ASSESSMENT OF PREGNANT WOMEN'S AWARENESS AND KNOWLEDGE OF MERCURY TOXICITY IN SMOKED FISH ON PREGNANCY OUTCOMES IN GREATER ACCRA REGION

BY

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DECLARATION

I, Faustina Vimariba Tour, hereby declare that this work is the result of my own research and that this dissertation has neither in whole nor in part been submitted to this University or elsewhere for another degree. All references to other people's work which served as a source of information in this research have been duly acknowledged.

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ABSTRACT

Background: Fish is recognised as a rich source of quality protein and other essential nutrients including omega-3 fatty acids needed for good health. However, it may be contaminated with mercury above tolerable limits which may pose health risks to consumers especially pregnant women and the developing foetus. The aim of this study was to assess the knowledge level of pregnant women on mercury toxicity in fish on pregnancy outcomes and determine the concentration of mercury and proximate composition of smoked fish.

Methodology: This was a cross-sectional study conducted among 384 pregnant women attending Adabraka Clinic, Madina Polyclinic and Tema General Hospital. A semi-structured questionnaire was used to gather information on participant's demographic characteristics, identify widely and frequently consumed fish and knowledge of mercury toxicity from fish consumption on pregnancy outcomes. Focus group discussion was organised among fish sellers to identify the most dominant and widely purchased fish.

The most widely consumed smoked fish species, apataa (*tilapia zilli*), brolovi (*chrysichthys nigrodigitatus*), salmon (*scomber japonicas*), herrings (katsuwono pelamis), tuna (*Sardinella* maderensis), saflo (*caranx crysos*), Oheneba (*bagrus bayad*) and red fish (*entex angolensis*) as reported by the pregnant women were bought from Madina, Tema and Adabraka markets and transported in polyethene bags to the laboratory for proximate analysis and determination of mercury concentration.

Results: Most (68.8%) of the participants consumed fish 5-7 meals/week. Though**,** more than half (57.3%) of the pregnant women who took part in this study were aware of mercury contamination of fish the majority (65.5%) of them had poor knowledge of its toxicity on pregnancy outcomes. All the analysed smoked fish species had high levels of protein, fat,

fibre and ash content. The mercury concentrations of the analysed smoked fish samples were all within the recommended (0.2 µg/g wwt) allowable safe limit intake for pregnant women except apataa (0.327±0.006 µg/g) from Madina and Brolovi from Tema (0.214±0.023 µg/g) and Adabraka (0.347±0.03 µg/g). All the fish species had lower target hazard quotients (THQ) values less than 1 (THQ < 1) except apataa (1.42) and brolovi (1.50) from Madina and Adabraka markets respectively.

Conclusion: Majority of the pregnant women consumed fish 5-7 meals/week and the most frequently consumed fish was herring. More than half of the pregnant women were aware of mercury contamination in fish but majority had poor knowledge of its toxicity on pregnancy outcomes. Mercury concentration and THQ were high in apataa from Madina and Brolovi from Tema and Adabraka. The high THQ in these fishes may pose health risk to pregnant women. There is the need to educate the general public especially pregnant women on mercury contamination of fish and its possible health risk on pregnancy outcomes.

DEDICATION

To my husband and children.

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LIST OF ABBREVIATIONS

CNS	Central Nervous System
FAO	Food and Agriculture Organization
FSS	Food Safety Surveys
Hg	Mercury
IMT	Intima-Media Thickness
IUGR	Intrauterine Growth Retardation
LSD	Least Significant Difference
MeHg	Methylmercury
PAHs	Polycyclic Aromatic Hydrocarbons
RfD	Oral Reference Dose
SPSS	Statistical Package for the Social Scientist
THg	Total Mercury
THHg	Total Hair Mercury Level
THQ	Target Hazard Quotient
USEPA	United State Environmental Protection Agency
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Globally, fish is a major source of protein and vital micronutrients for people. Compared to meat, fish is relatively abundant, cheap, contain complete amino acid composition, are easily digestible and are an excellent source of high quality protein (Louka, Juhel, Fazilleau and Loonis, 2004). The increase in human population has increased the need for food supply and approximately 1.5 billion people worldwide obtain their animal protein from the consumption of fish (FAO, 2013). Generally, there has been an increase in the consumption of fish and fish products globally in recent decades (Pauly, Christensen, Guénette and Pitcher, 2002). In 1997, fish consumption in developing countries was estimated to be 62.7 million metric tons and was predicted to increase to 98.6 million in 2020 (Delgado, 2003). Fish contributes 4.3% of total protein source in Africa. In Ghana, fish is recognized as a valuable source of animal protein, and provides over 60% of animal protein intake (Koranteng, Hutchful and Tetebo, 2004).

The importance of fish protein in human nutrition is well established in the literature. Apart its fundamental function of body building, fish is associated with brain development, cells repair, and growth and neurodevelopmental outcomes (Hibbeln *et al*., 2007; Oken *et al*., 2005). Moreover, regular consumption of fish is recognized as one of the best means of providing the body with essential nutrients, particularly polyunsaturated fatty acids. Despite these health benefits, contamination of fish with heavy metals particularly mercury, a known neurotoxicant, which poses adverse health risk has been widely reported. Globally, Mercury (Hg) has been reported as one of the prioritized environmental pollutants that can be converted to methylmercury (MeHg) when it enters aquatic food chains. Mercury, and its aquatic pollutant, methylmercury, are easily produced from such sources and endanger aquatic habitat as well as posing major human health risk when contaminated fish is consumed. Reports shows that methylmercury concentration in fish and shell fish is approximately 1000–10 000 times more than in other sea foods (Rice,Swartout,Mahaffey and Schoeny, 2000).

Some level of methyl mercury is present in all fish; however, higher levels may be present due to contamination of water bodies and other processing activities of aquatic food for human consumption. Also fish may be contaminated with mercury when they feed on mercury polluted vegetation and subsequently the mercury becomes biomagnified in the fish (Agusa *et al.*, 2005). Research indicates that mercury contamination in fish is implicated in many human health related issues with resulting effects more obvious in pregnancy outcomes. For instance, a study in South Carolina on mercury in fish and adverse outcomes revealed that women with low birth weight infants were more likely to live in areas with high mercury exposure levels as compared with women having normal birth weight infants (Burch *et al.*, 2014). A tolerable level of methylmercury in fish products and crustaceans of 0.50 mg Hg kg^{-1} have been set by the European Union as safe to pose no health risk (WHO, 2002). Studies by Burger, Gochfeld and Fote (2013), and Bortey-Sam *et al*. (2015), however, indicate that consumption of fish remain the major source of human exposure to mercury. A study by Obeid *et al*. (2017) to assess mercury health risk among young Lebanese population showed that total hair mercury level (THHg) was significantly correlated with higher fish consumption ($r = 0.27$; $p = 0.001$).

For the past decade, Ghana has witnessed a tremendous industrial growth. The growth of industries such as petrochemical plants, petroleum refineries, and mining companies are the main source of the pollution burden into the marine environment. The mercury and methylmercury contaminants concentrations in fish from water bodies and processing methods are not adequately studied particularly the known potential human neurotoxicant, methylmercury, which usually constitutes at least 90% of the total mercury (THg) load in fish (Campbell, Verburg, Dixon and Hecky, 2008). This study, therefore, sought to assess the knowledge level of pregnant women on mercury toxicity in fish on pregnancy outcomes and determine the concentration of mercury and proximate composition of smoked fish in the Greater Accra Region.

