SCHOOL OF PUBLIC HEALTH
COLLEGE OF HEALTH SCIENCES
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BIOMASS SMOKE EXPOSURE IN TRADITIONAL SMOKEHOUSES AND RESPIRATORY SYMPTOMS AMONG FISH SMOKERS AT ABOADZE/ABUESI IN THE WESTERN REGION OF GHANA.

BY

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THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PUBLIC HEALTH DEGREE

JULY, 2016

DECLARATION

This is to declare that this is a result of my own research under the supervision of Dr. Reginald Quansah. Other academic works that have been cited were duly acknowledged. This work has not been submitted to this or any other university for any degree.

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DEDICATION

I dedicate this piece of work to the Almighty God and my wonderful family who have always supported me with their prayers, support, advice and love. May God continually bless you.

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ABSTRACT

Background: Exposure to indoor biomass smoke is a major global public health issue affecting about half the world's population. Several studies have associated biomass smoke generated from unvented cook stoves to several diseases including chronic cough, phlegm production, COPD, lung cancer. But very few studies considered women in traditional smokehouses.

Objective: This study assesses the prevalence of self-reported respiratory symptoms, exposure indicators of biomass smoke (i.e. 6-hr personal carbon monoxide (CO), average number of years spent smoking fish and average number of hours spent per day smoking fish) and the association between indicators of biomass smoke exposure and respiratory symptoms among commercial fish smokers in traditional smokehouses at Aboadze and Abuesi in the Western Region.

Methodology: A cross-sectional study was conducted from May to July 2016 among smokehouse helpers. 314 women were recruited during the season and interviewed. Sixty one (61) women were randomly sub-sampled for 6hr-personal CO monitoring.

Results: Self-reported symptoms of chronic cough (72.90%), breathlessness (69.79%), phlegm production (67.65%) and wheezing (61.19%). The average mean 6hr-personal CO exposure was 18.23 ppm (standard deviation: 13.06 ppm). There was an increasing risk of self-reported chronic cough with increasing average number of years of experience in fish smoking (p=0.0459). The prevalence ratio (PR) for 10-18 hrs, 18-25 hrs and >25 hrs were 1.07 (1.00-1.15), 1.15 (1.01-1.32) and 1.24 (1.01-1.52) respectively. The risk of self-reported phlegm production increased with increasing average number of years of experience in fish smoking (p=0.0120). The PR for 10-18 hrs, 18-25 hrs and >25 hrs were 1.10 (1.02-1.18), 1.21 (1.04-1.40) and 1.33 (1.07-1.65) respectively.

Conclusion: In conclusion, this study shows that number of years spent as a fish smoker increased with increasing risk respiratory symptoms. Average number of hours spent in the smokehouse showed an exposure-response relationship with symptoms of wheezing and breathlessness. However, there was no significant association between personal CO exposure levels and respiratory symptoms.

Keywords: Smokehouses, respiratory symptoms, fish smokers, carbon monoxide, Aboadze and Abuesi.

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LIST OF ABBREVIATIONS

ALRIs	Acute Lower Respiratory Infections
AQI	Air Quality Index
ARI	Acute Respiratory Infections
BaP	Benzo[a]pyrene
BMF	Biomass Fuel
CO	Carbon Monoxide
COPD	Chronic Obstructive Pulmonary Diseases
DNA	Deoxyribonucleic Acid
FAO	Food and Agriculture Organization
IAP	Indoor Air Pollution
OSHA	Occupational Safety and Health Administration
PAHs	Polycyclic Aromatic Hydrocarbons
PM	Particulate Matter
TWA	Time Weighted Average
UNDP	United Nations Development Programme
VOCs	Volatile Organic Compounds
WHO	World Health Organization

DEFINITION TERMS

Biomass fuel - This refers to burned plant or animal materials; wood, charcoal, dung and crop residues.

Carbon monoxide (CO) -Carbon monoxide is a colorless, odorless, tasteless gas produced by burning gas, wood, propane, charcoal or other fuel burning with limited oxygen

COPD - Group of diseases that causes airflow blockage and breathing related problems.

Indoor air pollution (IAP) - Indoor air pollution refers to chemical, biological and physical contamination of indoor air.

Particulate matter (PM) - Particulate matter also known as particle pollution or PM is a complex mixture of extremely small particles and liquid droplets suspended in air, many of which are hazardous

Pollutants - A pollutant is a substance or energy introduced into the environment that has undesired effects, or adversely affects the usefulness of a resource

Smokehouse – A structure design for fish smoking

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Cooking and heating with biomass fuels on open fires or on traditional cook stoves results in emissions of high level health-damaging pollutants such as carbon monoxide, nitrogen dioxide, sulfur dioxide ,chlorinated dioxins, arsenic, lead, fluorine and vanadium (Romieu & Schilmann, 2012).Globally, more than 3 billion people, rely on biomass fuel (e.g. wood, crop residues, twigs, shrubs, dried dung, charcoal) to meet their basic domestic energy demands for cooking, lighting and heating (Rehfuess & World Health Organization., 2006).

The World Health Organization (WHO) identified indoor smoke from combustion of solid fuels as one of the top 10 risks for worldwide burden of disease, accounting for 2.7% of the global burden of disease and 2 million pre-mature deaths annually from acute lower respiratory infections, chronic obstructive pulmonary disease, and lung cancer (for coal smoke only), mainly occurring in developing countries (Naeher et al., 2007a).

Several factors have been associated with respiratory health problems and this include but not limited to air pollution, vehicular emissions, climate change, poverty, overcrowding, malnutrition, harmful live practices and life style. Incomplete combustion of biomass fuel indoor emits several pollutants and these pollutants have been associated with several health outcomes. The polluted indoor air contains a range of health- damaging pollutants, such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), volatile organic compounds (VOCs), and particulate matter (Alim et al., 2013). These pollutants are able to cross the alveolar–capillary barrier and penetrate deep into the lungs (Tesfaigzi et al., 2002).

In Ghana, the situation is not different especially, among women involved in fish smoking. Fish smoking invariably, is increasingly becoming a popular method for preserving fish globally. In Ghana, about 5.2% of the female population is involved in commercial fish smoking. This practice is popular along the coastal belt (about 576 km long), stretching from the east in the Volta Region through the greater Accra Region, the Central Region down to the Western Region. Commercial fish smoking is also practiced among women living along riverbanks and lakes. The process of fish smoking combines salting or brining, equilibration, drying on traditional mud ovens and in traditional smokehouses made from bamboo or cement.

In the pits underneath the oven, firewood, generally mangrove wood or any other combustible materials are place and burnt. Smoke then envelopes the hut.

1.2 Problem Statement

Indoor air pollution (IAP), resulting from incomplete combustion of biomass fuel has been associated with several respiratory health problems among women who spend most of their time indoors cooking and their children who play nearby the kitchen (Chen, Hong, Pandey, & Smith, 1990). Biomass fuel burning produces over 200 different chemical compounds, over 90% of which are in the inhalable size range. These include gaseous air pollutants such as carbon monoxide, nitrogen dioxide, sulfur dioxide ,chlorinated dioxins, arsenic, lead, fluorine and vanadium, all of which are toxic to human health (Salvi & Brashier, 2014). A large body of studies have associated indoor biomass smoke to several diseases including respiratory infection in children and exacerbation of inflammatory lung conditions, cardiac events, chronic obstructive pulmonary diseases, asthma, respiratory symptoms, and tuberculosis in adults (Welniak et al., 2015).

Very little is known about the effect of smoke generated in the occupational environment such as in traditional smokehouses on health. Biomass smoke generated in traditional smokehouses differ from that generated from unvented cook stove indoors in several ways: (i) the quantity of smoke generated in traditional smokehouses may far exceed that generated indoors, (ii) the duration of exposure to biomass smoke generated in smokehouses may be longer than that occurring in homes. For example, whereas, a woman and her child may spend 2 to hours in the kitchen, fish smoking in smokehouses may last for more than 8 hours. Health hazards related to occupational air pollution are likely to remain unnoticed in this population. This study will provide insight into levels of smoke generated in smokehouses and the associated health symptoms.

