory Health effects of PM$_{2.5}$, PM$_{10}$

Particulate Matter (PM) is the sum of all solid and liquid particles suspended in air, many of which are hazardous. This complex mixtures includes both organic and inorganic particles, such as dust, pollen, soot, smoke and liquid droplets. The association between inhaled particulate matter (PM$_{10}$, PM$_{2.5}$), that is, particles with aerodynamic diameter $\leq 10$ µm, 2.5 µm respectively, and harmful health effects is a relevant public health problem that has been widely documented in epidemiological studies carried out in various parts of the world. The World Health Organization (WHO) recommends that the average annual ambient PM$_{10}$ level be $<20$ µg/m$^3$ and PM$_{2.5}$ $<10$ µg/m$^3$ (Nandasena et al., 2010).
Particulate matter (PM) is classified as coarse (PM$_{10}$) or fine (PM$_{2.5}$) particles, which allows for its deposition in several parts of the respiratory system. PM less than or equal to 10 micrometers in diameter are so small that they can easily get inhaled into the lungs causing serious health problems when one is exposed to high levels. Burning of metals which produces hazardous smoke and dust are all sources of ambient air pollution and particulate exposure (Ferreira, Forti, de Freitas, Nascimento, Junger, Gouveia, et al., 2016). Harmful effects are associated with the various PM$_{10}$ fractions, among the chemical constituents that appear to pose greater risks to health are those derived from the burning of biomass and fossil fuels. Some studies suggest that the risk PM$_{10}$ poses to health is due to toxins produced from burning metals, this reinforces the need to assess the impact of its pollution on health among Agbogbloshie market women due to the proximity of the market to the electronic waste scrapyard.

This study therefore investigated concentration PM$_{2.5}$ and PM$_{10}$ in the market and the associations between PM (dust, smoke) and respiratory symptoms among market women.

Figure 2.0: Picture showing Agbogbloshie market, 2017
CHAPTER THREE

3.0 METHODOLOGY

3.1 Overview

This outlines the methods used in this study. It gives a description of the study area, study design, study procedures, sampling procedure, data collection tools, data analysis and ethical considerations.

3.2 Study area

Agbogbloshie is a former wetland and suburb of Accra, and a known destination for both locally generated and imported out of use and old electrical and electronic equipment. Agbogbloshie is also home to a large open food market for mainly onions and yams brought from the Northern part of Ghana for sale. The trading center can be located on the Abossey-Okai road behind the electronic waste dumpsite. The Agbogbloshie market is surrounded by the Agbogbloshie Township, known as Old Fadama or Sodom and Gomorrah and a variety of companies.
Figure 3.0: Map of Agbogbloshie: Source: www.environmentandsociety.org
3.3 **Study Design**

An analytic cross-sectional quantitative study design was carried out from June to July 2017 to assess the prevalence of respiratory symptoms among market women using a structured questionnaire and pulmonary function test by a professional medical doctor using spirometer. Ambient air concentration measurements were taken for PM$_{2.5}$ and PM$_{10}$ and CO$_2$. An interpreter was employed to facilitate translation of the questionnaire which was in English to the local Ga language.

3.4 **Dependent variables**

- Respiratory symptoms including cough, phlegm production, cold, sore throat, breathlessness, chest pain, wheezing, itchy ear, itchy eyes and throat, chest tightness and difficulty in breathing.

- Lung function measurements (e.g. Forced Expiratory Volume in one second (FEV$_1$), Forced Vital Capacity (FVC), Forced Expiratory Volume in one second percentage predicted (FEV$_1$ (%Pred.) and the ratio of Forced Expiratory Volume in one second and Forced Vital Capacity (FEV$_1$/FVC).

3.5 **Independent variables**

- These included the age of the woman, marital status, level of education, smoking status, alcohol use, past medical history of respiratory illness, exposure to hazards in the market environment and blood pressure.

3.6 **The confounding factors** include: age of respondents, cigarette smoking, alcohol intake, educational level, marital status and respiratory condition such as asthma.
3.7 Study Population

The study population was the entire market women in Agbogbloshie market who were engaged in the selling of variety of items mostly onion, yams and tomatoes.

3.8 Community entry

Initial community entry was done by talking to personnel at the local Accra Metropolitan Assembly office, secretary of the onion sellers union as well as selected market queen mothers before participants were recruited for the study.

3.9 Data collection

Anthropometric measurements (weight and height), as well as blood pressure were taken. Finally, each study participant was made to perform a lung function test by spirometry which was administered by a qualified physician. Eligibility criteria for study participation included willingness to participate in the study, signing or thumb printing of a consent form and working as a trader in the market for at least 6 months. Those who were unwilling to give consent or had any medical or surgical contraindications were excluded from the study.

3.10 Sampling procedure

Although a Global Positioning System (GPS) coordinates were not taken, the market was divided into three (3) sections along the total stretch of the market, and a total of five (5) women were randomly selected from each section, making a total of forty five (45) women. Each woman after selection was sent to a mobile clinic set up at the Accra Metropolitan Assembly (AMA) office, and then the questionnaire was administered by trained research assistants who could communicate in the language best understood by the market women with focus on respiratory health, lifestyle, perceived workplace hazards etc.
3.11 Determinants and outcomes of interest

The outcomes of interest were indices of lung function (e.g. FEV₁, FVC, FEV₁% Pred., FEV₁/FVC) and respiratory symptoms including cough, cold, sore throat, repeated sneezing, phlegm production, shortness of breath, chest pain, wheezing, itchy ear, watery eyes, itchy throat, difficulty in breathing and chest tightness. The determinants of interest were levels of ambient air pollutants (PM₂.₅, PM₁₀, and CO₂).