1.2 Rationale

Smoked fish, a delicacy in Ghana, is widely eaten by many people because of its unique characteristic taste and serves as the main source of protein for most Ghanaians, particularly those along the coastal belt. It is a cheaper source of protein and easy to preserve in contrast with fresh meat. Despite the nutritional and health benefits associated with the consumption of fish, it may be contaminated with methylmercury, a known neurotoxicant which has adverse effects on health. Studies by Asare-Donkor and Adimado (2016) and Essumang (2009) have shown that the activities of small scale mining lead to leaching of mercury and thus methyl mercury into water bodies in concentrations that are above the allowable intake levels. Fish consumption with higher levels of methyl mercury may pose health risks to the individual and during pregnancy it is especially harmful to the growing foetus. Some of the adverse consequences include low birth weight, preterm babies, poor cognitive development and other effects on the developmental milestones in children. The study therefore, sought to assess the knowledge level of pregnant women on mercury toxicity in fish on pregnancy outcomes and determine the concentration of mercury and proximate composition of smoked fish. This study will contribute to the body of scientific knowledge and provide data that will inform the design of interventions and for policy planning.

1.3 Objectives of Study

1.3.1 Main Objectives

The main objective of this study was to assess the knowledge level of pregnant women of mercury toxicity in fish on pregnancy outcomes and determine the concentration of mercury and proximate composition of smoked fish in the Greater Accra Region.

1.3.2 Specific Objectives

1. To assess the frequency of consumption of fish among pregnant women
2. To conduct a survey to identify the dominant smoked fish sold in the market and those that are widely purchased.
3. To assess the knowledge level of the effects of fish contamination with mercury on pregnancy outcomes.
4. To determine the proximate composition of the selected fish sample
5. To determine the concentration of mercury in selected smoked fish
6. To determine health risk assessment associated with mercury concentration in fish

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Fish Nutrition

Fish consumption is being promoted as a healthy component of a balanced diet because it provides essential nutritional benefits. Fish serves as good source of omega-3 fatty acids, proteins, and other essential micronutrients needed to ensure good health (Gebauer, Psota,harris and Kris-Etherton, 2006). The omega-3-fatty acid from fish contributes to neurotransmission and also provides cardio-protective effects.

Fish or fish oil consumption has been associated with growth and normal brain development (Hibbeln *et al*., 2007; Oken *et al*., 2005) and decreased weight and waist circumference (Bender, 2014). Again some studies (Leventakou *et al*., 2014; Taylor, Golding and Emond, 2016) have reported the benefits of high fish consumption among pregnant women including reduced prevalence of pregnancy related complications such as pregnancy-induced hypertension, high birth weight, and reduced risk of intrauterine growth retardation (IUGR). In some cultures, fishing and fish consumption are also important contributors to social, mental, and spiritual health (Johnston, Hoffman, Wing and Lowman, 2016). However, metal concentrations in fish, particularly mercury, and other organic pollutants such as Polycyclic Aromatic Hydrocarbons (PAHs), make it difficult to establish clearly the benefits of fish in a healthy diet.

2.2 Sources of Fish

Ghana, like many African countries, is endowed with rivers, lakes and Seas. These water bodies constitute a rich source of numerous species of fish for many people. Pollution of these water bodies by organic pollutants and heavy metals from mining activities and other industrial discharge affect the safety of fish consumed. Marine and freshwater constitute the main source of fish consumed in Ghana with the marine sub-sector serving as the most important source of fish production, delivering more than 85% of the total fish supply (Nunoo and Asiedu, 2013).

2.3 Characteristics of Mercury

Mercury, commonly known as quicksilver, is a naturally occurring element and the only metal that is liquid at room temperature. The metal and its compounds have no known physiologic functions but poses health risk to humans (Nabi, 2014). Mercury is silver in colour with a metallic lustre. Mercury exists in three major forms, elemental, inorganic, and organic mercury. In the inorganic form, the metal exists in three oxidation states: elemental (Hg^o), mercuric ion (Hg^{2+}) and mercurous ion (Hg^{2+}) (Hamann *et al*., 2014). All these forms of mercury act similarly with regard to damaging cells at a molecular level, but the elemental form is the most toxic (Santos-Gandelman *et al*., 2014).

The well-known organic form of mercury, methylmercury, results from methylation by microorganisms in the aquatic environment and bioaccumulation in the food chain. The proportion of methylmercury concentration present in total mercury in most fish species have been reported to range from 75 to 100% (Burger and Gochfeld, 2004). Research into mercury toxicity has focused on methylmercury due to its ability to cross the blood- brain barrier to cause neurological damage and foetal abnormalities. Mercury freezes at -39^{o}C and has a boiling temperature of 357^{o}C.

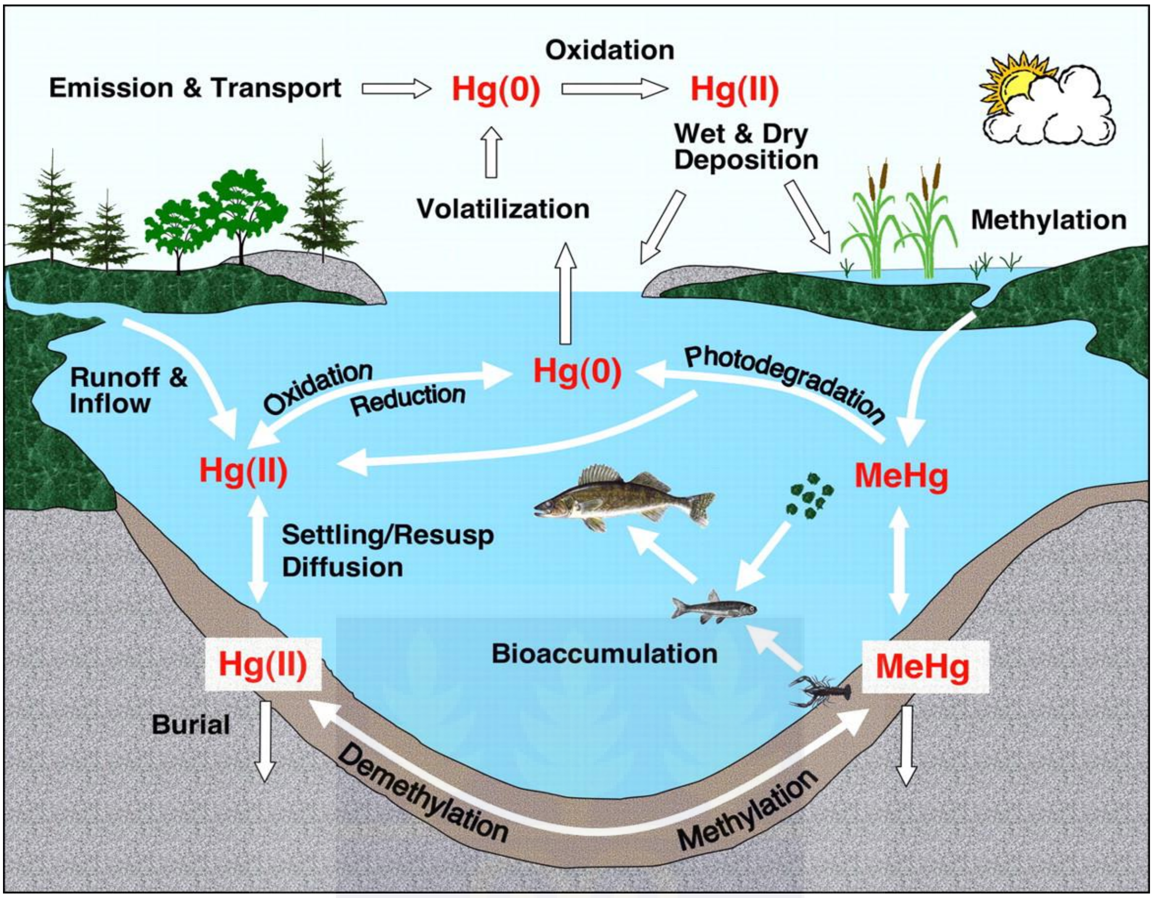

Figure 2.1: Methylation and Bioaccumulation of Mercury in the Aquatic Food chain (Engstrom, 2007).