1.3 Conceptual Framework

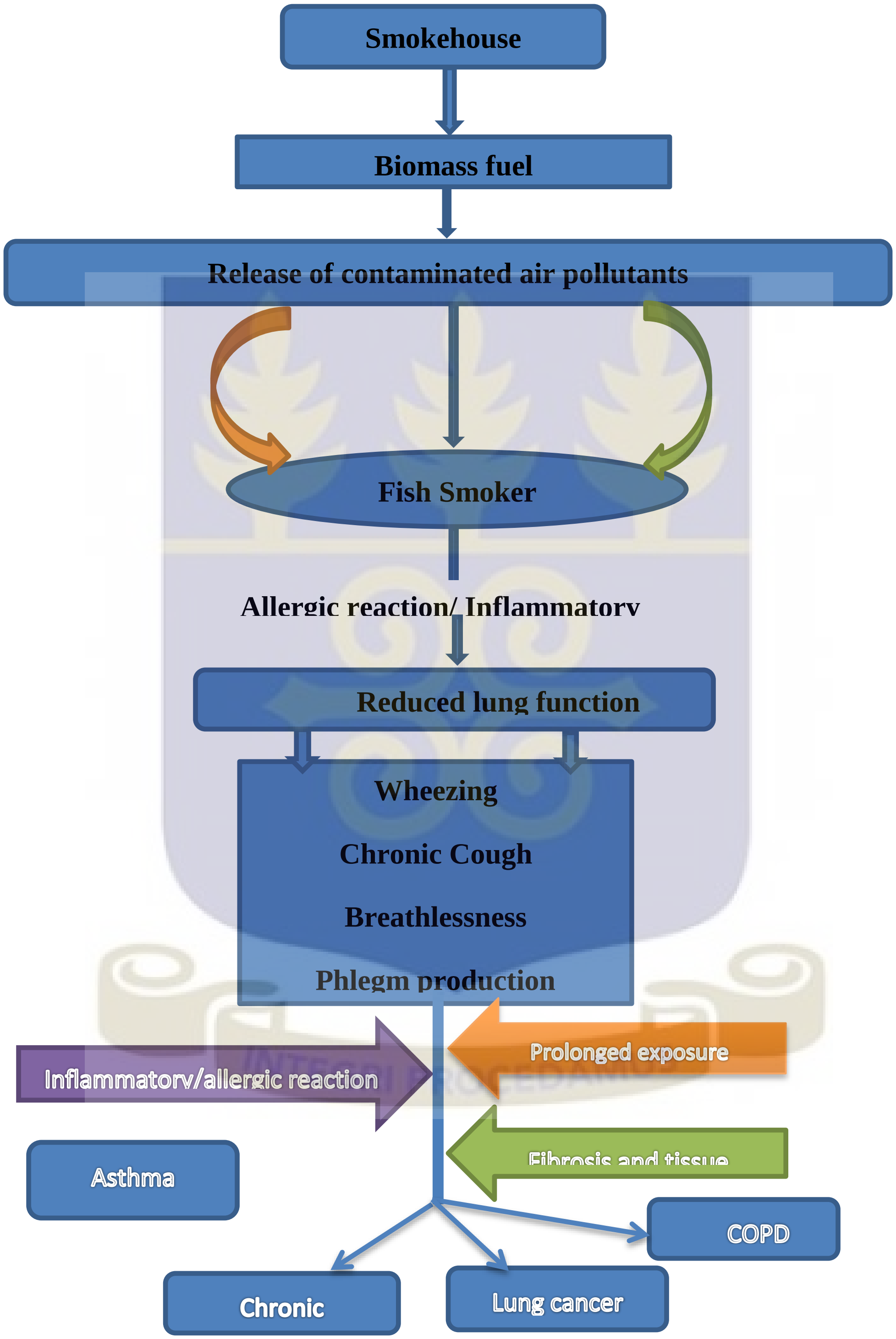

Figure 1: Conceptual framework of respiratory health problems associated with IAP

Considering the figure above (fig 1.), the dependent variable or outcome is the respiratory health problems and lung function. The major or main determinants are $PM_{2.5}$, CO including other air pollutants.

In the smokehouse, the wood use as the fuel is burnt. The burning of the wood releases into the atmosphere various types of air pollutants. Inhalation however is the main route of exposure. These pollutants are identified to consist of volatile organic compounds (VOCs), carbonyls, carbon monoxide (CO), nitrous oxides, sulfur oxides (principally from coal), formaldehydes, and polycyclic organic matter (e.g., carcinogenous benzo[a] pyrene) (Kim et al., 2011). Inhalation into the respiratory tract induces a hypersensitivity response leading to inflammation of the respiratory lining and giving rise to acute respiratory symptoms such as cough, cold, chest pains, difficulty in breathing and wheezing with associated reduced lung function. .

1.4 Justification

Air pollution is one of the main avoidable causes of disease and death globally. About 4.3 million deaths each year, most in developing countries, are associated with exposure to household (indoor) air pollution (WHO, 2014).

To date, only one study from Nepal has reported a relationship between directly measured household exposure and respiratory symptoms.

The proposed project will increase our scientific knowledge regarding the health effects of exposure to high levels of particulate matter and carbon monoxide. A better understanding of these relations may provide additional data to support exposure reduction interventions for biomass smoke generated in smokehouses.

1.5 Objectives

1.5.1 General objectives

The general objective of this study is to assess the prevalence of self-reported respiratory symptoms, exposure indicators of biomass smoke (i.e. 6-hr personal carbon monoxide (CO), average number of years spent smoking fish and average number of hours spent per day smoking fish) and the association between indicators of biomass smoke exposure and respiratory symptoms among commercial fish smokers in traditional smokehouses at Aboadze and Abuesi in the western region

1.5.2 Specific objectives

i. To determine the prevalence of self-reported respiratory symptoms resulting from exposure to smoke in traditional smokehouses (i.e. chronic cough, wheezing, phlegm production and breathlessness).

ii. To identify indicators of biomass smoke exposure measured as 6-hr personal CO, average number of years spent smoking fish and average number of hours spent per day smoking fish

iii. To determine the association between indicators of biomass smoke exposure (personal CO, number of years spent smoking fish and average number of hours spent per day) and self-reported respiratory symptoms

CHAPTER TWO

LITERATURE REVIEW

2.1 Scope of the review

This chapter will give a brief introduction to indoor air pollution (section 2.2), biomass fuel (section 2.3) and factors for using biomass fuel (section 2.4). Fish smoking (section 2.5) and carbon monoxide exposure (section 2.6). Section 2.7 and 2.8 will discuss $PM_{2.5}$ exposure and lung cancer respectively.

2.2 Indoor air pollution (IAP)

We acknowledge that indoor air pollution is and has long been recognized as a significant burden on public health, particularly in developing countries where solid fuels are used extensively for cooking and heating. Indoor air pollution can be trace to prehistoric times when humans first moved to temperate climates and it became necessary to construct shelters and use fire inside them for cooking, warmth and light (Bruce, Perez-Padilla, & Albalak, 2000).

IAP from biomass fuel has emerged as one of the top ten global threats to public health as it account for 2.7% of the global burden of disease especially among women who spend most time cooking (Alim et al., 2013).Cooking-related IAP is known to be affected by the combined effects of fuel types, food materials, cooking styles. Like many deleterious substances produced from food materials via fire-based cooking, they are also emitted in the form of smoke and particles from cooking fuel(Kim, Jahan, & Kabir, 2011).

Those pollutants are identified to consist of volatile organic compounds (VOCs), carbonyls, carbon monoxide (CO), nitrous oxides, sulfur oxides (principally from coal), formaldehydes, and polycyclic organic matter (e.g., carcinogenous benzo[a] pyrene) (Kim et al., 2011). China, Korea, South Africa, and some other countries also extensively use coal for domestic needs. These fuels are burnt indoors in open fires using poorly functioning stoves.

As combustion is incomplete in most of these stoves, it can also serve as a key route to transfer high levels of indoor pollutants to those who are responsible for cooking and their family members. Exposure to IAP may be responsible for nearly 2 million excess deaths in developing countries and for some 4% of the global burden of disease (De Maeseneer & Maeseneer, 2009). Children are particularly vulnerable to IAP because their metabolic pathways are underdeveloped and immature (Bruce et al., 2000) .

A tight relationship is thus expected to exist between such activities and an increased risk of non-respiratory illness such as: low birth weight in neonates, nutritional deficiencies, cardiac events, stroke, eye disease, nasopharyngeal, and laryngeal cancer (Kim et al., 2011). The impacts of both acute and long-term exposure to air pollution on health are substantial, but those resulting from long-term exposure are much greater compared to those observed for short-term exposure, suggesting that damage is due not just to exacerbate the underlying diseases but also to their progression.

Numerous follow-up studies that adjust for the effect of other factors such as tobacco smoking, diet or physical activity have consistently shown that long-term exposure to fine airborne particulates leads to increased incidence of premature mortality due to cardiovascular disease, chronic obstructive respiratory diseases as well as lung cancer.

Pollutants with the strongest evidence for public health concern are fine particulate matter and gases (mainly carbon monoxide, ozone, nitrogen oxides, sulfur dioxide and volatile organic compounds)(WHO, 2014). Fine particulate matter, which is widespread both indoors and outdoors, damages the health of more people than any other air pollutant, through the deposition of particles in smaller airways and alveoli in the lungs and their penetration into the bloodstream. (Larger or coarser particles, including dust and pollen are more restricted to the thoracic cavity and unable to penetrate the smaller airway systems). Among the types of fine particulate matter, particular concern centers on elemental carbon and organic materials, transition metals and metal compounds; inorganic sulfates and nitrates; ammonia; sodium chloride and mineral dust.

Absorbed particles can damage inter alia lung function and the cardiovascular system, through oxidative stress, alteration of the electrical processes of the heart and systemic inflammation, leading to endothelial cell activation and dysfunction; altered blood pressure and heart rate, including heart rate variability; arrhythmia; and deregulated coagulation pathways; and ischemia (WHO, 2013).

In Papua New Guinea, patients with chronic lung disease were identified to have lived (reside) in communities heavily polluted by indoor biomass smoke. A similar finding reported in Pakistan among adults population found women with greater number of chronic bronchitis despite their lower smoke rate (Ranabhat et al., 2015). Result from studies in India, Saudi Arabia , Turkey, Mexico and Nepal have also shown that women using biomass fuel for cooking have increased prevalence of respiratory symptoms attributable to COPD and substantially greater decline in lung function than women who do not use these fuels.

In a meta-analysis of 36 studies, Po and Co- workers showed that exposure to biomass smoke was significantly associated with COPD, ARTIs and wheezing (Fullerton, Gordon, & Calverley, 2009). China, Korea, South Africa and some other countries also extensively use coal for domestic needs and these fuels are burnt indoors using poorly functioning stoves. As combustion is incomplete in most stoves, it also serves as a key route to transfer high levels of indoor air pollutants to those who are responsible for cooking and their family members.

2.3 Biomass fuel

Biomass fuel (BMF) is any material derived from plants or animals, which are deliberately burnt by humans. Wood is the most common example, but the use of animal dung and crop residues is also widespread (Bruce et al., 2000). BMF account for more than one - half of domestic energy in most developing countries and for as much as 95% in lower income countries (Smith et al., 2004). Around 2.4 billion people rely on BMF as their main source of domestic energy for cooking, heating and lighting (Reddy et al., 1996; Smith et al., 2004).

It is estimated that 1.9 million people die prematurely due to exposure to smoke from solid fuel burning (Kurmi, Lam, Ayres, et al., 2012). According to WHO, exposure to smoke from solid fuel burning is ranked as the top environmental risk factor worldwide, being responsible for 3.3% of all mortality and 2.7% of all disability-adjusted life- years per year. Long-term exposure to solid fuel smoke is clearly associated with chronic obstructive pulmonary disease (COPD), increased risk of acute respiratory infections/pneumonia, lung cancer, tuberculosis (TB) and cataracts (Kurmi, Semple, Simkhada, Smith, & Ayres, 2010).

In developed countries, modernization has been accompanied by a shift from biomass fuels such as wood to petroleum products and electricity whiles in developing countries, however, even where cleaner and more fuels that are sophisticated are available, house- holds often continue to use simple biomass fuels (N. et al., 2000).The adverse health effects of indoor air pollution is often exacerbated by lack of ventilation in homes using BMF and by the poor design of stoves that do not have flues or hoods to take smoke off the living area. Solid fuel smoke produces

DNA damage and inflammatory and oxidative stress response gene expression in cultured human cells. Biomass smoke inhalation causes oxidative stress and DNA damage in lungs and it is said to be the possible mechanism for pathogenesis of COPD. Indian study by Pandey et al also demonstrated DNA damage in lymphocytes of women exposed to biomass smoke and impaired macrophage function.