3.12 Data collection Tools

The data collection tools are: questionnaires, spirometer for measuring lung function, carbon dioxide monitors, particulate matter (PM) monitors to measure particulate matter and carbon dioxide pollutant concentration in the market, a blood pressure monitor, a weighing scale and a stadiometer for standing height measurement.

3.13 Questionnaire

The interview questionnaire used were subdivided into four parts. The first part, section (A) gathered the socio-demographic information of the study participants, section (B) focused on the respondent's years of trading at the market, hazard exposure in the work environment, and use of PPE. The third part, section (C) enquired about past respiratory illness and respiratory symptoms and finally section (D) focused on questions about their habits and lifestyle.

3.14 Measurement of pulmonary function

A portable pulse oximeter spirometer was the equipment used to assess pulmonary function (FVC, FEV₁, FEV₁ (%Pred.) and FEV₁/FVC ratio). The spirometer is a portable, easy to read and use, rechargeable, battery powered equipment with disposable mouthpieces. The spirometer was used
in conjunction with a height measure, weighing scale for the measurement of weight and height required for performing accurate spirometry.

Lung function measurements were performed according to the guidelines of the American Thoracic Society/ERS (1995). Standing height in meters and weight in kilograms were measured prior to the performance of the lung function test. The stadiometer was used to measure height of the participants in the standing position without shoes on and the shoulders in an upright position. After data entry, the participants were assisted to perform maneuvers for measuring forced vital capacity, vital capacity and maximum ventilation volume. Computation of lung function volumes were based on variations in the height, weight, sex and ethnicity of respondents.

3.15 Particulate matter and carbon dioxide monitoring

To effectively determine the particulate matter and carbon dioxide concentrations the market women are exposed to, some monitors were used to measure these variables. The monitors are the Aerocet Comet 860 and the Hobo CO₂ monitor. Three points were chosen namely Point 1 (50 meters into the onion market), Point 2 (midpoint of the market) and Point 3 (50 meters before the exit of the market). These points were within 2 km of each other and stretched by the length of the Agbogbloshie market. The study participants were distributed around these points. At Point 1 and 3, a Comet Aerocet and Hobo CO₂ monitor were launched. Point 2 only had a CO₂ monitor. Figure 3.1 shows the positions of these points along the stretch of the Agbogbloshie market.
3.16 Quality control

The following measures were undertaken to ensure that the data collected were of superior quality so as to assure its validity: two research assistants with at least secondary school education were trained in administering questionnaires and trained to conform to the ethical guidelines of the study. The spirometer was disinfected daily and kept dry and clean.

3.17 Data analysis

The data were cross-checked to identify missing values and to correct inconsistencies in the data.

Data entry was done using Microsoft excel version 2013.

For continuous variables, means and standard deviations were computed and for categorical variables proportions were computed also. Association was drawn to ascertain relationship

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between dependent and independent variables. Chi-square was used to assess association between ambient pollutants and respiratory symptoms, multiple linear regression was used to find the association between lung function indices, alcohol use and respiratory symptoms and Spearman’s correlation analysis was used to test for strength of association between lung function measurements, age and blood pressure values. Lung function parameters were computed to find their means and standard deviation. A p-value of 0.05 was used for measure of associations. All data analyses were undertaken using STATA software version 14.1.

3.18 Ethical considerations

Ethical clearance was sought from the Ghana Health Service Ethical Review Committee. Permission was also sought from Environmental Protection Agency (EPA), Ghana and Accra Metropolitan Assemble (AMA), Ghana. A written and oral consent was sought from all the study participants after handing out an information leaflet to be read with thorough explanation. The information leaflet which contained information about the benefits, risks, and the procedures involved in the research was read out and explained to each participant before the appended their signature or thumbprint. They were at liberty to ask questions, and to seek clarifications or withdraw from the study unconditionally. Find attached consent form in appendix 5. Refer to ethical approval.
CHAPTER FOUR

4.0 RESULTS

4.1 Socio-demographic characteristics of participants

A total of 45 healthy market women were recruited for the study. The age of market women ranged from 19 years to 81 years with approximately 46.6% (21/45) below 39 years. They were all engaged in the selling of various items on the market and usually work from 6 to 12 hours daily for 5 to 7 days in a week. Most N (60%) were married, and a third, 36% (16/45) had no formal education whereas 64% (29/45) had primary or secondary education. None of the women smoked cigarette, and only (17.8%) were alcohol users. The socio-demographic characteristics of study participants is shown in Table 4.1:
Table 4.1: Demographic characteristics of market women (n=45)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency (N=45)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;30</td>
<td>10</td>
<td>24.4</td>
</tr>
<tr>
<td>30-39</td>
<td>11</td>
<td>22.2</td>
</tr>
<tr>
<td>40-49</td>
<td>9</td>
<td>20.0</td>
</tr>
<tr>
<td>50-59</td>
<td>6</td>
<td>13.3</td>
</tr>
<tr>
<td>&gt;50</td>
<td>15</td>
<td>33.3</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>27</td>
<td>60.0</td>
</tr>
<tr>
<td>Single</td>
<td>18</td>
<td>40.0</td>
</tr>
<tr>
<td><strong>Level of education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No formal education</td>
<td>16</td>
<td>36.0</td>
</tr>
<tr>
<td>Primary</td>
<td>18</td>
<td>40.0</td>
</tr>
<tr>
<td>Secondary</td>
<td>11</td>
<td>24.0</td>
</tr>
<tr>
<td><strong>Alcohol use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None user</td>
<td>37</td>
<td>82.2</td>
</tr>
<tr>
<td>User</td>
<td>8</td>
<td>17.8</td>
</tr>
<tr>
<td><strong>Cigarette smoking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None user</td>
<td>45</td>
<td>100.0</td>
</tr>
<tr>
<td>User</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
4.2 Number of years respondent had worked at Agbogbloshie