2.4 Sources of Mercury

The release of mercury into the environment may result from emission from both anthropogenic and natural sources. Naturally mercury is found in the environment but its concentration has increased greatly due to human activities, accounting for about 80% of global emissions (Mahaffey, 1999). Environmental pollution of mercury from anthropogenic sources includes coal-burning facilities, industrial processes including mining activities and some consumer products (batteries, thermometers). Natural occurrences include volcanic activities, weathering of rocks, flooding, volatilization from the ocean, and forest fires (Mahaffey, 1999; Schuster *et al*., 2002).

2.5 Mercury Exposure and Toxicity

Most metals especially mercury has been well recognised several decades as an environmental pollutant and poses a threat to human health. As early as the 1950's, it was established that emissions of mercury to the environment could have serious effects on human health. Mercury is toxic and poses health risk to humans if levels exceed certain thresholds (Laws, 2000; Carvalho, Santiago and Nunes, 2005). Urbanization and increase in population may be the main contributors to the elevated levels of mercury in the atmosphere (Voegborlo and Akagi, 2007). Mercury exposure to humans is mainly from fish consumption which may result in both chronic and developmental toxicity (Clarkson, Magos and Myers, 2003). Toxicity varies according to the different chemical forms of mercury and their ability to interfere with enzyme-mediated processes and disruption of cellular structure (Laws, 2017). The most toxic and most reported form is the organic form, methylmercury, due to its unique biochemical properties.

The most stable form of mercury is its organic form, methylmercury, which is taken up by the body through the consumption of seafood. It has been estimated that more than 95% of consumed methylmercury is absorbed from the intestinal tract and eventually distributed to all tissues and target organs via the bloodstream (Guynup and Safina, 2012). methylmercury has lipophilic characteristic which means it penetrates the blood–brain barrier and the placenta where it causes damage to the central nervous system (CNS) and the developing foetus (Aschner, 2002). This happens prenatally when the foetus brain is developing more rapidly (Myers and Davidson, 2000). The accumulation of methylmercury in the brain results in loss of cells in specific brain areas such as the cerebellum, visual cortex and vital parts of the brain. The neurotoxicity of methylmercury was first reported in Minamata in Japan, during 1956 when humans consumed methylmercury-contaminated fish and shellfish which resulted in the death of almost half of the people infected with the ‘Minamata disease’

(Harada, Akagi,Tsuda,Kizaki and Ohno, 1999; Clarkson, Magos and Myers, 2003). The neurotoxicity of methylmercury is articulated to the fact that a high proportion (98%) accumulates in the brain. While some studies (Carocci ,Rovito, Sinicropi and Genchi, 2014, Taylor *et al*., 2016)) have reported no adverse effect of prenatal or postnatal and foetal methylmercury exposure, others (Grandjean, White, Weihe and Jorgensen, 2003; Strain *et al*., 2015) have showed that prenatal exposure to methylmercury is associated with neurodevelopmental deficits, specifically learning and memory.

2.6 Health Effects of Mercury Exposure from Fish Consumption

Although the consumption of fish provides essential nutritional benefits, they may be contaminated with mercury which may pose health risk to consumers. The contaminants levels in fish especially mercury are of interest not only because of the potential negative effects on the fish themselves, but also because of the health risk on humans that consume them (Hylland, 2006). Health effects from mercury exposure from fish consumption include neurological impacts (Harada, 1995), cardiovascular risks, (Roman *et al*., 2011; Stern, 2005) immune function impairment (Karagas *et al*., 2012), and adverse pregnancy outcomes. People at risk of mercury toxicity from fish consumption are women of reproductive age, pregnant women, nursing mothers, developing foetus and frequent fish consumers (Legrand, Feeley, Tikhonov, schoen and Li-Muller, 2010; Wilson, 2004).

2.6.1 Neurological Effects

The neurological impacts of methylmercury from fish consumption have been widely reported in the literature. Epidemiology studies in animals and humans indicate that exposure to methylmercury may have adverse health effects on neurologic function in both adults and children (Harada *et al*., 1999). Neurological problems were earlier reported in 1956 in Japan, Minamata, where effluents from a chemical plant were discharged into the

Minamata Bay and Agano River. This resulted in methylmercury accumulation in fish and shellfish and subsequently causing a mass poisoning of people who consumed these contaminated fish; (Harada *et al*., 1999), . It was termed as the 'Minamata disease' characterized mainly by neurological defects and deficits in sensation, vision, and hearing (Harada *et al*., 1999; Uchino *et al*., 2005). Neurological problems were high among children who were highly exposed in utero and resulted in neurotoxic effects including cerebral palsy, cognitive impairment and low birth weight (Karagas *et al*., 2012)

In a comparative study in Japan, Ninomiya, Ohmori., Hashimoto, Tsuruta, and Ekino (1995) in their long-term cohort study of low-dose methylmercury exposure, reported typical neurological symptoms (ataxia, hypoesthesia, impairment of hearing, and dysarthria) in participants from the fishing village in comparison to a non-polluted fishing village. A cross-sectional study in another fishing village in Brazil showed that hair mercury levels between 0.56 and 13.6 ppm were associated with disruptions of motor speed, dexterity, verbal learning, and memory (Yokoo *et al*., 2003). Findings from these studies show that chronic low-dose dietary exposures to methylmercury potentially affect neurological functioning.

Reports from animal studies also indicate that methylmercury exposure can adversely affect the central nervous system (CNS). A study conducted by Montgomery *et al*. (2008) demonstrated that adult mice that were exposed to low levels of methylmercury during prenatal development exhibited impaired motor function, decreased memory retention, and produced permanent changes in cerebellar circuitry. This study showed that even low level exposure to mercury affected brain development and functioning.

2.6.2 Cardiovascular Risk

Cardiovascular risk associated with mercury exposure is an increasing area of research. There is a growing body of evidence suggesting the potential association between methylmercury exposure and an increased risk of developing cardiovascular disease (Roman *et al*., 2011) . The strongest evidence is the association between methylmercury exposure and acute myocardial infarction (Roman *et al*., 2011; Stern, 2005). The cardiovascular outcomes of methylmercury exposure include atherosclerosis, acute myocardial infarction, heart rate variability, and increased blood pressure (Roman *et al*., 2011). In a study by Choi *et al*. (2009) to assess the possible cardiovascular health effects from methylmercury exposure, the authors concluded that long-term methylmercury exposure was significantly associated with the development of cardiovascular disease, as indicated by increased blood pressure and increased intima-media thickness (IMT) of carotid artery. A case-control study by Gullar (2002) and a prospective cohort study by Virtanen *et al*. (2005) have also shown strong evidence for an association between the risk of cardiovascular disease and exposure to mercury in adult men with the risk increasing levels of mercury exposures. In a large cohort study among 1871 elderly men in Finland, Virtanen *et al*. (2005) reported a strong positive association of hair mercury levels with acute coronary problems and cardiovascular disease. In contrast to these cardiovascular effects associated with mercury exposure, other authors (Hallgren *et al.*, 2001; Mozaffarian *et al*., 2011) have found non-significant associations with mercury exposure and cardiovascular health effect.