A study conducted in Nepal showed biomass smoke caused significantly more respiratory disorders than cleaner fuels. Several randomized control trials in rural Mexico have also shown cleaner fuels were significantly associated with reducing of respiratory symptoms among women (Alim et al., 2013).

The combustion efficiency of BMF is also very low, thus it yields relatively high levels of products of incomplete combustion, which are more damaging to health. Four factors that appear to be most relevant in a household's choice of fuel type are: (a) cost of fuel, stove type and accessibility to fuels; (b) technical characteristics of stoves and cooking practices; (c) cultural preferences; and lastly, if at all, (d) the potential health impacts (Masera, Saatkamp, & Kammen, 2000).

Inefficient burning of BMF on an open fire or traditional stove generates large amounts of particulate matter as well as carbon monoxide, hydrocarbons, oxygenated organics, free radicals and chlorinated organic (Naeher et al., 2007b). BMF smoke is associated with an interstitial lung disease referred to as 'hut lung' (Gold et al., 2000; Grobbelaar and Bateman, 1991), a form of pneumoconiosis in rural women from developing countries, originally described as 'Transkei silicosis' because it was thought to be due to silica particles. However, it is the contribution of BMF smoke in the pathogenesis of chronic obstructive pulmonary disease (COPD) that causes a greater global burden of disease (Fullerton, Bruce, & Gordon, 2008). Again, research has shown BMF smoke is responsible for COPD in non-smoking women living in rural areas. With women from rural Turkey, it is has been estimated that the fraction of COPD attributed to exposure to biomass smoke, after adjusting for possible confounding factors, is 23.1% (Ekici et al., 2005).

Epidemiological studies from Nepal and India have associated indoor cooking using BMF with cataracts or blindness (Saha, Kulkarni, Shah, Patel, & Saiyed, 2005). Smoke induces oxidative stress and depletes plasma ascorbate, carotenoids and glutathione, which provides antioxidant protection against cataract formation. However, knowledge of occupational exposure to biomass smoked is limited. A systematic search of the scientific databases (i.e. Pubmed and Google scholar) identified 2 studies on occupational exposure in traditional smokehouses. Umoh et al (2014) for example, compared lung function of women in smokehouses to that of non-smokehouse workers in Nigeria, the authors noted that compared to non- smokehouse women, women in traditional smokehouses have 1.5-fold decrement in peal expiratory flow rates, FEV1 and FVC. The prevalence of chronic bronchitis was 68% in smokehouses workers compared to non-smokehouse workers.

Result from studies in India, Saudi Arabia , Turkey, Mexico and Nepal have also shown that women using biomass fuel for cooking have increased prevalence of respiratory symptoms attributable to COPD and substantially greater decline in lung function than women who do not use these fuels. In a meta-analysis of 36 studies, Po and Co- workers showed that exposure to biomass smoke was significantly associated with COPD, ARTIs and wheezing (Fullerton, Gordon, & Calverley, 2009).

There is now evidence linking an increased risk of cooking emissions with diverse diseases, which include respiratory tract infections, exacerbations of inflammatory lung conditions, cardiac events, stroke, eye disease, tuberculosis (TB), and even cancer. Although IAP is not the direct cause of such disease, pollution arising from biomass fuels has been implicated to accelerate the infection of TB and/or related disease. Enormous studies have reported the association between exposure to biomass smoke and chronic bronchitis and/or chronic obstructive pulmonary disease.

Most sources of both ambient and household air pollution are directly influence by the choice of energy technologies and fuels use, the energy efficiencies of homes and transport systems, and patterns of energy transmission and distribution. Therefore, the prevention of diseases related to air pollution depends on the implementation of specific sector policies that reduce air pollution at point of source (for instance, in energy and power generation, transport, urban planning, buildings, industry and agriculture). There are many reports (Gao and Mann, 2009; Lee et al., 2005; Mann et al., 2007) which collectively suggest that chronic inhalation of biomass smoke may lead to inflammation and oxidative stress which, in turn, can rise arterial blood pressure.

As most sources of air pollution co-exist, the relative importance or proportional contribution of specific sources in a particular setting needs to be identifying in order to direct mitigation efforts appropriately for the greatest benefits to health.

2.4 Factors for using biomass fuel

The influence on the choice of fuel used is multi-factorial, but cost and socioeconomic status appear to be the main drivers. Most of these households spend most of their income purchasing food and clothes and for medical expenses. Depending upon the availability of biomass fuels and the distance required to travel to acquire these fuels, those living in the least developed countries can spend, on average, 2–3 h per week collecting biomass, leaving little or insufficient time for education thus making it very difficult for these families to improve their socioeconomic status hence their reliant on the cheaper but dirtier alternatives. The other important factor is the unavailability of clean fuels in rural areas, because of the lack of a sustainable supply-chain mechanism and/or the necessary infrastructure to deliver clean fuels unlike the biomass fuel where suppliers from the industries practically bring the wood as well as all other fuels to their doorsteps. Consequently, clean fuel is not available at all or the demand for clean fuel cannot be met consistently, forcing rural dwellers and these women to continue their dependence on biomass fuels (Kurmi, Lam, Ayres, et al., 2012) (See. Fig. 2).

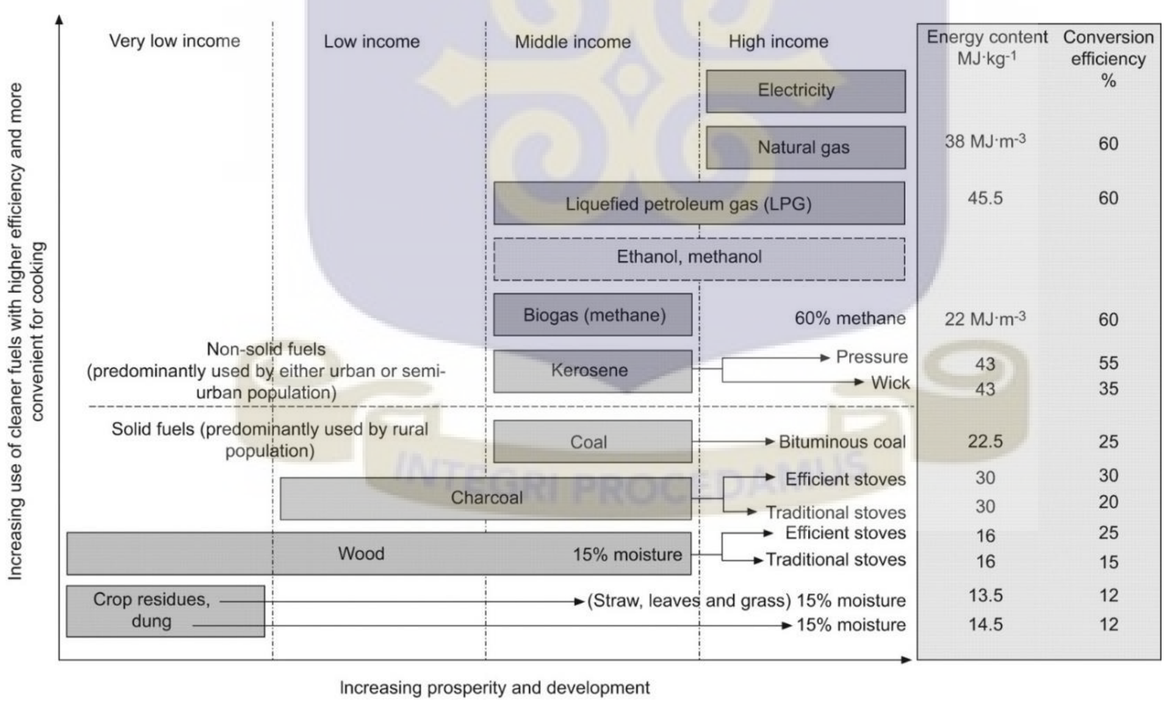

Figure 2: The energy ladder

2.5 Fish Smoking

Fish is an important dietary component of people all around **the world** and represent a relatively cheap and accessible source of high quality protein for poorer household (Adeyeye, S.A.O, Oyewole, O.B., Obadina, A.O, Omenu, A.M., Oyedele, H.A. and Adeogun, 2015). Ghana's national demand for fish is always greater than the country can supply and the gap is widening year after year.

Fish is the most important animal protein in Ghana, accounting for the about 82% of protein consumption (FAO 2001). The fishery sector plays a major role in the nation's economy, contributing 3% of the GDP (Ayinsa & Maalekuu, 2013), providing employment to the labor force which includes the fishers, their wives, children, close relatives, canoe carvers, input suppliers as well as office workers for industrial fleet accounting an estimated number of 1.5-2 million of the nation's population. With a population of about 27 million people, the average per capital fish consumption is 27 kg per annum, which is higher than the world's average of 13 kg. It is noticeable that a significant plentiful (bumper) harvest occurs as well as lean seasons. Hence to ensure the availability of fish throughout the year, particularly during the lean seasons, it is essential to preserve fish in appreciable quantities and good conditions until it is needed (Ayinsa & Maalekuu, 2013).

Fish smoking is the most widely practiced method **of fish preservation** in Ghana, accounting for smoked fish being the commonest form of fish consumption. Bernaseck (1991) on his quest found that the shelf life of the smoked fish depends more on the cooking and the state of dryness than the smoke itself. The process of fish smoking combines salting or brining, equilibration, drying on traditional mud ovens and finally smoking in traditional smokehouses made from bamboo or cement. There are mainly two types of smoked fish, the hot- smoked fish and the dry-smoked fish and the choice of whether the fish should be hot smoked or dry smoked solely depends on the type of fish and how long it is going to be stored for future use. The hot smoking process could last for about 3 hours and the resulting smoked fish have a moisture content of about 35% - 45% with a limited shelf- life of 1-3 days. A smoked- dry process may take about 10 - 18 hours, and sometimes 3 – 4 days and the resulting smoked fish have a moisture content of about 10% -15% with a shelf-life of 3 - 9 months when stored properly (Omodara & Olaniyan, 2012).