Most of the participants N (71.1%) have been traders at the market for more than 4 years as shown in Figure 4.1 below:

**Figure 4.1: Number of years worked at the market**
4.3 Exposure of participants to hazards in the market

Figure 4.2 below is a summary of reported environmental hazards participants are exposed to daily at the market. These hazards were (dust, smoke, heat, fumes). Majority of respondents (95.6%) reported they were exposed to dust, (75.6%) said they were exposed to smoke, 73.3% and 64.4% of respondents said they were exposed to heat and fumes respectively.

![Bar Chart of Exposed Market Women to Hazards]

**Figure 4.2: Exposure of market women to hazards**
4.4 Prevalence of respiratory symptoms present among market women

Respiratory symptoms experienced among market women is presented in Figure 4.3 below:

All the respondents complained of cough, colds, sore throat, easily tiredness and repeated sneezing. However, symptoms such as wheezing, chest tightness, shortness of breath and difficulty in breathing were not common among respondents.

Figure 4.3: Respiratory symptoms (self-reported) among market women
4.5 Chronic Respiratory Illnesses among Agbogbloshie market women

The participants recruited for the study were asked whether they have been diagnosed of any chronic respiratory illness. Only 7 participants answered in the affirmative of being diagnosed and confirmed by a medical doctor with chest infection. This is shown in Table 4.2 below:

Table 4.2: Respiratory illness among Agbogbloshie market women

<table>
<thead>
<tr>
<th>Variable</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic Respiratory Illness</td>
<td>44</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>Diagnosis by Doctor</td>
<td>7</td>
<td>38</td>
<td>45</td>
</tr>
<tr>
<td>Illness made worse by work</td>
<td>42</td>
<td>3</td>
<td>45</td>
</tr>
<tr>
<td>Use of PPE</td>
<td>10</td>
<td>35</td>
<td>45</td>
</tr>
</tbody>
</table>

4.6 Associations between respiratory symptoms and ambient air pollutant exposure

Chi-square tests was used to explore the relationship among symptoms and hazard exposures. The p- values revealed that there was no associations between respiratory symptoms and hazard exposures and hence no correlation between the study variables, although percentage differences were a bit wide in some instances. Table 4.3 shows the Chi-Square of association for respiratory symptoms and ambient air pollutants:
Table 4.3: Association between respiratory symptoms and ambient air pollutant exposure

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>% with symptoms within each exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dust</td>
</tr>
<tr>
<td></td>
<td>p=0.347</td>
</tr>
<tr>
<td>Cough</td>
<td>53.49</td>
</tr>
<tr>
<td>Cold</td>
<td>69.77</td>
</tr>
<tr>
<td>Prolonged or repeated sneezing</td>
<td>41.86</td>
</tr>
<tr>
<td>Tiredness</td>
<td>58.14</td>
</tr>
<tr>
<td>Chest pain</td>
<td>44.19</td>
</tr>
<tr>
<td>Sore throat</td>
<td>97.67</td>
</tr>
<tr>
<td>Excessive phlegm</td>
<td>76.74</td>
</tr>
<tr>
<td>Itchy ears and throat</td>
<td>62.79</td>
</tr>
<tr>
<td>Itchy and watery eyes</td>
<td>51.16</td>
</tr>
<tr>
<td>Wheezing</td>
<td>34.88</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>25.58</td>
</tr>
<tr>
<td>Difficulty in breathing</td>
<td>16.28</td>
</tr>
<tr>
<td>Chest tightness</td>
<td>27.91</td>
</tr>
</tbody>
</table>
4.7 Pulmonary function test results of market women

The results of pulmonary test values showed an average of 0.75 (FEV₁/FVC) have airflow obstruction with a minimum of 0.47 and a maximum of 1.00 participants. % Pred. (FEV₁) showed an average mean of 77.8% of participants may suffer from COPD.

Pulmonary function test results of participants is shown in Table 4.4 below:

Table 4.4: Summary of mean values of pulmonary function test

<table>
<thead>
<tr>
<th>Lung function parameters</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Mini.</th>
<th>Maxi.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>2.4004</td>
<td>0.6878</td>
<td>0.96</td>
<td>4.58</td>
</tr>
<tr>
<td>FEV₁ (L/s)</td>
<td>1.7811</td>
<td>0.5027</td>
<td>0.59</td>
<td>3.06</td>
</tr>
<tr>
<td>FEV₁/FVC</td>
<td>0.7502</td>
<td>0.1135</td>
<td>0.47</td>
<td>1.00</td>
</tr>
<tr>
<td>% Pred. (FEV₁)</td>
<td>77.800</td>
<td>20.6195</td>
<td>42</td>
<td>139</td>
</tr>
</tbody>
</table>

FEV₁/FVC measures volume exhaled per second per volume inhaled.