2.6.3 Immune Effects

Fish consumption can be harmful or beneficial to human immune system depending on the level of contaminants. Frequent fish consumption can promote the defence mechanism for protection against invasion of human pathogens because fish has antimicrobial peptides

(Ravichandran *et al*., 2010). On the other hand, methylmercury exposure may impair immune function although data are limited. High methylmercury levels exposure results in reduced cell function and immunotoxic changes in lymphocytes and decreased phagocytic ability (Shenker,Guo and Shapiro, 1998). In a cross-sectional national adult survey in USA, Somers *et al*. (2015) found an association of hair and blood mercury levels with anti-nucleolar auto-antibodies. In an in-vitro toxicological experiment, a high dose of methylmercury exposure to human immune cells prevented B cell proliferation, and these suppressive effects were more severe when the exposure occurred before immune cell activation (Shenker *et al*., 1998). Additionally, high exposure to methylmercury causes lymphocytes and monocytes to undergo apoptosis 16-24 hours after exposure (Shenker *et al*., 1998). Since the immune system functions in host defence, these reports may have important implications for human health due to methylmercury exposures in the environment.

2.6.4 Pregnancy Outcomes

It is evident that mercury in fish is implicated in health issues related to humans. Pregnant women may exhibit paraesthesia at lower methylmercury exposure levels than non-pregnant women, suggesting a greater risk for pregnant women (WHO, 1990). Several studies have been conducted to determine the public health impact of mercury consumption, most of these studies focus on pregnant women, teenagers and young children. Pregnant women can easily transfer mercury through the placenta to the developing foetus to cause foetal abnormalities and neurological damage (Arbuckle *et al*., 2016). A cohort study in New Zealand found that there was a three-point deficiency in IQ scores of children whose mothers had greater than 6 micrograms of mercury/gram of hair sample (Trasande, Landrigan and Schechter, 2005). There have also been reports on a significant dose-response relationship between prenatal mercury exposure and adverse effects on developmental aspects such as memory, attention, and visual-spatial perception tests. A recent study by Tatsuta *et al*. (2017a) has found a significant association of cord-blood THg with low birth weight. This was observed in the male newborns, but not in the females.

Trasande *et al*. (2005) attempted to quantify the economic and public health costs of methylmercury toxicity by comparing the concentrations of mercury in cord blood to the loss of intelligence in children. They estimated that the loss of productivity amounts to about 8.7 billion dollars annually and urge stronger controls of mercury emissions into the environment. Saccone and Berghella (2015) reported that the supplementation of fish oil to women who previously had delivered a pre-term baby, appeared to be associated with longer latency and greater weight at birth and further elaborated that the supplementation did not appear to be associated with differences in risk of another pre-term birth.

As a result of pregnant women consuming fish with high levels of methylmercury, from the incidence of mass mercury poison in Japan, their children had cerebral palsy (Harada *et al*., 1999). A study in South Carolina on mercury in fish and adverse outcomes revealed that women with low birth weight infants were more likely to live in areas with higher predicted total mercury levels as compared with women having normal birth weight infants (Burch *et al*., 2014). Jeong *et al.* (2017) in their recent study concluded that fish intake is an effect modifier of child IQ and further stated that high maternal blood mercury level is associated with low verbal IQ in children.

Again, Tatsuta *et al*. (2017b) concluded in their 18-month follow-up of children prenatally exposed to methylmercury that intrauterine methylmercury exposure may affect psychomotor development, boys appeared to be more vulnerable to exposure than girls.

To protect vulnerable groups in particular, pregnant women, those under 15 years of age, and frequent fish consumers, from mercury toxicity as a result of fish consumption, the World health Organisation (WHO) has recommended the lower T-Hg guideline of 0.2 µg/g wet wt. (WHO, 1990).

2.7 Mercury Variability in Fish

Exposure to methylmercury largely depends on the type and frequency of fish species consumed. Mercury concentrations in fish are highly variable and may depend on several factors including fish body size, type, trophic level and source of fish (Piraino and Taylor, 2009). Another important factor for mercury contamination and variability in fish include bioaccumulation process based on its bioavailability, uptake, toxicokenetics and physiological differences among fish species (Buger and Gochfeld, 2001).

Studies (Sunderland, 2007; Karimi,Fitzgerald and Fisher, 2012) have documented different contents of mercury in different fish taxa and concluded that this mercury variability may be due to the above mentioned factors. Karimi *et al*. (2012) in their recent review reported that the concentration of mercury within a taxon may vary, ranging from 0.3–2.4 orders of magnitude, depending on the taxon. This variability often poses a challenge in estimating mercury exposure from the consumption of seafood, and makes it difficult to assess and measure the risk associated with consuming specific fish taxa. Source of fish have also been reported to determine the concentration of mercury. Shah, Kazi, Afridi and Arain (2016) reported in their assessment of mercury exposure from two cities of Pakistan with respect to freshwater and marine fish consumption that the levels of mercury in freshwater fish were significantly lower than in marine fish species ($p < 0.001$).

Among all the factors associated with mercury content, body size has been widely reported to be more strongly associated with the concentration of mercury (Karimi *et al*., 2012). This is because larger fish eat higher trophic level prey which may have significant amount of concentration of mercury. However, Burger and Gochfeld (2011) have also reported that the concentration of mercury is more strongly correlated with age than length or weight of the fish. Generally, this study showed all the factors (fish size, age, trophic level, source of food and geographic region) each have an influence on the mercury content of fish.

2.8 Fish Consumption Pattern

Globally, the consumption of fish and its products have generally increased in recent times (Olsen, Scholderer,Brunso,2007; Verbeke, Sioen,Pieniak , Van and De Haenauw, 2005) as a result of the shift from animal protein to fish protein which has less cholesterol levels (Sen, Shandil and Shrivastava, 2011). Based on this increasing demand in the world, the quality and safety of fish and fishery products has, therefore, become a major issue around the world (Ababouch, 2006).

Fish is a major source of protein and other nutrients worldwide. The consumption of fish has been reported to be the best source of fat-free protein and vitamins (Patade, 2005). The presence of omega-3-fatty acids in oily fish provides optimum brain function, help reduces the risk of developing cardiovascular diseases, strokes and osteoporosis but they also contain methylmercury, a neurotoxin which can pose health risk to humans especially pregnant women and the foetus.

In many African countries, the consumption of fish is relatively high particularly in coastal countries than the hinterland. The West African coastal region annual average fish consumption is approximately 20 kg per capita. However Sahel countries of Chad, Mali and the Sudan, per capita fish consumption is lower, ranging from 2 to 9 kg per annum. In many countries in Africa the per capital fish consumption also varies within the country depending on the proximity to the source of fish. In Ghana for instance the per capital fish consumption is higher in the coastal part of the country especially people living around the harbour, the sea and the Volta lake. Ecological factors, income levels, traditional beliefs, house rearing system, as well as urbanization, and the type of animal protein available in a community may also influence fish consumption pattern.

In Ghana about 60% of protein is derived from fish and the pattern of fish consumption depends on how the fish is prepared (Essuman, 1992). It is reported that the pattern of consumption of frozen/fresh fish, smoked fish and fried fish is 20%, 60% and 5% respectively with the per capital fish consumption been 20.0kg, the second highest to Senegal (20.7kg) in Africa (Essuman, 1992). This is reported to be nearly twice the world's average of 13kg.

The relatively low level of fresh fish consumption may be due to a lack of proper storage facilities and poor road system, making it difficult for efficient distribution of fish to consumers. This means about 80% of fish consumed in Ghana are cured. That is either smoked, salted or fried. More than 60% of the people in Ghana prefer to use smoked fish for their soups. Smoking is thus the main method of fish preservation in Ghana. Smoked fish is available throughout the year. The reasons for the choice of smoked fish include its price, availability and flavour.