2.6 Carbon Monoxide Exposure

Carbon monoxide is a colorless, odorless gas formed by incomplete combustion of carbonaceous material, such as gasoline, natural gas, oil, coal, tobacco, and other organic materials.

It has been suggested as a cheaper but surrogate measure of indoor air pollution caused by burning biomass fuel (Kurmi, Lam, Ayres, et al., 2012). Carbon dioxide is measured by using either color-changing diffusion tubes or electrochemical monitors. Normally the amount of carbon monoxide produced by these sources is not a cause for concern. However, if used in a closed or partially closed space the carbon monoxide can build to dangerous levels. When ones exposure to carbon monoxide is high, their body replaces the oxygen in the red blood cells with carbon monoxide. Carbon monoxide combines with hemoglobin to form carboxyl haemoglobin with reduced delivery of oxygen to tissues and developing fetus. This leads to low birth weight babies and increases perinatal deaths. It increases bronchial reactivity leading to wheezing, repeated respiratory tract infections and exacerbations of asthma.

Symptoms of carbon monoxide exposure can include everything from headaches, dizziness and drowsiness to nausea, vomiting or tightness across the chest. Severe carbon monoxide poising can cause neurological damage, coma and death (Study & Reed, 2011).

2.7 $PM_{2.5}$ Exposure

Particulate matter also referred to as particle pollution is linked to a number of significant health effects. Particles less than or equal to 10 micrometers in diameter are so small that they can get into the lungs and potentially causing serious health problems. $PM_{2.5}$ (fine particles) are 2.5 micrometers in diameter or smaller, and can only be seen with an electron microscope. Produced from all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes $PM_{2.5}$ is believed to possess the largest health risk. Children and older adults are more susceptible to PM-induced effects because of physiological differences. Children are more susceptible than adults to the effects of PM because of the greater amount of time spent both in and outdoors, activity levels and minute volume per unit body weight of the subpopulation that lead to increases in PM dose per lung surface area and, in turn, increases in the susceptibility of developing lungs to adverse effects. The elderly are generally considered a susceptible population because of the gradual decline in physiological processes over time. Compared with children or younger adults, elderly individuals have a higher prevalence of pre-existing cardiovascular and respiratory diseases, which may also confer susceptibility to PM.

Environmental epidemiology research conducted in recent decades has proven that short-term or long-term exposure to ambient PM increases mortality and morbidity, reduces life expectancy and increases the risk of respiratory and cardiovascular diseases. Studies on asthmatic children have reported that increases in respiratory symptoms, increased medication use and decreases in pulmonary function are associated with short-term $PM_{2.5}$ exposure. A case-crossover study in Taipei found that chronic obstructive pulmonary disease (COPD) admissions are significantly and positively associated with higher $PM_{2.5}$ levels during warm and cool days (Hu, Zhong, &

Ran, 2015). Moreover, large amounts of toxic compounds, such as gases, organic compounds and heavy metals, adhere to the surface of $PM_{2.5}$, resulting in increased toxicity, interference with chromosomes, DNA and other genetic material. $PM_{2.5}$ and toxic compounds are also implicated in the development of cancers. Long-term fine particulate air pollution exposure is associated with small but measurable increase in lung cancer mortality (Turner et al., 2011).

Consistent evidence from epidemiological studies demonstrates that short and long-term exposure to PM, specifically PM2.5, is associated with cardiovascular morbidity and mortality (Dockery, 2001). PM concentration is also linked to myocardial infarction, heart failure and arrhythmia. The elderly, diabetics and those with known coronary artery disease appear specifically susceptible to the harmful effects triggered by PM exposure. Long-term exposure to fine particulate air pollution is also an important risk factor influencing cardiovascular disease mortality via mechanisms that include pulmonary and systemic inflammation, accelerated atherosclerosis and altered cardiac autonomic function (Fuller et al., 2013).

The U.S. EPA has developed a formula to convert $PM_{2.5}$ readings into an air quality index (AQI) value that can help inform health-related decisions. Studies from Nigeria also showed anxiety among women with chronic bronchitis had a strong level of association with biomass exposure (Umoh, Ibok, Edet, Essien, & Abasiubong, 2013) .

2.8 Lung cancer

Lung cancer is one of the leading causes of death, accounting for 1.3 million deaths annually worldwide. While smoking is the major risk factor, as many as a quarter of cases are not attributable to tobacco use. Lung cancer in never-smokers is more common in females than males, although there is considerable regional variation in the proportions of nonsmoking females with lung cancer; for instance, in east and south Asia, up to 83% of female lung cancer cases are never-smokers, compared with 15% in the USA (Rudin, Avila-Tang, & Samet, 2009). Emissions from combustion of solid fuels have been shown to have high concentrations of PAHs, BaP and $PM_{2.5}$, which in turn have been associated with high lung cancer rates (Rudin et al., 2009).

A meta-analysis of 28 studies relating to lung cancer in subjects exposed to solid fuel smoke showed a greater effect of coal smoke on lung cancer rates (OR 1.82, 95% CI 1.60–2.06) with biomass smoke, predominantly wood (OR 1.50, 95% CI 1.17–1.94) and mixed biomass fuel smoke (OR 1.13, 95% CI 0.52–2.46), showing lesser effects (Kurmi, Lam, & Ayres, 2012). The general mechanism emerging from the study of PAHs such as BaP is genotoxicity, where BaP is metabolized to an electrophilic form that adducts DNA.

Data from China imply that domestic coal smoke is a significant risk factor for the development of lung cancer (Du et al., 1996; Zhao et al., 2006). In studies from India and Mexico, data for non-smoking women exposed to BMF smoke for a number of years suggest that long-term exposure to BMF smoke from cooking may contribute to the development of adenocarcinoma of the lung (Behera and Balamugesh, 2005; Hernandez-Garduno et al., 2004). The International Agency for Research on Cancer (IARC) recently termed biomass smoke a 'probable carcinogen' (Group 2a) and coal (used as domestic fuel) was termed carcinogenic to humans (Group 1) (Straif et al., 2006).

CHAPTER THREE

METHODOLOGY

3.1 Study design and setting

A cross-sectional study was carried out from June to July 2016 among fish smokers in traditional smokehouses at Aboadze and Abuesi in the western region. Aboadze and Abuesi are twin towns in the western region and are popularly known fishing communities in the region. Both towns are about 20 kilometers from the western regional capital, Takoradi. They are bordered on the east by Shama, the north by Inchaban, the west by Injreisia, and the south by the Atlantic Ocean. Literacy rate is low. Houses in both communities are mostly built with cement blocks/bricks, but few are mud houses. Pipe borne water is the main source of drinking water and the towns are connected to the national grid. The estimated population in both towns is about 10,000 and about 60% are females. The major occupation of the males in the community is sea fishing and the women are mostly engaged in fish smoking which is normally carried out in traditional smokehouses (Figure 3). There are two types of smokehouses: enclosed and open smokehouses. An example an enclosed smokehouse is in Fig 3a. An open smokehouse there is no outer wall around the smokehouse.

Women find their way into fish smoking business as inheritance either from their mothers or by taking it up because it is a profitable business that needs little capital investment. Most women entrepreneurs who do not have enough capital are engaged in small scale commercial fish smoking. A small-scale entrepreneur may employ 2 or 3 smokehouse helpers (a smokehouse helper is a woman who has been employed to assist in fish smoking by the entrepreneur) whereas, a large scale entrepreneur employs as many as 10 or more smokehouse helpers.

There are two main fishing seasons, the bumper (i.e. from August to October and December) and the lean seasons (i.e. April to mid-July). Fishes that the women smoke include salmon, silver fish, eel, herring, anchovy, and red grouper and so on.

3.2 Fish smoking process

Fish is normally smoked in traditional smokehouses (Fig. 3a). A traditional smokehouse is built normally of wood and/or blocks/bricks. In Abuesi and Aboadze, smokehouses are usually located about 2 to 5 km away from the community or are located within the community**.**

To start with, women entrepreneurs buy the fish at the beach. The helpers carry the fish in trays Figure 3b shows various activities in the smokehouse. Except for larger fishes such a grouper, tuna, snapper, etc., the gills, guts and scales are normally not removed.

The larger fishes are normally cut into steaks or fillets, but fish of small and medium size are smoked whole. The fish are washed in clean water (fresh or salt) and carefully arranged on the trays made of wiring net. Sometimes they are left for about an hour to dry in the sun before smoking. The trays filled with fish are stacked on top of each other upon the ovens, resulting in a smoking chamber. Up to 15 trays may be used on one oven, though most commonly the women use 10-12 trays for one smoking cycle (with a total of 100-160 kg. of wet fish).

In the pits underneath the oven, firewood, generally mangrove wood or any other combustible materials are place and burnt. Smoke then envelopes the hut. The women stay in the smokehouse to turn the fish from time to time to prevent it from burning. This women may stay in the smoke house the smoke house for more than 10 hours during the bumper seasons and 5 hours when in the lean seasons.

Figure 3: Traditional smokehouse and activities in the smokehouse

3.3 Source/Study Population

The source population includes all smokehouse helpers at Abuesi and Aboadze who smoked fish in enclosed smokehouses (Figure 3). Three hundred and fourteen participants were randomly selected for this study (see section 3.6 and 3.5 for sampling procedure and sample size calculation). Sixty-one (61) participants were randomly selected from the 314 participants for 6-hr personal CO monitoring.

3.4 Study Variables

3.4.1 Independent variables

The main independent variables were three: (i) average number of years spent smoking fish, (ii) average number of hours per day spent smoking fish and (iii) 6-hr personal CO levels.

3.4.2 Dependent variables

The main outcome of interest was self-reported respiratory symptoms measured as chronic cough, wheezing, phlegm production and breathlessness in the last 12 months.

3.4.3 Covariates

Covariates considered in this study included marital status, level of education, material makeup of the smokehouse, level of education, average annual household income age, religion, and household size.

3.5 Sample size calculation

The sample size was calculated using a single population proportion formula (Cochran 1977). The parameters considered were: 95% confidence level (1.96), margin of error (0.05), prevalence of wheezing reported among farmers at Akumadan (27%) (Abdul-Rahaman 2015):

$$n = \frac{Z_{1-\alpha/2}{}^{2} P(1-p)}{d^{2}}$$

$$n = \frac{1.96^{2} \times 0.27 \times .73}{0.05^{2}}$$

$$n = \frac{0.757}{0.05^{2}}$$

$$n = 302$$

5% was added to take care of non-response. With this, an estimated population of 314 smokehouse helpers was selected.