4.8 Lung function measurements: FEV₁ (% Pred.) that revealed COPD

Pulmonary function measures of FEV₁ (% Pred.) revealed majority of respondents (53.3%) suffer from moderate Chronic Obstructive Pulmonary Disease (COPD) and about (4.4%) showed symptoms of severe COPD as shown in Figure 4.4:
4.9 Association between lung function (FEV₁, FVC, FEV₁/FVC), blood pressure and Age

A correlation analysis was conducted to test the strength of potential linear relationships between lung function test measurements, blood pressure and age of respondents.

Obviously there was significant positive correlation of 76.1% (p<0.001) between FEV₁ and FVC. Systolic blood pressure had a significant negative correlation of 50.6% (p<0.001) with FVC, and diastolic blood pressure had a positive correlation of 25.6% (p=0.090) with FVC.

There was a negative correlation of 39.8% (p=0.007) between Age and FVC and a positive correlation with systolic blood pressure of 41.2% (p=0.005).
<table>
<thead>
<tr>
<th></th>
<th>FVC</th>
<th>FEV₁</th>
<th>FEV₁/FVC</th>
<th>Systolic BP</th>
<th>Diastolic BP</th>
<th>Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV₁</td>
<td>0.761</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p=0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV₁/FVC</td>
<td>-0.237</td>
<td>0.360</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p=0.117</td>
<td>p=0.015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic BP</td>
<td>-0.506</td>
<td>-0.502</td>
<td>-0.020</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p=0.000</td>
<td>p=0.000</td>
<td>p=0.897</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diastolic BP</td>
<td>-0.256</td>
<td>-0.174</td>
<td>0.141</td>
<td>0.577</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p=0.090</td>
<td>p=0.252</td>
<td>p=0.354</td>
<td>p=0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.398</td>
<td>-0.375</td>
<td>-0.117</td>
<td>0.412</td>
<td>0.250</td>
<td>1.000</td>
</tr>
<tr>
<td>(years)</td>
<td>p=0.007</td>
<td>p=0.011</td>
<td>p=0.444</td>
<td>p=0.005</td>
<td>p=0.097</td>
<td></td>
</tr>
</tbody>
</table>

### 4.10 Association between lung function, respiratory symptoms and alcohol use

A multiple linear regression was conducted to ascertain the effect of respiratory symptoms and alcohol use on lung function. There was no significant relationship from the p-values for cough, sneezing, wheezing, shortness of breath, and chest tightness when unadjusted. After adjusting for the joint effects of these variables, traders who were alcohol users had an average lung function of 0.122 (12.2%) less than those who did not, p=0.005.

An increase in the frequency of wheezing also led to an average reduction in lung function of 0.081 (8.1%) and this was also significant (p=0.020). Increases in the frequency of difficulty in breathing obviously also led to an average decrease in lung function of 0.133 (13.3%) which was also significant (p=0.024). Presence of the other respiratory symptoms did not affect lung function after adjusting.
The variability in lung function explained by the variables in the model was about 29.35% (adjusted R-squared = 0.2935).

Table 4.6: Multiple linear regression of lung function on alcohol use and symptoms

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean difference (95% CI)</th>
<th>p-value</th>
<th>Mean difference (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted</td>
<td></td>
<td>Adjusted</td>
<td></td>
</tr>
<tr>
<td>Alcohol</td>
<td>-0.102 (-0.187, -0.017)</td>
<td>0.019</td>
<td>-0.122 (-0.205, -0.039)</td>
<td>0.005</td>
</tr>
<tr>
<td>Cough</td>
<td>-0.053 (-0.012, 0.014)</td>
<td>0.118</td>
<td>0.063 (-0.015, 0.142)</td>
<td>0.109</td>
</tr>
<tr>
<td>Sneezing</td>
<td>-0.018 (-0.088, 0.051)</td>
<td>0.593</td>
<td>0.043 (-0.038, 0.125)</td>
<td>0.289</td>
</tr>
<tr>
<td>Wheezing</td>
<td>-0.019 (-0.088, 0.051)</td>
<td>0.593</td>
<td>-0.081 (-0.148, -0.013)</td>
<td>0.020</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>-0.029 (-0.090, 0.032)</td>
<td>0.348</td>
<td>0.064 (-0.029, 0.158)</td>
<td>0.173</td>
</tr>
<tr>
<td>Difficulty in breathing</td>
<td>-0.074 (-0.136, 0.012)</td>
<td>0.020</td>
<td>-0.133 (-0.248, -0.018)</td>
<td>0.024</td>
</tr>
<tr>
<td>Chest tightness</td>
<td>-0.048 (-0.107, 0.012)</td>
<td>0.113</td>
<td>0.016 (-0.086, 0.117)</td>
<td>0.758</td>
</tr>
</tbody>
</table>

Adjusted R-squared = 0.2935

4.11 Concentration of Particulate Matter (PM$_{2.5}$) and (PM$_{10}$)

Particulate matter (PM) concentrations were monitored at three points in the Agbogbloshie market for 8 hrs. Concentrations for PM$_{2.5}$ were high in the morning around 10am and in the evening from 2 pm to 6 pm, PM$_{10}$ recorded variations in concentrations which were also high. The market exit (Point 2) also showed high concentrations of PM$_{2.5}$ and PM$_{10}$ as shown in Figures 4.5 and 4.6:
Figure 4.5: Graph of PM levels at Point 1 (entrance)

Figure 4.6: Graph of PM levels at Point 3 (exit)
4.12 Concentration of carbon dioxide (CO₂)

Carbon dioxide monitors measured concentrations at three locations in the market around where the study participants were distributed. The entrance to the market (Point 1) recorded a high concentration of 3587.62 ppm around 6 pm. The market exit (Point 3) recorded about 3635.22 ppm at the same time. Variation in these concentrations are shown in Figures 4.7, 4.8 and 4.9 below:

![Hourly average of CO2 (ppm)](image)

**Figure 4.7: Graph of CO₂ level at Point 1(entrance)**

![Hourly averages of CO2](image)

**Figure 4.8: Graph of CO₂ levels at Point 2 (centre)**
Figure 4.9: Graph of CO₂ at point 3 (exit)
CHAPTER FIVE

5.0 DISCUSSION

5.1 Summary of main findings

The study assessed the effect of ambient air pollution on the respiratory health among market women at Agbogbloshie food market. This was achieved by first evaluating the knowledge of these market women on environmental hazards that could impact on respiratory health and prevalence of respiratory symptoms (cough, colds, repeated sneezing, and sore throat). Next, lung function test was performed on each study participant by spirometry to obtain pulmonary function parameters; FVC, FEV₁, FEV₁/FVC and FEV₁ (%Pred.), a predictor of Chronic Obstructive Pulmonary Disease (COPD). Finally, diurnal measurements of ambient air pollutants, particulate matter (PM₁₀ and PM₂.₅), and CO₂ were taken using Aerocet Comet 860 and the Hobo CO₂ monitor.

5.2 Knowledge of air pollutants, prevalence of respiratory symptoms and lung function among market women

Most market women were aware of air pollutants in their environment, they knew that dust, smoke and vehicular fumes could affect their respiratory health. Responses from these women showed that 95.6%, 75.6% and 73.3% were exposed to dust, smoke and vehicular fumes respectively. However, majority (77.8%) had never used any form of personal respiratory equipment (PPE) to protect themselves from exposures. The most commonly self-reported respiratory symptoms were cough, colds, repeated sneezing, sore throat and few cases of shortness of breath, wheezing and chest pains in participants who were all nonsmokers. There was a high prevalence in cough and excessive phlegm production and repeated sneezing and a low prevalence in wheezing, and chest
tightness. A similar study on respiratory health effects of ambient air in a fabrication company also showed a prevalence of chronic cough and chronic phlegm, in nonsmokers, but there was also prevalence of chronic wheeze and chest tightness 36.0% and 50.5%, respectively. Employment in the fabrication company was said to be associated with patterns of obstructive air flow limitation and respiratory symptoms and consistent with exposure to pulmonary irritants of dust, and PVC thermal degradation products (Kappos, Bruckmann, Eikmann, Englert, Heinrich, et al., 2004).

About 48.9% of study respondents stated that symptoms become better when they were away from their work Caravanos, et al., (2013) also reported a similar finding in their study among the e-waste workers at Agbogbloshie.

The common self-reported respiratory symptoms among the market women were cough, colds, repeated sneezing, sore throat and frequent production of phlegm. Prevalence of respiratory symptoms were higher among respondents who reported frequent exposures to dust and fumes.

For example, a study conducted among women on the use of PPE while engaged in the use of biomass fuel for cooking showed that women working for 1 to 20 hours per week were less likely to wear personal protective equipment (PPE) such as hearing, eye, or breathing protective equipment, women exposed to smoke reported more frequent cough and phlegm, but with minimal average adverse changes in lung function (Regalado, Sansores, Brauer, Vedal, Pérez-Padilla, et al., 2006).

A similar study by Gorkeh-Miah et al., (2008) on the use of PPE reported only 25% of the farmers were concerned about respiratory risks, the use of a dust mask or respirator however decreased respiratory symptoms significantly, from 54% in 1993 to 37% in 2004.
A study conducted on lung function reduction and chronic respiratory symptoms among workers in the cement industry reported respiratory symptoms such as chest pain, cough, running nose, wheezing, difficulties in breathing, shortness of breath, and irritation of the throat were reported, among the dust-exposed subjects were corresponding respiratory illnesses including cough (22.0%), chest tightness (17.0%) and shortness of breath (30.0%). Subsequently, it was concluded that exposure to occupational dusts results in the development of respiratory illness (Eagan, Bakke, Eide, Gulvik, Qaderi, et al., 2002).

Average lung function indices for market women in the study were; FVC (2.4±0.69), FEV$_1$ (1.8±0.50), FEV$_1$/FVC (0.8±0.11), FEV$_1$ %Pred. (77.8±20.61). Most of the parameters recorded were low compared to the 2004 American Thoracic Society (ATS)/ European Respiratory Society (ERS) criteria (Normal: FEV$_1$/FVC: ≥0.70 and FEV$_1$ (% pred.) for COPD stages; normal: ≥ 85%; mild: ≥ 80%; moderate: 50% -80% and severe :< 50%) revealing possible lung function abnormalities among market women. However, there were no significant relationship between respiratory symptoms and lung function indices.

Most studies have reported findings on the inhalation of ambient particulate matter such as dust results in their interaction with lung cells, leading to lung pathology. The Global Initiative for Chronic Obstructive Lung Disease (GOLD) working group criteria of forced expiratory volume in 1 second (FEV$_1$)/forced vital capacity (FVC) less than 70 percent and FEV$_1$ percent predicted %Pred. less than 80 was used to interpret lung function parameters. There was a high risk of COPD among participants in the present study (4.4%) with approximately severe COPD indices and 53.3% with moderate COPD range. Also the study reported about 31.0% with values that showed presence of air flow obstruction. Several general population based studies also reported associations with specific occupational exposures. A study conducted in Tucson, Arizona, found
an association between airflow obstruction and self-reported exposure to automobile exhaust, and
collection work. Furthermore, a six city study in the united states found associations of chronic
respiratory symptoms and COPD with working with dusts, fumes, and gases (Kappos et al., 2004).