2.9 Mercury Regulation from Fish Consumption

The risk of eating fish and shellfish contaminated with mercury is not a health concern for most people. Some species of fish, however, contain considerably high levels of mercury that are likely to pose neurological threat to the developing foetus. This is of global health concern and has led to mercury regulation by many agencies and environmental bodies setting tolerable limits that are likely to pose no mercury related health risk to consumers, especially vulnerable groups like pregnant women, nursing mothers and young children. For instance, the US Environmental Protection Agency and the US Food and Drug Administration recommend that pregnant women limit their total fish intake to no more than 2-6 ounce servings per week and avoid eating large predatory fish. The concentration limit for mercury in fish for human consumption is set at 0.5 μgg^{-1} wet weight, (ww), (EEC, 2001; US EPA, 1997); and 0.2 μgg^{-1} (ww) (WHO, 1990) for vulnerable groups, such as pregnant women, individuals under 15 years or frequent fish consumers.

In Ghana reports indicates that mercury concentration in fish samples from the Atlantic coast of Ghana had mercury concentrations less than the WHO limit of 0.5μgg^{-1} wet weight (Voegborlo and Akagi, 2007). In contrast, Gbogbo and Otoo (2015) in their work to assess concentrations of heavy metals in components of an economically important urban coastal wetland in Ghana concluded that mercury concentrations in wetland's resources (fish) were above recommended guidelines and were unsafe for regular human consumption. Other organic pollutants have also been documented in fish above tolerable limits in Ghana, making it unsafe for human consumption (Nyarko and Klubi, 2011). In Ghana there are no known set limits by regulatory agencies regarding the safe limit of fish consumption for the general public and vulnerable groups.

2.10 Awareness of Mercury Toxicity

Studies have shown that high concentrations of methylmercury in fish can cause irreversible and fatal neurological effects in humans, and is even more toxic to the developing nervous systems of foetuses and infants. This results from the consumption of contaminated fish. It is, however, not advisable to eliminate fish from our diet because of mercury contamination considering the benefits of fish to humans. It is therefore more beneficial to assess public awareness on mercury contamination of fish and equip the public with information and guidelines to make better choices in their diets. Birch, Bigler, Rogers, Zhuang, and Clickner (2014) emphasized that the advisory issued jointly by the U.S. EPA and the U.S. FDA recommends to, "check local advisories about the safety of fish caught by family and friends in your local lakes, rivers, and coastal areas with the main targets been women of child bearing age and women with young children". In a national pooled data analysis from 2001 and 2006 Food Safety Surveys (FSS) among US population, Lando and Zhang (2011) found an increase in awareness from 69% to 80% respectively. Regular screening for mercury in bloodstream could in many ways help increase public awareness and education for people whose main source of protein is fish.

2.11 Health Risk Assessment of Mercury

The US Environmental Protection Agency (USEPA) defines health risk assessment as the description of the potential adverse health effects of humans as a result of contaminant exposure (Koki, Bayero, Umar and Yusuf 2015). Fish consumption is an important source of proteins and other minerals but can pose serious health risk to consumers when contaminated with heavy metals and organometals.

Several methods have been proposed for estimation of the potential risks to human health caused by toxic metals. Among them is the common parameter, the target hazard quotients (THQ), proposed by the US Environmental Protection Agency (USEPA), which has been recognized as an important index for the assessment of heavy metals intake by consumption of contaminated food (Malakootian, Mortazavi and Ahmadi (2016). The THQ is a ratio of the dose intake of a toxic metal to the oral reference dose (RfD) proposed by the USEPA.

THQ has no unit and value above 1 means that contaminated foods (fish) intake may have harmful effects on the exposed population. The higher the THQ value is, the higher the likelihood of the toxic contaminant to pose health risk to consumers. THQ of some metals in fish species in Ghana have been reported to be less than 1 and did not indicate a danger to the local fish consumers (Bandowe *et al*., 2014). However, Asare-Donkor and Adimado (2016) in their work found the influence of mining related activities on levels of mercury in water, sediment and fish from the Ankobra and Tano River basins in South Western part of Ghana, high THQ far above one was reported for the analysed fish and attributed it to pollution of the source of these fish.

2.12 Proximate Analyses

Proximate analysis of food involves the determination of moisture, crude protein (CP), lipid and ash contents (Ali, Ahmadou,Mohamadou, Saidou and Tenin, 2011). Determining proximate composition of fish will provide knowledge on the nutrient content and be useful to consumers in choosing fish based on their nutritive value. It is also important to estimate their energy value and to ensure that they meet the dietary requirements and commercial specifications (Watchman, 2000; Annathai, Shakila and SA, 2014). The biochemical composition of fish is generally 70 to 80% water, 15 to 20% protein, 2 to 12% lipid and 1 to 2% minerals (Annathai *et al*., 2014). However, the nutrient composition of fish may vary depending on the seasons, type of species, feeding behaviour and geographic variations (Annathai *et al*., 2014).

2.12.1 Moisture

Moisture is an important factor in food quality, preservation and resistance to deterioration. The main constituent of fish is water which accounts for about 80% of the weight. The percentage of water is good indicator of its relative contents of energy, proteins and lipids

(Dempson, Schwarz,Shears and Furey, 2004). Studies on proximate analysis of fish on wet basis have found an average moisture contents of some fish species to range from 67% - 81% (Annathai *et al*., 2014), 65.6%-72.8% (Ali *et al*., 2005), 59.3-82.1% (Nurnadia, Azrina, & Amin, 2011), 75.9%-78.1% (Teame, Natarajan, & Tesfay, 2016). High moisture content in fish may increase susceptibility to microbial spoilage, oxidative degradation of polyunsaturated fatty acids and could make it unwholesome for preservation purpose (Adewuni ,Adewole and Olaleye, 2014).

2.12.2 Crude Protein

Generally, fish are low in fat and carbohydrate contents, but present high quality source of protein. The lower the percentage of water in fish, the higher the crude protein content (Aberoumad and Pourshafi, 2010). It is also inversely proportional to crude fat. Crude protein has been reported to be high in smoked fish than fresh or other processed fish (Chuku, 2009; Kumolu-Johnson, Aladetohun and Ndimele, 2010; Holma and Maalekuu, 2013).

2.12.3 Crude Fat

Fish can generally be put into four groups according to their fat content: lean fish (<2%), low fat (2–4%), medium fat (4–8%), and high fat (>8%) (Ackman, 1989). Low moisture content has been correlated with high fat content in fish (Aberoumad and Pourshafi, 2010).

2.12.4 Ash

Ash is a measure of the total amount of mineral within a food. It is the inorganic residue that is left after the water content and organic residue have been removed or dried by heating. Most analytical techniques have been employed to measure the ash content of food with the principle of not heating above temperatures to destroy the mineral content because they have low volatility compared with other food components (Clement and Lovell, 1994).

Mineral concentration and trace elements content that contribute for the total ash are known to vary in fish depending on their feeding behaviour, environment, ecosystem and migration even within the same area (Canli and Atli, 2003). Ash content is also generally influenced by fish size. Smaller sized fish species tend to have higher ash content due to the higher bone to flesh ratio (Daramola, Fasakin and Adeparusi, 2007). Minerals in fish are generally higher in marine fish than in fresh water fish (Adewumi Adewole and Olaleye, 2014).