3.6 Data Collection Procedure

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

Phase 1: Stakeholder meeting: The Principal Investigator and research assistants who have extensive knowledge of the local area met opinion leaders and the chief fisherman in the two (2) towns (i.e. Abuesi and Aboadze) to inform them about the project; and also sought permission to carry out the project.

Phase 2: Enrolment of Study Participants: Once approval was given, a meeting was held with a section of the fish smokers to tell them about the project. Following this meeting, the principal investigator and the research assistants identified all enclosed smokehouses in the 2 towns and listed the names of entrepreneurs who owe these smokehouses. In all 397 entrepreneurs who have enclosed smokehouses were identified. Simple Random Sampling was used. Numbers were allocated to the lists of entrepreneurs. Using a random number generator, 314 entrepreneurs were selected. Each entrepreneur was asked to volunteer one smokehouse helper who has worked for her for at least 6 months and is willing to follow the study protocol.

Phase 3: Data Collection: The tools for data collection included interview guide with a structured questionnaire and a 6-hr personal CO monitoring with a LASCAR CO monitor (MicroDAQ, Contoocook, NH, USA). All 314 smokehouse helpers were interviewed by trained research assistants with a structured questionnaire in the local (fante) language. The questionnaire ascertained information on age, marital status, education, type of fuel used, number years of employment, and average number of hours per day spent smoking. There were also questions on experience of respiratory symptoms in the last 12 months. Due to time constraint, 61 smokehouse helpers were randomly selected and monitored for 30 days from Monday to Saturday from 09:00 to 15:00 or 13:00 to 19:00. Smokehouse helpers wore LASCAR CO on their vest close to the breathing zone. The monitor has been set to record CO levels at 30 seconds interval. Mean CO levels are recorded and later downloaded onto a PC.

3.7 Data Processing and Analysis

The questionnaires were cross checked for completeness and internal consistency. The data were crossed checked to identify missing values and to correct inconsistencies in the data. Data entry was done using Excel 10 (Microsoft) and was transferred into Stata 13 for analysis. Means and standard deviations were computed for continuous variables and proportions for categorical variables. A generalized linear model with binomial distribution and log link function was used to assess the association between indicators of biomass smoke and respiratory symptoms. The effect measure is prevalence ratio (PR). The following variables marital status, religion, education, material make of smokehouse were significant at $p<0.05$ when adjusted in the analysis.

3.8 Quality Control

The following measures were undertaken to ensure that the data collected were of superior quality so as to assure its validity: Research assistants received training in questionnaire administration and CO monitoring. Research assistants were allocated randomly to traditional smokehouses in order to avoid systematic observer bias. Meetings were held daily after collection of data to identify challenges and solutions were proffered by the team.

3.9 Ethical Consideration

Ethical clearance was sought from the Ghana Health Service Ethical Review committee.

Informed consent

Permission was sought from the leaders of the community as well as the leaders of the local fish smokers association. The objectives and details of the study was clearly explained to the participant. At the initial meeting, an oral script introducing the study was given to those who can read and write read for those and by a translator for those who cannot read and write. Those interested in participating in the study and could read and write were given the written consent form whiles those who could not read and write had translators to help them fill the consent form. It was explained to them that Participation in the study was voluntary and that they could withdraw from the study at any point if they so desire.

Participants in the study were informed that, there is no direct benefit to the participants of this study. However, the information provided will contribute to the overall knowledge about biomass exposure in traditional smokehouses and respiratory health problems among traditional fish smokers.

Record Storage and Protection: All research records and data was protected against inappropriate use or disclosure, or malicious or accidental loss or destruction in order to protect the confidentiality of subject data. Data was locked with restricted access and restrictions on copying study-related materials on a secure laptop. Data was appropriate and safely disposed/destroyed (e.g., shredding paper documents, destroying disks or thumb drives, secure erasure of electronic media).

CHAPTER FOUR

RESULTS

4.1 Characteristics of study population

The characteristics of the study population are shown in Table 4.1. The mean age of the 314 fish smokers was 41.23 years (standard deviation: 10.28 years). Most of the participants (38.94%) were between 35 to 45 years, were married (78.34%), had no formal education (50.32%), worked in a smokehouses constructed of wood (81.85%), had a household size above 5(41.10%) and earned annual average income below GHS 1200.

Table 4.1: Demographic Characteristics of fish smokers (n=314)

Characteristics of the study participants	Frequency	Percentage (%)
Age Groups		
≤ 25	15	4.79
25 – 35	87	27.80
35 – 45	122	38.98
> 45	89	28.43
Marital status		
Married	246	78.34
Single	68	21.66
Religion		
Christian	251	79.94
Muslim	59	18.79

Table 4. 1 continued.

Characteristics of the study participants	Frequency	Percentage (%)
Traditionalist	4	1.27
Highest level of education		
No formal education	158	50.32
Primary school	99	31.53
JHS / SHS	57	18.15
Material make of smokehouse		
Cement	53	16.88
Wood	257	81.85
Other*	4	1.24
Household size		
< 4	107	34.63
4 – 5	75	24.27
> 5	127	41.10
Average household income		
< 1200	74	23.57
1200- 1800	44	14.01
1800- 3000	62	19.75
> 3000	50	15.92

*other – constructed of cement and wood

4.2 Prevalence of respiratory symptoms

When the respondents were asked to report the respiratory health symptoms they experienced, 72.90% of them cited chronic cough, 69.79% had breathlessness, 67.65% had phlegm production and 61.19% cited wheezing. Majority (38.5%) of the women who reported chronic cough were between age 35 to 45 years , worked in smokehouses constructed of wood (80.97%), had no formal education with a household size of more than 5 members (43.37%). For women who cited

Table 4.2Prevalence of Respiratory Symptoms among fish smokers in Traditional smokehouses at Abuesi/Aboadze (n=314)

Characteristics of study population	Respiratory Symptoms							
	Cough n (%)		Phlegm production n (%)		Wheezing n (%)		Breathlessness n (%)	
	Yes 226 (72.90)	No 84 (27.10)	Yes 207 (67.65)	No 99 (32.35)	Yes 164 (61.19)	No 104 (38.81)	Yes 201 (69.79)	No 87 (30.21)
Age (years)								
≤ 25	11 (4.87)	4 (4.82)	11 (5.31)	4 (4.04)	10 (6.10)	4 (3.88)	10 (5.00)	3 (3.45)
25-35	58 (25.66)	29 (34.94)	47 (22.71)	38 (38.38)	41 (25.00)	35 (33.98)	54 (27.00)	26 (29.89)
35-45	87 (38.50)	31(37.35)	80 (38.65)	38 (38.38)	65 (39.63)	40 (38.83)	72 (36.00)	37 (42.53)
>45	70 (30.97)	19 (22.89)	69 (33.33)	19 (19.19)	48 (29.27)	24 (23.30)	64 (32.00)	21 (24.14)
Missing	5		8		47		27	
Marital status								
Married	66 (77.88)	176 (78.57)	164 (79.23)	76 (76.77)	130 (79.27)	85 (81.73)	158 (78.61)	71 (81.61)
Single	18 (22.12)	50 (21.43)	43 (20.77)	23 (23.23)	34 (20.73)	19 (18.27)	43 (21.39)	16 (18.39)
Missing	4		8		46		26	
Highest level of Education								
No formal education	37 (24.03)	117 (75.97)	107 (51.69)	47 (47.47)	77 (46.95)	51 (49.04)	106 (52.74)	40 (45.98)
Primary school	29 (29.29)	70 (70.71)	70 (33.82)	27 (27.27)	56 (34.15)	35 (33.65)	60 (29.85)	28 (32.18)
JHS or Some SSS	18 (31.58)	39 (68.42)	30 (14.49)	25 (25.25)	31 (18.90)	18 (17.31	35 (17.41)	19 (21.84)
Missing	4		8		46		26	
Material make of smokehouse								
Cement	42 (18.58)	10 (11.90)	41 (19.81)	12 (12.12)	34 (20.73)	19 (18.27)	23 (11.44)	27 (31.03)
Wood	183 (80.97)	71 (84.52)	165 (79.71)	86 (86.87)	130 (79.27)	83 (79.81)	177 (88.06)	57 (65.52)
Other	1 (0.44)	3 (3.57)	1 (0.48)	1 (1.01)	-	2 (1.92)	1 (0.50)	3 (3.45)
Missing	4		8		46		26	

Table 4.2 continued

Characteristics of study population	Respiratory Symptoms							
	Cough n (%)		Phlegm production n (%)		Wheezing n (%)		Breathlessness n (%)	
	Yes 226 (72.90)	**No 84 (27.10)**	**Yes 207 (67.65)**	**No 99 (32.35)**	**Yes 164 (61.19)**	**No 104 (38.81)**	**Yes 201 (69.79)**	**No 87 (30.21)**
Abuesi	80 (95.13)	215 (95.24)	92 (92.93)	199 (96.14)	161 (98.17)	96 (92.31)	192 (95.52)	85 (97.70)
Aboadze	4 (4.87)	11 (4.76)	7 (7.07)	8 (3.86)	3 (1.83)	8 (7.69)	9 (4.48)	2 (2.30
Missing	4		8		46		26	
Household size								
<4	28 (33.73)	78 (35.14)	70 (34.48)	36 (36.73)	66 (40.99)	29 (28.43)	80 (40.20)	20 (23.81)
4 to 5	19 (22.89)	55 (24.77)	48 (23.65)	23 (23.47)	42 (26.09)	28 (27.45)	39 (19.60)	28 (33.33)
>5	36 (43.37)	89 (40.09)	85 (41.87)	39 (39.80)	53 (32.92)	45 (44.12)	80 (40.20)	36 (42.86)
Missing	9		13		51		31	
Average household income (GHS)								
<1200	56 (34.78)	16 (24.62)	45 (31.25)	28 (35.44)	38 (32.48)	26 (34.67)	49 (32.03)	20 (36.36)
1200-1800	25 (15.53)	19 (29.23)	28 (19.44)	16 (20.25)	21 (17.95)	13 (17.33)	28 (18.30)	11 (20.00)
1800-3000	47 (29.19)	15 (23.08)	40 (27.78)	19 (24.05)	30 (25.64)	18 (24.00)	42 (27.45)	12 (21.82)
>3000	33 (20.50)	15 (23.08)	31 (21.53)	16 (20.25)	28 (23.93)	18 (24.00)	34 (22.22)	12 (21.82)
Missing	88		91		122		106	

breathlessness, 42.53% were between age 35 to 45 years , 81.61% were married or had no formal education (52.74%), 88.06% worked in smokehouses constructed of wood and 36.36% earn an annual average household income below GHS 1200.00 (Table 4.2).