5.3 Diurnal levels of particulate matter (PM$_{2.5}$, PM$_{10}$) and carbon dioxide (CO$_2$)
Particulate matter, PM$_{2.5}$ and PM$_{10}$ measurements were calculated based on two endpoints (entry
and exit) in the market for 8 hours during the study period in June. Concentrations of PM$_{10}$ and
PM$_{2.5}$ exceeded recommended WHO permissible exposure limits for annual/daily averages of
(20µg/m$^3$-50µg/m$^3$) for PM$_{10}$ and (10 µg/ m$^3$ - 25 µg/ m$^3$) for PM$_{2.5}$. Also, in Ghana recommended
values for monthly/daily averages at industrial / commercial areas has a maximum limit of 500 µg/
m$^3$ /260 µg/ m$^3$ for PM$_{10}$. Other ambient particle concentrations for PM$_{10}$ and PM$_{2.5}$ for instance
in Germany are in the range of 10 – 45 (10 – 30) µg/m$^3$ as annual mean and 50 – 200 (40 – 150)
µg/m$^3$ as maximum daily mean. With regards to CO$_2$ the normal background concentration for
outdoor ambient air is 250ppm - 350ppm.

Levels of PM$_{2.5}$, PM$_{10}$ and CO$_2$ were significantly higher, above the recommended limits. Indeed
during the course of this study, smoke from open air burning and vehicular emissions as well as
dusty conditions were observed, which is reflected in the rise and fall of the curves shown in the
PM and CO$_2$ graphs. PM$_{2.5}$ can travel directly into the alveoli in the lung and cause damage. It is
however predicted that the values recorded in the study will be higher in the dry season since the
study was conducted during the raining season.

A study by Zhang et al., (2017) on the effects of exposure to carbon dioxide and bio effluents on
perceived air quality with health and other human outcomes found that the association of CO$_2$
concentration and ventilation rates were statistically significant in worsening one or more
respiratory health conditions.
Many epidemiological and toxicological studies on health effects of particulate matter (PM) have suggested association between long-term exposure and elevated cardiovascular or respiratory symptoms and impaired immune function. Short-term exposure studies have shown consistent associations of exposure to daily concentrations of PM and morbidity of asthma, COPD, pneumonia and other respiratory diseases (Kampa & Castanas, 2008). The strongest associations were found with PM$_{2.5}$ followed by PM$_{10}$, with no indication of a threshold value for the health effects (Jiřík, Machaczka, Miturová, Tomášek, Šlachtová, et al., 2016). A study on levels and health risk assessment of PM$_{10}$ reported that concentrations are highly correlated with respiratory symptoms, especially in traffic regions. In this study, the diurnal (24-hours) limit was exceeded in several cases. The highest number of cases with a given health outcome was estimated in traffic regions especially for cardiovascular disease, premature mortality, respiratory disease and chronic bronchitis (Bulejko, Adamec, Skeril, Schüllerová, Bencko et al., 2017).

5.4 Relationship between pulmonary function test, respiratory symptoms and blood pressure.

A study conducted by Menzies, et al., (2006) reported sustained and significant improvements were observed in the spirometry data for asthmatic and no asthmatic participants after introduction of the smoke free policy. A number of previously published studies have also reported impaired pulmonary function in adults and children in association with respiratory symptoms. Results in the current study showed a significant relationship for wheezing ($p=0.020$) and difficulty in breathing ($p=0.024$).

In the present study, there was a positive correlation of systolic blood pressure ($p<0.001$) and FEV$_1$, FVC. Also, diastolic blood pressure had a positive correlation ($p=0.090$) with FVC this data is in agreement with a study conducted by Selby et al., (1990) on precursors of essential
hypertension: pulmonary function, heart rate, uric acid, serum cholesterol, and other serum chemistries in which pulmonary function tests, several serum chemistries, and heart rate were strongly predictive in univariate analyses. Adjusting for the risk factors (weight gain, alcohol consumption, parental history of hypertension, excessive use of salt, and centralized body fat) forced vital capacity \( p < 0.001 \) remained independently predictive. Forced vital capacity remained a strong, inverse predictor for baseline blood pressure. It was stated that, although the association is presently not understood, forced vital capacity are closely linked to development of hypertension and may be a marker of susceptibility or intermediate steps in pathways leading to hypertension.
CHAPTER SIX

6.0 CONCLUSION, RECOMMENDATIONS AND LIMITATIONS

6.1 Conclusion

In conclusion, the results of the present study showed that respiratory infection symptoms, air flow obstruction and COPD can possibly be due to the effect occupational exposures contribute significantly to the overall burden of COPD.

More research is needed to confirm increased risk of COPD among market workers and to identify causal risk factors. This would help maximize the impact of this research and reduce the prevalence of respiratory symptoms.

Also, there were low pulmonary function tests results, showing a possibility in lung function problems among market women.