2.12.5 Crude fibre

Dietary fibre consists of polysaccharides and lignin that are not digested by human digestive enzymes. The major components of dietary fiber include cellulose and noncellulose. Human foodstuffs contain mainly noncellulose polysaccharides, some cellulose and little lignin. The average proportions of noncelluloe polysaccharides according to a study by Laura, Matarese, Michele and Gottschlich (2003) cellulose and lignin for common foodstuff are about 70%, 20% and 10% respectively

2.13 Fish Processing Method (Smoking)

Without any preservation measures, fresh fish species are highly susceptible to deterioration due to high moisture content. It is reported that about 80% of the total fish produced in Ghana is cured in various ways before consumption (Essuman, 1992). There are various traditional methods that are employed to preserve and process fish for consumption and storage. These methods include; smoking, drying, salting, grilling, fermenting and frying (Essuman, 1992; Akinola, Akinyemi and Bolaji, 2006; Holma and Maalekuu, 2013). These processing methods may either be used alone or combined in order to achieve the desired product. For instance, smoking is often accompanied by drying. Similarly salting and sun-drying are often combined to get a well preserved product. Invariably, the final product is distinguished by peculiar qualities such as aroma, flavour and colour according to the consumer's preference. Of these processing methods, smoking remains the predominant and most important method of fish preservation in Africa (Essuman, 1992).

In Ghana, smoking is the most widely practised method. It has been estimated that about 60% of Ghana's total fish production are usually smoked before distribution (Essuman, 1992). Smoked fish has many advantages: longer shelf life, enhanced flavour, it is also easier to pack, transport and market. Some consumers have also reported that smoked fish unlike fresh fish remains intact when used to prepare traditional soups. This is important because most Ghanaians prefer the piece of fish to remain whole (Essuman, 1992). Nerquaye-Tetteh, Dassah and Quashie-Sam (2002) have also concluded that smoking as a method of fish processing and preservation is an effective method to reduce microbial load.

2.13.1 Effect of Fish Smoking on Proximate Composition

Processing and preserving fish by smoking may be beneficial but lead to loss of essential nutrients. When fish is heated above certain temperatures, protein denaturation may occur. Longwe and Kapute (2016) concluded, after a study to determine the nutritional composition of two smoked and sundried pond fish, that smoking negatively affected (reduced) the protein and other nutrient content of the fish species. Since smoking reduces the moisture content, protein and fat content are often increased. Holma and Maalekuu (2013) in their work to determine the effect of traditional fish processing methods on the proximate composition of red fish stored under ambient room conditions in Ghana concluded that smoking and other processing methods increased the proximate composition of red fish and partly attributed it to the loss of moisture which concentrates the nutrients.

Al-Reza *et al*. (2015) have also concluded that smoking is an efficient method of fish processing in terms of the retention of protein value and reduction in the moisture content. Other authors (Kumolu-Johnson *et al*., 2010; Olopade,Taiwo and Agbato., 2013, Akintola, 2015) have also reported that traditional smoking method is an important preservation method which could enhance the nutritive values of fishes and possibly reduce post-harvest losses and benefit human consumption. On the other hand, Steiner-Asiedu, Julshamn and Lie (1991) have concluded that traditional fish processing (cooking, frying and smoking) per se have no effect on the composition of fish.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area and Design

The study was in two parts; the first part was a cross sectional survey to identify pregnant women in the study locations who consume smoked fish and attending antenatal care at the study locations,Adabraka, Tema and Madina. These areas were purposely selected because fish from freshwater and marine are predominantly sold in these markets. Adabraka market is a fish wholesale point, where fish from all over the country is sold to retailers. In the case of Tema market, marine fish is usually wholesaled to retailers. Madina Market is a big market where traders who buy from the wholesale points usually retail. It is a central location and widely patronized by consumers. Pregnant women attending health facilities at Madina polyclinic, Adabraka Polyclinic and Tema general hospital were conveniently selected to participate in the study. Questionnaires were used to interview the pregnant women on their awareness and knowledge level of mercury toxicity of fish and on pregnancy outcomes, background information, widely consumed fish and frequency of fish consumption. Focus group discussion was organised among the fish sellers in the markets to identify the most predominant and widely purchased fish. The second part was a laboratory analysis of the most widely consumed fish as reported by the pregnant women. Mercury content in the fish species was analyzed together with the proximate composition.

3.2 Study Population

The study population included all eligible pregnant women who attended antenatal clinics at Madina polyclinic, Adabraka polyclinic and Tema general hospital.

3.3 Sample Size and Sampling

Using an alpha level of 0.05, power of 95%, and 50% prevalence of knowledge of the effect of consumption of smoked fish contaminated with mercury on pregnancy outcomes, the sample size was determined using the Snedecor and Cochran (1989) equation:

$$N = \frac{Z^2 P (1-P)}{D^2}$$

Where;

N = required sample size,

Z = Statistical certainty of 1.96 at confidence interval (95%),

P = percentage of pregnant women with knowledge on the effects of mercury on pregnancy outcomes (50%)

D = margin of error/ level of precision (5%)

A total of 384 pregnant women attending antenatal clinics were recruited from the selected study areas including Madina polyclinic (143), Tema polyclinic (179) and Adabraka polyclinic (62).

3.3.1 Inclusion Criteria

- Pregnant women who consumed smoked fish and resides at the study location (Madina, Tema or Adabraka).
- All pregnant women attending antenatal care in the selected hospitals and willing to participate.
- Pregnant women who have their antenatal cards at the selected health facilities.

3.3.2 Exclusion Criteria:

- Pregnant women who live outside the study locations.
- Pregnant women who do not consume smoked fish

3.4 Data Collection

Data were obtained from the cross sectional survey and the laboratory analysis of the fish.

3.4.1 Cross Sectional Survey

All eligible pregnant women who attended antenatal clinics in the chosen hospitals were interviewed using a semi-structured questionnaire on their fish consumption patterns and knowledge on mercury toxicity on pregnancy outcomes. The questions were read out to the participants to answer.

In the determination of the participants' knowledge level on mercury toxicity in fish on pregnancy outcomes, four questions were asked. These questions were asked in the affirmative way using 5- point Likert scale ranging from strongly agrees, agrees, don't know, disagrees and strongly disagrees. The key domains addressed by the questions include; knowing that ingestion of fish contaminated with mercury during pregnancy causes low birth weight, leads to preterm birth, underweight and causes stillbirths

3.4.2 Key Informant Interview

Four smoked fish sellers were selected for the key informant interview from each of the three markets. The key informant interviews were conducted to identify the predominant smoked fish available in the market and the most widely purchased smoked fish by consumers. A list of local names of fish sold in the market was given to them to select the most predominant and the most widely purchased ranging from first position to the tenth position. Based on the information obtained from the key informant interviews frequencies were used to determine the most widely purchased and predominant marine and water fish available in the markets.

3.4.3 Sample Collection and Laboratory Analysis

The most widely consumed fish species as reported by the pregnant women were obtained for analysis. Smoked samples of the following fish species: apataa (*Tilapia zilli*), brolovi (*Chrysichthys nigrodigitatus*), salmon (*Scomber japonicas*), herring (*Sardinella maderensis*), tuna (*Katsuwono pelamis)*, saflo (*Caranx crysos*), Oheneba (*Bagrus bayad*) and red fish (*Entex angolensis*) were bought from the different markets, labelled and transported to the laboratory in polyethene bags for analysis.

3.4.3.1 Proximate Composition

The smoked fish samples were weighed using a digital weighing scale to obtain the individual weight from each market. The sample of each species was blended, homogenised and 2 grams taken for moisture content analysis.