4.3 Personal CO levels

Daily personal CO and peak personal CO levels were taken from 61 women who were available during the monitoring period. Mean personal CO level among fish smokers was 18.23 ppm (standard deviation 13.06 ppm) and the mean peak personal CO level was 111.23 ppm (standard deviation of 84.01 ppm). With respect to personal carbon monoxide, 34.43% of women were exposed to CO levels below the WHO guideline level of 10 ppm, whereas 65.57% of the women were exposed to levels above this guideline. Majority of the women exposed to levels less than 10 ppm were married (76.19%), 66.67% had no formal education, 85.70% were Christians and between age 35- 45 years (47.62%), 47.62 % were in household of more than 5 members and 53.33% earn an average annual household income of less than GHS 1200. With respect to women exposed to personal CO levels above the WHO guideline, 40% were between 35 to 45 years, 87.50% were married, 47.50% had no formal education, 82.50% were Christians, 55% had less 4 members in the household and 29.41% earn on the average less GHS 1800.00 per annum (Table 4.3).

***Table 4.3*: Characteristics of study population by average personal carbon monoxide levels (n=61)**

Characteristics of study population	Carbon Monoxide levels (ppm)	
	<10 n (%)	≥ 10 n (%)
	21(34.43%)	40(65.57%)
Age (years)		
≤ 25	1 (4.76)	2 (5.00)
25-35	4 (19.05)	11 (27.50)
35-45	10 (47.62)	16 (40.00)
>45	6 (28.57)	11 (27.50)
Marital status		
Married	16 (76.19)	35 (87.50)
Single	5 (23.81)	5 (12.50)
Highest level of Education		
No formal education	14 (66.67)	19 (47.50)
Primary school	6 (28.57)	15 (37.50)
JHS or Some SSS	1 (4.76)	6 (15.00)
Material make of smokehouse		
Cement	-	4 (10.00)
Wood	21 (100.00)	36 (90.00)
Other	-	-
Religion		
Christian	18 (85.71)	33 (82.50)
Muslim	3 (14.29)	7 (17.50)
Traditional	-	-
Place of Residence		
Abuesi	19 (90.48)	35 (87.50)
Aboadze	2 (9.52)	5 (12.50)
Household size		
<4	6 (28.57)	22 (55.00)
4 to 5	5 (23.81)	4 (10.00)
>5	10 (47.62)	14 (35.00)
Average household income (GHS)		
<1200	8 (53.33)	10 (29.41)
1200-1800	-	10 (29.41)
1800-3000	5 (33.33)	6 (17.65)
>3000	2 (13.34)	8 (23.53)

** Other – cement and wood

4.4 Average number of years of employment as a fish smoker

With respect to the number of years of employment, 27.79% of the women had worked for less than 10 years, 23.32% had worked for 10 to 18 years, and 24.28% had worked for either 18 to 25 years or more than 25 years. For women with more than 25 years of experience in fish smoking, majority had no formal education (65.79%), had worked in smokehouses constructed of wood (82.89%) were Christians (82.89%), had a household size of more than 5 and earns an average annual household income below GHS 1200 (33.33%). For women with less than 10 years of experience in fish smoking, 47.13% were between ages 25-35 years, 14.94% were single, 77.76% were Christians, 36.78% had no formal education and 48.28% had household size below 4 (Table 4.4).

Table 4.4: Characteristics of study population by number of years of employment (n=314)

Characteristics of study population	**Length of employment as a fish smoker (years)**			
	<=10	10-18	18-25	>25
	n(%) 87(27.79)	**n(%) 73(23.32)**	**n(%) 76(24.28)**	**n(%) 76(24.28)**
Age (years)				
≤ 25	13 (14.94)	2 (2.78)	-	-
25-35	41 (47.13)	32 (44.44)	13 (16.67)	1 (1.32)
35-45	26 (29.89)	25 (34.72)	49 (62.82)	22 (28.95)
>45	7 (8.04)	13 (18.06)	16 (20.51)	53 (69.74)
Missing	1			
Marital status				
Married	74 (85.06)	54 (73.97)	63 (80.77)	55 (72.37)
Single	13 (14.94)	19 (26.03)	15 (26.03)	21 (27.63)

Table 4. 4: continued.

Characteristics of study population	Length of employment as a fish smoker (years)			
	<=10	<=10	<=10	<=10
Highest level education				
	32(36.78)	29(53.42)	37(47.44)	50(65.79)
No formal education	33 (33.93)	24 (32.88)	28 (35.90)	14 (18.42)
Primary school	22 (25.99)	10 (13.70)	13 (16.66)	12 (15.79)
JHS or Some SSS				
Material make of smokehouse				
Cement	9 (10.34)	13 (17.81)	18 (23.08)	13 (17.11)
Wood	19 (21.84)	59 (80.82)	58 (74.36)	63(82.89)
Other*	1 (1.16)	1 (1.37)	2 (2.56)	-
Religion				
Christian	67 (77.04)	50 (68.49)	71 (91.03)	63 (82.89)
Muslim	19 (21.84)	23 (31.51)	7 (8.97)	10 (13.16)
Traditional	1 (1.16)	-	-	3 (3.96)
Place of Residence				
Abuesi	82 (94.25)	68 (93.15)	75 (96.15)	74 (97.37)
Aboadze	5 (5.75)	5 (6.85)	3 (3.85)	2 (2.63)
Household size				
<4	42 (48.28)	24 (32.88)	17 (22.97)	24 (32.00)
4 to 5	18 (20.69)	17 (23.29)	22 (29.73)	18 (24.00)
>5	27 (31.03)	32 (43.84)	35 (47.30)	33 (44.00)
Average household income (GHS)				
<1200	26 (38.81)	18 (33.96)	11 (20.75)	19 (33.33)
1200-1800	12 (17.91)	8 (15.09)	15 (28.30)	9 (15.79)
1800-3000	20 (29.85)	19 (35.85)	13 (24.53)	10 (17.54)
>3000	9 (13.43)	8 (15.09)	14 (26.42)	19 (33.33)

4.5 Average number of hours spent a day smoking fish in a traditional smokehouse

Of the fish smokers, 81.21% spent on average more than 4 hours a day in the smokehouse smoking fish, 9.87% spent between 2 to 4 hours a day and 8.59% spent less than 2 hours a day. Majority of the women who spent on the average more than 4 hours per day in the smokehouse fishing were married (80.88%), had no formal education (51.76%), were between 35 to 45 years (37.25%), worked in smokehouses constructed of wood (85.49%), were Christians (79.22%), resides in Abuesi (94.51%), earn average annual income below GHS 1200.00. Considering women who spent on average less than 2 hours a day in a smokehouse smoking fish, majority are between 35 to 45 years (51.85%), were married (75.00%), had no formal education (50.00%), had worked in smokehouses constructed of wood (64.29%), had a more than 5 household member (50.00%), were Christians (71.43%) and earn an average annual household income of less GHS 1200 (Table 4.5).

Table 4.5: Characteristics of study population by average number of hours spent in a day smoking fish in a smokehouse (n=314)

Characteristics of study population	Average hours per day in a smokehouse smoking fish		
	≤2 hrs/day 28(8.92)	2- 4 hrs / day 31(9.87)	>4 hrs/day 255(81.21)
Age (years)	**n (%)**	**n (%)**	**n (%)**
≤ 25	1 (3.70)	2(6.45)	12(4.71)
25-35	7 (25.93)	8(25.81)	72(28.24)
35-45	14(51.85)	13(41.94)	95(37.25)
>45	5(18.52)	8 (25.81)	76(29.80)
Marital status			
Married	21 (75.00)	25 (80.65)	200 (80.88)
Single	7 (25.00)	6 (19.35)	55 (21.57)
Highest level of Education			
No formal education	14 (50.00)	12 (38.71)	132 (51.76)
Primary school	8 (28.57)	11 (35.48)	80 (31. 37)
JHS or Some SSS	6 (21.43)	8 (25.81)	43 (16.86)
Material make of smokehouse			
Cement			
Wood	10 (35.71)	10 (32.26)	33 (12.94)
Other	18 (64.29)	21 (67.74)	218 (85.49)
	-	-	4 (1.57)
Religion			
Christian	20 (71.43)	29 (93.55)	202 (79.22)
Muslim	8 (28.57)	2 (6.45)	49 (19.22)
Traditional	-	-	4 (1.56)
Place of Residence			
Abuesi	28 (100)	30 (96.77)	24 (94.51)
Aboadze	-	1 (3.23)	14 (5.49)
Household size			
<4	4 (14.29)	7 (24.14)	96 (38.10)
4 - 5	10 (35.71)	12 (41.38)	53 (21.03)
>5	14 (50.00)	10 (34.48)	103 (40.87)
Average household income (GHS)			
<1200			
1200-1800	5 (35.71)	3 (16.67)	66 (33.33)
1800-3000	3 (21.43)	6 (33.33)	35 (17.68)
>3000	2 (14.29)	7 (38.89)	53 (26.77)
	4 (28.57)	2 (11.11)	44 (22.22)

* Other – constructed of both cement and wood *hrs - hours

4.6 Association between Exposure indicators and respiratory symptoms

There was an increasing risk of self-reported chronic cough with increasing average number of years of experience in fish smoking (p=0.0459). The prevalence ratio (PR) for 10-18 hrs, 18-25 hrs and >25 hrs were 1.07 (1.00-1.15), 1.15 (1.01-1.32) and 1.24 (1.01-1.52) respectively (Table 4.6). The risk of self-reported phlegm production increased with increasing average number of years of experience in fish smoking (p=0.0120). The PR for 10-18 hrs, 18-25 hrs and >25 hrs were 1.10 (1.02-1.18), 1.21 (1.04-1.40) and 1.33 (1.07-1.65) respectively. Self-reported wheezing also increased with increasing average number of years of experience in fish smoking (p=0.0014). The prevalence ratio (PR) for 10-18 hrs, 18-25 hrs and >25 hrs were 1.14 (1.05-1.24), 1.30 (1.11-1.53) and 1.48 (1.17-1.88). The analysis of average number of years of experience in fish smoking with self-reported breathlessness was not significant (p=0.1478). There was no association between average number of hours per day spent smoking fish in a smokehouse and self-reported chronic cough and phlegm production. Nevertheless, an increasing risk of self-reported wheezing with increasing average number of hours per day spent smoking fish in a smokehouse (p=0.0490). The PR for ≤2 hr/day, 3-4 hr /day and >4 hr /day were 1.16 (0.98-1.37) and 1.35 (0.96-1.89). Self-reported breathlessness also increased with increasing average number of hours per day spent smoking fish in a smokehouse. The PR for ≤2 hr/day, 3-4 hr/day and >4 hr/day were 1.26 (1.03-1.54) and 1.60 (1.07-2.38) (Table 4.6).