There was a high concentration of Particulate Matter values (PM\textsubscript{2.5} : 92 \mu g/ m\textsuperscript{3} -169 \mu g/ m\textsuperscript{3} and PM\textsubscript{10} : 492 \mu g/ m\textsuperscript{3} -1691 \mu g/ m\textsuperscript{3}) and CO\textsubscript{2} values (3053ppm-3635ppm) as compared to standard values from WHO (20\mu g/m\textsuperscript{3} -50\mu g/m\textsuperscript{3} for PM\textsubscript{10} and 10 \mu g/ m\textsuperscript{3} - 25 \mu g/ m\textsuperscript{3} for PM\textsubscript{2.5}), and EPA Ghana standard values for commercial environments which are: 500 \mu g/ m\textsuperscript{3}/260 \mu g/ m\textsuperscript{3} for PM\textsubscript{10} and 250ppm - 350ppm for CO\textsubscript{2} concentration for outdoor ambient air, hence a high risk of developing pulmonary health conditions.
6.2 Recommendations

There is a need for a thorough medical examination and a medical surveillance system for all market women in Agbogbloshie. These programs will ensure early detection and management of respiratory disease conditions.

Given that some cases of Chronic Obstructive Pulmonary Disease may be attributable to occupational exposures, clinicians and health policy-makers should address this potential avenue of chronic obstructive pulmonary disease causation and its prevention.

The provision of recommended PPE is highly recommended. The use of the PPE provided must also be strictly enforced. Education on the effects of ambient air pollutants should be enforced to encourage PPE usage.

Also, a similar study can be conducted during the dry season to measure levels of ambient air pollutants (particulate matter and carbon dioxide) as this study was conducted during the raining season to show a representation of pollutant exposure during that period.

EPA should intervene in ambient air pollutant concentrations of particulate matter and carbon dioxide in the market environment to help reduce its health effects on the market women. This will ensure healthier women and an environment that aids in productivity.
6.3 Limitations

There could be errors in the spirometry measurement, because the procedure depends, to a large extent, on participant’s understanding of the maneuvers and their effort during measurement. However, participants who had difficulty were allowed multiple attempts in order to improve the accuracy of the results.

Secondly, the small sample size thereby, reducing the power of the study to detect any effect.

Also, a wide range of the market for PM and CO₂ monitoring in the market at different locations was not covered to enhance evaluation of the respiratory health burden.

Another limitation of the study is the fact that it’s a cross-sectional design and precludes the determination of a causal relationship.
REFERENCES


**Appendix 1: Hourly averages of PM$_{2.5}$ and PM$_{10}$**

<table>
<thead>
<tr>
<th>Time</th>
<th>PM$_{2.5}$</th>
<th>PM$_{10}$</th>
<th>Time</th>
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<th>PM$_{10}$</th>
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<tbody>
<tr>
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<td>1690.62</td>
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<td>11:00</td>
<td>91.51</td>
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<td>107.45</td>
<td>568.05</td>
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<td>1476.05</td>
<td>12:00</td>
<td>95.05</td>
<td>895.96</td>
</tr>
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</tr>
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<td>712.76</td>
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<tr>
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<td>94.86</td>
<td>567.00</td>
<td>17:00</td>
<td>168.84</td>
<td>1324.86</td>
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<td>827.52</td>
<td>18:00</td>
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<td>1324.86</td>
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</table>

**Appendix 2: Hourly averages of CO$_2$**

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<thead>
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<th>Point 1</th>
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<th>Point 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>CO$_2$(ppm)</td>
<td>Time</td>
</tr>
<tr>
<td>9:00</td>
<td>3053.33</td>
<td>9:00</td>
</tr>
<tr>
<td>10:00</td>
<td>3158.37</td>
<td>10:00</td>
</tr>
<tr>
<td>11:00</td>
<td>3106.72</td>
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<td>12:00</td>
<td>3111.38</td>
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<td>13:00</td>
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</tr>
<tr>
<td>15:00</td>
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</tr>
<tr>
<td>16:00</td>
<td>3587.62</td>
<td>16:00</td>
</tr>
</tbody>
</table>
Appendix 3: Questionnaire

Dear Participant,

We would be very grateful if you would assist in helping us carry out an important study at the School of Public Health at the University of Ghana.

This study will provide you with some helpful work-related health information that will help you to maintain good health.

Could you please help us complete this questionnaire by answering a few questions about yourself, your occupation, respiratory health and medical history? Your participation is vital to the success of this research project.

We would like to assure you that whatever information you give us will be confidential and will be known by only the researchers. The information will be reported in statistical summary form only.

Should you have any questions about the study, or problems with questions in this questionnaire, please do not hesitate to contact the Principal Investigator whose contact information is provided below.

Thank you for you willingness to participate in this important research project.

Ms. Joyce Enyonam Nafrah (Student)

Phone number: 020 148 5021

Email: JoyceNafrah@gmail.com
Firstly, could you please tell us about yourself?

A. General Information

1. In which year were you born? Year ......................

3. What is your current marital status? □ Single □ Married

4. What is your highest level of education? □ No formal education □ Primary □ Secondary

B. The next set of questions is about your work

5b. How long do you stay in the market? .........................

5c. Number of working days .....................

6. How long have you worked in this market? □ 6months -1year □ 2 -4years □> 4years.

7. Does your work expose you to any of the following hazards? Tick (✓) as appropriate

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust</td>
<td></td>
</tr>
<tr>
<td>Smoke</td>
<td></td>
</tr>
<tr>
<td>Heat</td>
<td></td>
</tr>
<tr>
<td>Fumes</td>
<td></td>
</tr>
</tbody>
</table>

9a. Do you think the environment you work can harm your health in any way? □ Yes □ No □ Don't know

9b) If yes please specify how ............................................

9c. Do you wear any personal protective equipment when you are working?

□ Yes □ No □ sometimes
C. This set of questions is about your health in relation to your working environment?