3.4.3.2 Moisture Content

The moisture content is determined by measuring the mass of a food sample before and after the water is removed by evaporation. The moisture content of the fish samples was determined by measuring the initial mass ($M_{INITIAL}$) of the sample using a digital weighing scale. The samples were then placed in an oven to dry at 105°C overnight until they reached constant mass and the mass recorded as dried mass (M_{DRIED}). The percentage moisture content was then determined by the equation below:

$$\%\text{Moisture} = \frac{M_{INITIAL} - M_{DRIED}}{M_{INITIAL}} \times 100$$

The fish samples were then grounded in a porcelain can until homogenized samples were obtained. Approximately 2g each of the homogenized samples was weighed to determine the proximate composition. Analyses of the samples were done in triplicates for protein, fat, fibre and ash contents according to the methods described by the Association of Official Analytical Chemists, AOAC (2005).

3.4.3.3 Crude Protein

Crude protein of the fish samples was determined using the Kjeldahl method, which evaluates the total nitrogen content of the sample after it has been digested in sulphuric acid with a catalyst.The samples were digested with 15mls of concentrated Sulphuric acid (H_2SO_4) in the presence of a catalyst (mixture of potassium sulphate and copper sulphate) for about one-and-half hours and allowed to cool for about 15 minutes. The resulting digestate were distilled in the presence of strong alkali, sodium hydroxide (NaOH). The ammonia released was collected in aqueous solution of boric acid and titrated against 0.01M HCl. Blank determination was carried out in a similar manner. Based on the determined ammonia, equivalent nitrogen was calculated. The percentage crude protein was estimated by multiplying the sample percentage nitrogen by a factor 6.25. (AOAC, 2005).

3.4.3.3 Crude Fibre

Transfer residue from ether extract to a digestion flask and add about 200ml of the boiling H2SO4 solution and allow it for about 30 minutes. Remove flask, filter immediately through linen and wash with boiling water until washings are no longer acid. Heat a quantity of NaOH solution to boiling point and keep at this temperature under reflux condenser until used. Wash residue back into flask with 200ml of the boiling NaOH solution. Connect flask with condenser and immediately filter through the Gooch crucible. After thorough washing with boiling H2O, wash with about 15ml of 95% ethanol and then dry the crucible and its content at 1100C to constant weight. Then cool in a desiccator and weigh. Weight loss gives the crude fibre content. Calculation % Crude fibre= (A-B)/C ×100 A= weight of dry crucible and sample, B= weight of incinerated crucible and ash, C= sample weight.

3.4.3.4 Ash Content

The ash content of a sample is the residue left after ashing in a muffle furnace at about 550-600°C till the residue becomes white. Ash content was determined by incineration of two grams of each fish sample in a muffle furnace at 600°C for 2 hours. The percentage residue weighed was expressed as ash content.

3.4.3.5 Fat Content

Fat content was measured by drying the fish samples at 100°C in an oven and then extracting the crude fat with petroleum ether in a Soxhlet extractor for 4 hours.

3.4.3.6 Determination of Methyl Mercury Concentration in Fish using the Direct Mercury Analyser.

Approximately 0.2g of the homogenized sample was weighed in a tarred sample boat. The sample boat containing the sample was then introduced into the DMA-80. In the machine, the sample is first dried for 50°C for about 50 seconds and then combustion took place at 580°C for 120 seconds and then amalgamation at 120°C for 60 seconds. The mercury content was then desorbed for quantification and finally determined using atomic absorption spectrophotometry at a wave length of 257.3nm. The whole process took place in about 5 minutes. The total mercury concentration was analysed in triplicate using the direct mercury analyser. Certified reference material NIST 2976 was measured with each batch of the sample.

Figure 3.1: Direct mercury analyser connected to a desktop computer (Image taken with Samsung Camera ST76 x 1Mag.)

3.4.3.7 Human Risk Assessment of Mercury from Fish Consumption

The potential non-carcinogenic human health risk of consuming fish contaminated with mercury was done for each fish sample by calculating the Target Hazard Quotient (THQ), a function of ingestion rate and reference dose (USEPA 2000; Yi *et al*., 2011).

$$\text{THQ} = \frac{\text{EF}\times\text{ED}\times\text{IFR}\times\text{C}}{\text{RfDo}\times\text{BWa}\times\text{ATn}} \times 10^{-3}$$

Where:

EF is exposure frequency ($year^{-1}$)

C is the mercury concentration ($mg\ kg^{-1}$)

RfD the oral reference dose ($mg\ kg^{-1}\ day^{-1}$).

ED is the exposure duration (y);

BWa is the average body weight of adult population (Nyarko and Klubi, 2013)

ATn is the averaging time (period over which exposure is averaged in days).

The average body weight and exposure duration were estimated to be 60 kg and 70 years respectively (Jiang *et al* 2004; (Nyarko and Klubi, 2013), whiles IR, and EF were estimated to be 0.06849 kg d^{-1}, and 365 d y^{-1} respectively. The averaging time, period over which exposure is averaged in days, was also estimated to be 25550 days. THQ < 1 are associated with negligible effects to human health while THQ > 1 are associated with probable adverse effects.

The Table below is the local and scientific names of the fish species that were used for the laboratory analysis (proximate and mercury concentration).

Table 3.0 List of the Sampled Fish Species

Local name	Scientific name
Salmon	*Scomber japonicas*
Saflo	*Caranx crysos*
Apataa	*Tilapia zilli*
Oheneba	*Bagrus bayad*
Brolovi	*Chrysichthys nigrodigitatus*
Red fish	*Dentex angolensis*
Tuna	*Katsuwonos pelamis*
Herring	*Sardinella maderensis*

Refer to Appendix 2 for photos

3.5 Data Analysis

Data entry and analyses were done using Statistical Package for the Social Scientist version 20 (SPSS). In the determination of mercury concentration in smoked fish using the Direct Mercury Analyzer (DMA) as well as the proximate analyses, samples were run in triplicates and the mean used for analyses.

The concentration of mercury (µg/g) in the smoked fish, proximate analysis (ash, moisture and protein content) was presented as means and standard deviations. Categorical variables such as background characteristics of participants and maternal characteristics were presented in frequencies and proportions. Analysis of Variance (ANOVA) was used to compare means of the mercury concentration levels and the proximate composition data. Further analysis (Post-Hoc test) was carried out where there were significant differences ($p<0.05$) using Least Significant Difference (LSD).

Knowledge level of mercury toxicity by pregnant women were assigned scores as follows; strongly agrees and agrees score 2 and 1 respectively. Strongly disagree, disagree or don't know scores 0. The maximum score for knowledge assessment was 8. Knowledge level were categorized as poor when scores were below 4.0 or 50%, moderate for scores between 4.0 and 6.4 (50% to 80%) while above 6.4 or 80% were considered good. Knowledge level was eventually presented in proportions.

All p-values below 0.05 were considered statistically significant. Data from key informant interviews were analysed using frequency distribution to determine the most dominant and widely purchased fish in the study areas (Markets).