I also looked the personal mean CO and personal mean peak CO levels as continuous and categorical variables and no association were observed with self-reported respiratory symptoms (Table 4.6).

Table 4.6Association between Exposure indicators of Biomass smoke exposure in Traditional smokehouses and Respiratory Symptoms among Fish smokers at Aboadze / Abuesi (n=314)

Exposure Indicators	Respiratory Symptoms							
	Cough		Phlegm production		Wheezing		Breathlessness	
	Crude PR	Adjusted PR$	Crude PR	Adjusted PR$	Crude PR	Adjusted PR$	Crude PR	Adjusted PR$
Average years of experience in fish smoking (yrs)								
<=10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	1.05 (0.99-1.12)	1.07 (1.00-1.15)	1.07 (1.00-1.15)	1.10 (1.02-1.18)	1.14 (1.05-1.24)	1.14 (1.05-1.24)	1.01 (0.95-1.08)	1.04 (0.98-1.10)
10-18	1.11 (0.98-1.25)	1.15 (1.01-1.32)	1.15 (1.01-1.31)	1.21 (1.04-1.40)	1.30 (1.10-1.53)	1.30 (1.11-1.53)	1.02 (0.90-1.17)	1.08 (0.97-1.21)
18-25	1.16 (0.96-1.40)	1.24 (1.01-1.52)	1.23 (1.01-1.51)	1.33 (1.07-1.65)	1.48 (1.16-1.90)	1.48 (1.17-1.88)	1.04 (0.85-1.26)	1.13 (0.95-1.34)
>25	0.1173	0.0459	0.0422	0.0120	0.0020	0.0014	0.7131	0.1478
p- value								
Average number of hours per day spent smoking fish in a smokehouse (hr/day)								
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1 or 2	0.94 (0.85-1.03)	0.94 (0.85-1.04)	0.95 (0.84-1.08)	0.95 (0.85-1.06)	1.14 (0.97-1.35)	1.16 (0.98-1.37)	1.46 (1.18-1.80)	1.26 (1.03-1.54)
3 or 4	0.88 (0.73-1.06)	0.88 (0.72-1.09)	0.90 (0.71-1.16)	0.90 (0.72-1.11)	1.31 (0.93-1.83)	1.35 (0.96-1.89)	2.12 (1.39-3.24)	1.60 (1.07-2.38)
>4	0.2342	0.2997	0.4478	0.3662	0.0846	0.0490	<.0001	0.0032
p- value								
Personal carbon monoxide level (continuous)*	0.991 (0.891-1.001)	NA	0.992 (0.890-1.001)	NA	1.015 (0.991-1.035)	NA	1.005 (0.991-1.016)	NA
Personal carbon monoxide level (categorical)*(ppm)								
<10	1.00	NA	1.00	NA	1.00	NA	1.00	NA
≥10	0.96 (0.70-1.29)		0.89 (0.64-1.22)		0.93 (0.53-1.62)		0.96 (0.73-1.27)	
Personal peak carbon monoxide level (continuous)**	0.999 (0.997-1.001)	NA	0.999 (0.997-1.001)	NA	1.002 (0.996-1.006)	NA	1.001 (0.990-1.016)	NA
Personal peak carbon monoxide level								
<50	1.00	NA	1.00	NA	1.00	1.00	1.00	NA
≥50	1.13 (0.74-1.74)		0.93 (0.64-1.35)		2.06 (0.62-6.85)	3.91 (0.64-23.8)	0.81 (0.64-1.03)	

*adjusted for age, marital status, level of education, household size, material make of smoke house and average annual household income

* PR: Prevalence Ratio

*NA: adjusted PR same as Crude PR and adjusted was not reported

CHAPTER FIVE

DISCUSSION

5.1 Summary of main findings

In this cross- sectional study of biomass exposure in traditional smokehouses and respiratory health problems among traditional fish smokers at Aboadze/Abuesi, a relatively high prevalence of respiratory symptoms among women working in smokehouses was observed. There was a significant exposure – response relationship between number of years of employment as a fish smoker with chronic cough, phlegm production and wheezing but not for breathlessness. A significant exposure- response association was observed for average number of hours spent in the smokehouse smoking fish with wheezing and breathlessness but not for chronic cough and phlegm production. However, there was no positive significant association with mean personal CO exposure levels and respiratory symptoms.

5.2 Methodological validity

This study has a number of strengths. To the best of my knowledge, this study is the first among fish smokers in Ghana. The study reported here is population- based cross-sectional among working in enclosed smokehouses at Abuesi and Aboadze. Participation rate was also high (almost 100%), thus, minimizes the potential influence of selection bias. The source population included all fish smokers in the designated geographical area. The use of questionnaire enabled me to collect information on potential confounders which were accounted for in the analysis. Prior to the collection of the data, an extensive orientation and training was held for the research assistants to explain the study and need for accuracy in data collection. It is necessary to state that despite attempt to undertake a very rigorous survey there were few limitations to the study. First, it is a cross-sectional design and it is not possible to establish any temporality. However, exposure-response relations were observed and this suggest that exposure to biomass smoke may be important determinant of self-reported symptoms. Secondly, some of the exposures used were proxy measures and may not have direct relationship with biomass smoke. It could be argued that not until future studies have proved otherwise the proxy measures are valid indicators. Thirdly, few participants were monitored for personal CO in this study for that reason it was not possible to detect any effect. The monitoring period was very short and 48-hr or 24-hr monitoring would have been better. This study was carried out during the lean season and the findings are not valid for the bumper season.

5.3 Comparison of the findings with previous studies

Exposure to indoor biomass smoke is a major global public health issue affecting about half the world's population (Rylance et al., 2013). Several studies have associated biomass smoke generated from unvented cook stoves to several diseases including chronic cough, phlegm production, COPD, lung cancer (Sanbata et al., 2014). A systematic search of the scientific databases (i.e. PubMed, and google scholar) identified 2 studies on this subject. Umoh et al (2014), compared lung function of women in smokehouses with those of non-smokehouse workers in Nigeria. Compared to non-smokehouse workers, women in traditional smokehouses have 1.5-fold decrement in peak expiratory flow rates, FEV1 and FVC. The prevalence of chronic bronchitis was 68% in smokehouse workers compared to those in non-smokehouse workers. The authors concluded that both women groups were exposed to indoor biomass smoke and that additional occupational exposure among smokehouse workers may account for the worsened respiratory health problems in these women. Motorykin et al (2015) also developed a method to measure 19 parent PAHs (PAHs) and 34 hydroxylated PAHs (OH-PAHs) in urine and personal PM2.5 samples collected from the operators of two different fish smoking facilities (tipi and smoke shed), burning two different wood types (alder and apple) on the Confederated Tribes of Umatilla Indian Reservation (CTUIR) while they smoked salmon. The results showed an increase in OH-PAH concentrations in urine after 6 hrs of fish smoking and an increase in PAH concentrations in air within each smoking facility. In general, the PAH exposure in the smoke shed was higher in the tipi facility and the PAH exposure from burning apple wood was higher than burning alder. In the current study the 6-hr mean personal carbon monoxide levels was lower than those reported in studies that monitored women in the kitchen for 48-hrs or 24-hrs (Balakrishnan et al., 2015), but comparable to 48-hr personal CO levels reported in the RESPIRE study (Guarnieri et al., 2014). Exposure-response relations were also observed between average numbers of years spent smoking fish in a smokehouses and self-reported respiratory symptoms; and average number of hr/day spent smoking fish in a smokehouse was associated with self-reported wheezing and breathlessness in exposure-response manner six hour (6-hr) mean personal CO levels was not related to respiratory symptoms. This finding is consistent with those of previous studies (Kurmi et al., 2014) but does not agree with those of others (Smith et al., 2010). In this study, it was observed that the average number of hours spent in the smokehouse using biomass fuel has a strong association with respiratory symptoms. This is similar to studies done by (Alim et al., 2013). When adjusted for potential confounders including age, the reported respiratory symptoms showed high levels of significance this study again endorses Kurmi et al. (2014) whose findings indicate the risk of ever wheeziness increased with age for the biomass exposed population but not for the non-exposed population suggesting that prolonged exposure to biomass smoke increases the risk although in other studies respiratory symptoms have generally increased with age. Majority of fish smokers were above age 35 + such a finding is at variance with that of (Umoh & Peters, 2014)., who found that most of the women involved in fish smoking were aged 40+ years. This findings suggest the opportunity for public health intervention measures to educate and reduce exposures to in traditional smokehouses

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

In conclusion, this study shows that number of years spent as a fish smoker increased with increasing risk respiratory symptoms. Average number of hours spent in the smokehouse showed an exposure-response relationship with symptoms of wheezing and breathlessness. However, there was no significant association between personal CO exposure levels and respiratory symptoms.

6.2 Recommendations

Based on the evidence derived from the study and the conclusion drawn, the following recommendations have been made.

i. Ministries of Gender and fisheries should put in place educational workshop to educate women working in smokehouses on the harmful health effects relating to their work and the need for them to use of personal protective equipment (PPEs)

ii. Ministries of Gender and fisheries should collaborate with the fish smokers to improve the design and construction of locally made traditional stoves by the use of chimney, fume hoods, etc.

iii. Finally , there is the need for further studies to measure CO and PM as indicators of biomass smoke exposure and respiratory symptoms

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APPENDICES

Appendix 1: Informed Consent

Institutional Affiliation

Department of Biological Environmental and Occupational Health Sciences (BEOHS): School of Public Health, College of Health Sciences, University of Ghana-Legon.