8. Have you had any respiratory illnesses? □ Never □ During childhood □ All the time

8c. Was it diagnosed by a doctor? □ Yes □ No

8d. Is the illness brought on or made worse when you come to the market? □ Yes □ No

9. Do you suffer from any of the following in the course of your work? Please tick (√)

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cough</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prolonged or repeated sneezing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy tiredness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest pains</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sore throat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bringing out excessive phlegm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Itchy ears and throat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Itchy and watery eyes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheezing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shortness of breath</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty in breathing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest tightness</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. Do these symptoms stop when you are away from your work place? □Yes □No

D The next set of questions is about your habits/ lifestyle.

11a. Do you smoke cigarettes? □Yes □No □In the past

12a. Do you take alcohol? □Yes □No □In the past

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

Appendix 4: Clinical examination

Weight ........................................... kg

Height............................................ m

BP ................................................... mmhg

Spirometry

FVC..................................................

FEV1.................................................

FEV1/FVC........................................

FEV1 (% Pred.).................................
Appendix 5: Informed Consent

Title: The effect of ambient air pollution on the respiratory health of market women at Agbobloshie food market in Accra, Ghana.

Principal investigator: Joyce Enyonam Nafrah

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

General information about the research

This research is being conducted to assess the respiratory health and lung function of market women in Agbobloshie market. The entire research will over a 3-month period.

The market environment exposes them to dust particles, fumes from vehicles and inorganic metal pollution which are injurious to human health.

The study is purely an academic exercise and it forms part of the researcher’s work towards the award of a Master of Public health.

Possible risk or discomfort

There are no major risks associated with participating in this study. The procedures involved in this study are non-invasive and will not cause any discomfort to the participants. However, a few participants may experience slight dizziness during the lung function measurement.

Description of level of research burden

Study participants would be requested to answer a questionnaire and participant in lung function test.
**Possible benefits**

The benefit to the participants is that, those who require treatment will advised to contact the nearest health facility for treatment. Also, findings of the study will reposition the EPA to work more on effective preventive health policies to address environmental causes of respiratory diseases and injury.

**Confidentiality**

Confidentiality will be assured. The study participants will be assured that all their information will be confidential and will not be disclosed to anyone without their permission.

**Data security**

All information obtained, will be kept in locked files by the principal investigator with secured pass codes.

**Plans for record keeping**

The study materials (data on test results, questionnaires, inform consents) will not be labeled with participant’s names but rather a unique identification number for each study participant.

**Person responsible and phone number**

The person responsible for the data storage will be

**Joyce Enyonam Nafrah (Student)**

School of Public Health, University of Ghana, Legon.

Mobile number: 020 148 5021.

**Voluntary participation and the right to leave the research**
Participating in this research is entirely voluntary. Declining to enter the study, answering a question will have no negative consequences.

Contacts for additional information

Please call the person responsible for this study, Joyce Nafrah on 020 148 5021 if you have questions about the study. If you have any questions about your rights as a research participant or feel you have not been treated fairly, you may contact any of the following:

- GHS/ Ethical Review Committee Administrator, Hannah Frimpong (mobile: 0507041223)

School of Public health, University of Ghana, Legon, for further clarification or redress.
Appendix 6: Consent form

The above document describing the benefits, risks and the procedures for the research title ("The effect of ambient air pollution on the respiratory health of market women at Agbogbloshie food market in Accra, Ghana") has been read and explained to me. I have been given the opportunity to ask questions and all the questions that I have asked about the research have been answered to my satisfaction. I agree to participate as a volunteer.

.......................................................... ..........................................................

Date                                                                                         Signature or Thumbprint of Participant

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 volunteer. All questions were answered and the volunteer has agreed to take part in the research.

.......................................................... ..........................................................

Date                                                                                         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                                                                                         Signature of persons who obtained consent
Ghana Health Service Ethics Review Committee

GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

Research & Development Division
Ghana Health Service
P. O. Box MB 190
Accra
Tel: +233-302-681109
Fax: +233-302-685424
Email: ghserc@gmail.com

Re: Ref. GHS/RDD/ERC/Admin/App/17/521

Ref. No.

Afrah Joyce Enyonam
University of Ghana
School of Public Health
Accra, Ghana

The Ghana Health Service Ethics Review Committee has reviewed and given approval for the implementation of the Study Protocol.

<table>
<thead>
<tr>
<th>IS-ERC Number</th>
<th>GHS-ERC: 67/02/17</th>
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<tbody>
<tr>
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<td>Effect of Ambient Air Pollution on the Respiratory Health of Agbogbloshie Market Women</td>
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<td>Approval Date</td>
<td>24th May, 2017</td>
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<tr>
<td>Expiry Date</td>
<td>23rd May, 2018</td>
</tr>
<tr>
<td>IS-ERC Decision</td>
<td>Approved</td>
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</table>

This approval requires the following from the Principal Investigator:

- Submission of yearly progress report of the study to the Ethics Review Committee (ERC)
- Renewal of ethical approval if the study lasts for more than 12 months
- Reporting of all serious adverse events related to this study to the ERC within three days verbally and seven days in writing
- Submission of a final report after completion of the study
- Informing ERC if study cannot be implemented or is discontinued and reasons why
- Informing the ERC and your sponsor (where applicable) before any publication of the research findings.

Please note that any modification of the study without ERC approval of the amendment is invalid.

The ERC may observe or cause to be observed procedures and records of the study during and after implementation.

Please quote the protocol identification number in all future correspondence in relation to this approved protocol.

SIGNED...

DR. CYNTHIA BANNERMAN
(GHS-ERC CHAIRPERSON)

The Director, Research & Development Division, Ghana Health Service, Accra