Background

Dear participant, Alice Flintwood-Brace is my name, a student of the School of Public Health, University of Ghana, Legon. I am undertaking a study on biomass exposure in traditional smokehouses and respiratory health problems among traditional fish smokers at aboadze /abuesi.

The study hopes to assess the relationship between biomass smoke exposure and respiratory symptoms among the women who work in the smokehouses.

Procedures

The study will involve answering questions from a structured questionnaire. 24- hr personal Co monitoring. This is purely an academic research, which forms part of my work for the award of a master of public health degree .I would be very grateful to have you as part of this study.

Risks and Benefits

The study will not cause any discomfort to participants. It is hoped that results obtained for this study will be used by policy makers and the community in particular to either improve upon existing safety measures or to enforce existing ones with the objective of protecting women working in smokehouses from incidences of these respiratory symptoms and other possible diseases.

Right to refuse

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

Anonymity and Confidentiality

I would like to assure you that whatever information provided will be handled with strict confidentiality and will be used purely for the research purposes. Your responses will not be shared with anybody who is not part of the research team. Data analysis will be done at the aggregate level to ensure anonymity.

Dissemination of results

The result of this study will be sent to you if you provide your address below.

Before taking the consent, do you have any question you wish to ask about the study?

Yes (if yes, questions to be noted bellow)

No

……………………………………………………………………………………………………

……………………………………………………………………………………………………

If you have questions later, you may contact on 0208548853.

Your rights as a Participant

If you have any questions about your rights as a research participant, you can contact the Administrator of the GHS Ethical Review Committee at the following address:

Hannah Frimpong

GHS-Ethical Review Committee

Research and Development Division

Ghana Health Service

P. O. Box MB 190

Accra

Office: 0302 681 109

Mobile: 024 323 5225 or 050 704 1223

Email: Hannah.Frimpong@ghsmail.org

Consent

I……………………………………., declare that the purpose of the study have been thoroughly explained to me in Fante and I have understood. I hereby agree to answer the questions

Signature…………………………. Date………………………………

Thumb print

Interviewer's Statement

I, the undersigned, have explained this consent form to the subject in the Fante that she understands the purpose of the study, procedures to be followed as well as risks and benefits involved. The subject has freely agreed to participate in the study.

Interviewer's signature…………………………

Date……………………………..

Address……………………………

Contact of GHS-ERC Administrator

(Hannah Frimpong- 0507041223).

Appendix 2: Questionnaire

SCHOOL OF PUBLIC HEALTH

UNIVERSITY OF GHANA

DEPARTMENT OF BIOLOGICAL, ENVIRONMENTAL AND OCCUPATIONAL HEALTH (BEOH)

QUESTIONNAIRE

This research instrument is design to collect data from women working in smokehouses at Aboadze and Abuesi

INTERVIEWER:
Your participation in the study as said earlier is completely voluntary.
We would also like to assure you that all information collected in the course of the study will remain confidential.

Thanks a lot for your participation. In case you have any questions, please let us know.
Please also ask when you have a problem understanding the meaning of any of the questions

SECTION 1: SOCIO-DEMOGRAPHIC PROFILE OF RESPONDENTS

1	How old are you?	Record as mentioned:	
2	What is your relationship status?	Single	1
		Married	2
		Separated/Divorced	3
		In a relationship	4
		Remarried	5
		Widowed	6
3	What is your highest level of educational attainment?	No formal education	0
		Primary	1
		JHS	2
		SHS	3

		Tertiary	4
		Other (specify)………………………	7
4	What is the total number of people living in your household?	1 to 3	1
		4 to 5	2
		6 or more	3
5	What is your religion? Religion	Christian	1
		Muslim	2
		Traditional religion	3
		Other (specify)……………..	7
6	Would you mind if I ask you about your household's average income per month (in GHS)? Income per month	Record as mentioned:	
7	Place of residence.	Aboadze	1
		Abuesi	2
8	How many years have you lived in this community?	Record as mentioned:	
9	How many years of experience do you have in your occupation (fish **smoking)**	Record as mentioned:	

SECTION 2: ABOUT THE SMOKEHOUSE

10	What is the construction material of the smokehouse?	Wood	1
		Stone	2
		Bricks	3
		Cement	4
		Other	7
11	Which of the following types of fuel do you use in the smokehouse?	Firewood	1
		Charcoal	2
		LPG	3
		Other biomass e.g straw, tree pruning	7
12	Which is the commonest and most available type of fuel in your community?	Firewood	1
		Charcoal	2
		LPG	3
		Other biomass e.g. straw, tree pruning	7
13	Do you use this type of fuel throughout your smoking period?	No	0
		Yes	1
14	What is the mode of acquiring the biomass fuel?	Own cuttings	1
		Firewood Suppliers	2
		Industries	3
		Others	7
15	How long do you stay in the smokehouse?	1 hour	1
		2 hours	2
		3 hours	3
		4 or more continuous hours	4
16	Do you wear any form of protective materials during fish smoking?	No	0
		Yes	1

SECTION 3: RESPIRATORY SYMPTOMS

17	**COUGH** Do you usually have a cough? If No, please skip to question 19	No	0
		Yes	1
18	Do you usually cough as much as 4 to 6 times a day, 4 or more days out of the week?	No	0
		Yes	1
19	Do you usually cough at all on getting up, or first thing in the morning?	No	0
		Yes	1
20	Do you usually cough at all during the rest of the day or at night?	No	0
		Yes	1
21	Do you usually cough like this on most days for 3 consecutive months or more during the year?	No	0
		Yes	1
		Does not apply	2
22	For how many years **have you had this cough?**	Record as mentioned:	
23	**PHLEGM** Do you usually bring out phlegm from your chest?If No, please skip to question 19	No	0
		Yes	1
24	Do you usually bring up phlegm as much as 4 to 6 times a day, 4 or more days out of the week?	No	0
		Yes	1
25	Do you usually bring up phlegm at all on getting up, or first thing in the morning?	No	0
		Yes	1
26	Do you usually bring up phlegm at all during the rest of the day or at night? IF NO TO ALL, SKIP TO THE NEXT SECTION (WHEEZING)	No	0
		Yes	1
27	Do you bring up phlegm like this on most days for 3 consecutive months or more during the year?	No	0
		Yes	1
28	For how many years have you had trouble with phlegm?	Record as mentioned:	
29	Have you had periods or episodes of (increased) cough and phlegm lasting for 3 weeks or more each year ?	No	0
		Yes	1
30	**WHEEZING**Does your chest ever sound wheezy or whistling when you have a cold?	No	0
		Yes	1
31	Does your chest ever sound wheezy or whistling occasionally apart from cold?	No	0
		Yes	1
32	Does your chest ever sound wheezy or whistling most days and nights?	No	0
		Yes	1
33	If you answered YES to questions 30, 31 or 32, how many years has this condition been present	Record as mentioned:	
34	Have you ever had an attack of wheezing that had made you short of breath?	No	0
		Yes	1
35	If you answered YES to question 34, how many times have you had this experience in the past 1 year?	Record as mentioned:	
36	How many years has this condition been present?	Record as mentioned:	
37	How old were you when you had your first such attack?	Record as mentioned:	

38	**BREATHLESSNESS**Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill?	No	0
		Yes	1
39	If yes to 38, do you have to walk slower than people of your age on level because breathlessness?	No	0
		Yes	1
40	Do you ever have to stop for a breath when walking at your own pace on level?	No	0
		Yes	1
41	Are you too breathless to leave the house or on dressing?	No	0
		Yes	1
42	**CHEST COLDS AND CHEST ILLNESS** If you get a cold, does it usually go to your chest?	No	0
		Yes	1
43	During the past 3 years, have you had any chest illnesses that have kept you off work, in doors at home, or in bed?	No	0
		Yes	1
44	Did you produce phlegm with any of these chest illnesses?	No	0
		Yes	1
45	In the last 3 years, how many such illnesses, with (increased) phlegm, did you have which lasted a week or more?	Record as mentioned:	
46	**PAST ILLNESSES** Did you have any lung trouble before the age of 16?	No	0
		Yes	1
47	Have you ever had any attacks of bronchitis?	No	0
		Yes	1
48	If you answered yes to question 47, did a doctor diagnose it?	No	0
		Yes	1
49	At what age (in years) did you first experience it?	Record as mentioned:	
50	Have you ever had any attacks of Hay fever?	No	0
		Yes	1
51	If you answered yes to question 50, did a doctor diagnose it?	No	0
		Yes	1
52	At what age (in years) did you first experience it?	Record as mentioned:	
53	Have you ever had chronic bronchitis?	No	0
		Yes	1
54	If you answered yes to question 53, did a doctor diagnose it?	No	0
		Yes	1
55	At what age (in years) did you first experience it?	Record as mentioned:	
56	Do you still experience it?	No	0
		Yes	1
57	Have you ever had pneumonia?	No	0
		Yes	1
58	If you answered yes to question 57, did a doctor diagnose it?	No	0
		Yes	1
59	Have you ever had asthma?	No	0
		Yes	1
60	If you answered yes to question 59, did a doctor diagnose it?	No	0
		Yes	1
61	If you answered yes to question 59, do you still experience	No	0

	the asthma?	Yes	1
62	Do you experience any other chest illness?	No	0
		Yes	1
63	If you answered yes to question 62, please specify	Record as mentioned:	

THANK YOU VERY MUCH FOR PARTICIPATING IN THIS STUDY

Appendix 3: Ethical Clearance

GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

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

My Ref. GHS/RDD/ERC/Admin/App/
Your Ref. No.

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

Alice Flintwood - Brace
University of Ghana
School of Public Health
Legon, Accra

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

GHS-ERC Number	**GHS-ERC 96/12/15**
Project Title	Biomass Exposure in Traditional Smokehouses and Respiratory Health Problems among Traditional Fish Smokers at Aboadze/Abuesi in the Western Region of Ghana
Approval Date	8th June, 2016
Expiry Date	7th June, 2017
GHS-ERC Decision	**Approved**

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.

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

SIGNED...
DR. CYNTHIA BANNERMAN
(GHS-ERC CHAIRPERSON)

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