CHAPTER FOUR

4.0 RESULTS

4.1 Socio-Demographic Characteristics

The study involved 384 pregnant women attending antenatal clinics in three selected study area (Madina, Tema and Adabraka). Most of the pregnant women (87.5%, n=336) were between the ages of 20-39 years. Of the 384 pregnant women, (47.9%, n=184) were traders, (8.9%,n=34) were engaged in formal work and (16.1%,n=62) were house wives. More than half (63.8%,n=245) of the participants had Junior or Senior High School education, while few (13%,,n=50) had no formal education. A greater number of participants were Christians (80.7%, n=310) with few (19.3%, n=74) in the Islamic religion as shown in Table 4.1

Presented in Table 4.1 are details of maternal characteristics. More than half (61.7%; n=237) of the participants had previous births. Cases of preterm, underweight and still birth were reported among the subjects interviewed. As shown in Table 4.1, still birth was highest (6.3%; n=15) and closely followed by underweight babies (2.1%; n=5) among the subjects who had previous births

Table 4.1: Background Characteristics of Respondents

Characteristics	Frequency	Percentage (%)
Age (years)		
14-19	23	6
20-39	336	87.5
40-59	25	6.5
Occupation		
Trader	184	47.9
Housewife	62	16.1
Vocation	104	27.1
Formal work	34	8.9
Education		
No formal education	50	13
Primary	57	14.8
JHS/SHS	245	63.8
Tertiary	32	8.3
Religion		
Christianity	310	80.7
Islam	74	19.3
Parity		
Multiparous	237	61.7
Primiparous	147	38.3
Had preterm baby		
Yes	2	0.8
No	235	99.2
Had underweight baby		
Yes	5	2.1
No	232	97.9
Still Birth		
Yes	15	6.3
No	222	93.7

4.2 Widely Consumed Smoked Fish

The analysis of data on widely consumed fish species among the studied subjects is depicted in Figure 4.1. By numerical strength, it is obvious that majority of the participants (81.7%) widely consumed herring, followed by salmon (71.8%), tuna (60.4%), apataa (57.3%), saflo (45.4%) and red fish (39.7%). The least consumed fish were mud fish (10.5%) and kpala (18.4%).

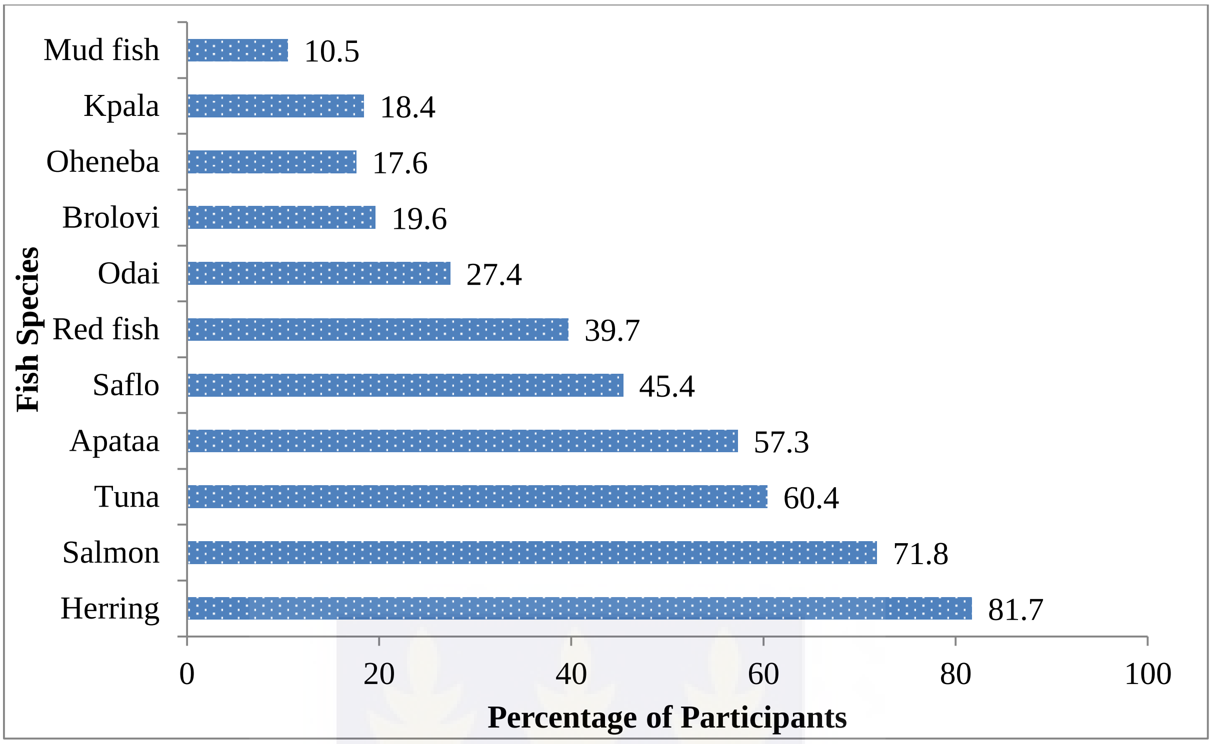

Figure 4.1: Widely Consumed Fish

4.3 Frequency of Fish Consumption

Fish consumption was grouped into 1-2 meals to 5-7 meals according to its intake frequency per week. Majority (68.8%) of the participants consumed fish 5-7 meals/week (Figure 4.2). The most frequently consumed fish within the week was herring.

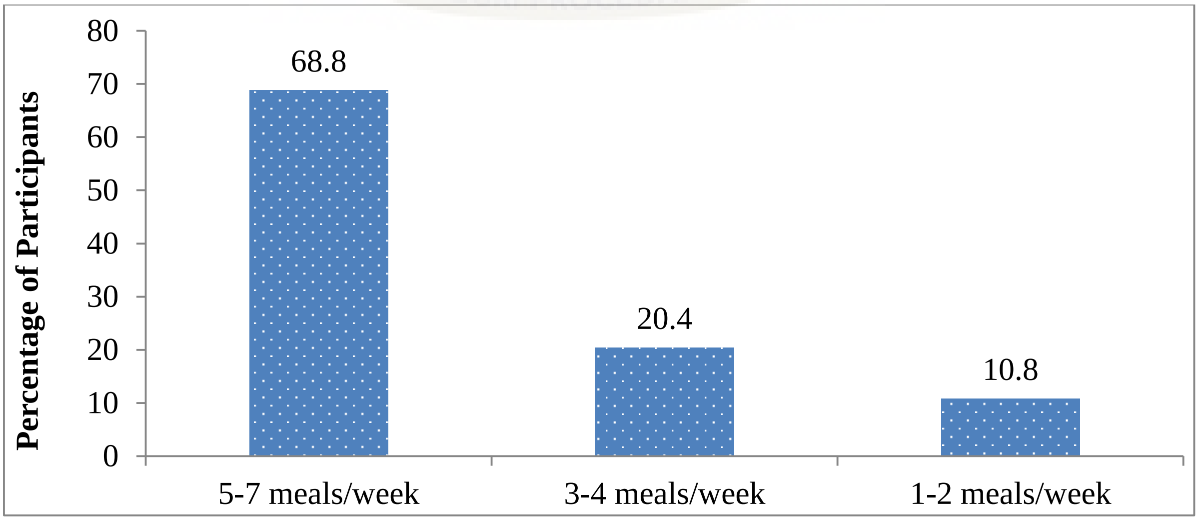

Figure 4.2: Frequency of Weekly Fish Consumption

4.4 Predominant and Widely Purchased Fish in the Selected Markets.

Most of the predominant fish reported by the fish sellers from the key informant interviews were almost the same at the three different markets. Salmon, tuna, brolovi and oheneba emerged as the predominant smoked fish species at the three market places. . Among these commonly sold species, oheneba, brolovi, salmon, and apataa were the most widely purchased fishes from all the market locations. Finally, the smoked fish samples form the three markets were organised into marine and fresh water sources (Table 4.2).

Table 4.2: Predominant and Widely Purchased Fish from the Markets

Market	Predominant fish		Widely purchased fish	
	Marine water	**Fresh water**	**Marine water**	**Fresh water**
Madina	Salmon	Yenyinanyimnyim	Salmon	Oheneba
	Tuna	Brolovi	Saflo	Brolobi
	Red Fish	Oheneba	Red Fish	Apataa
Tema	Salmon	Yenyinanyimnyim	Red Fish	Apataa
	Tuna	Brolovi	Salmon	Oheneba
	Saflo	Oheneba	Tuna	Brolobi
Adabraka	Salmon	Oheneba	Saflo	Oheneba
	Odoi	Akweibi	Odoi	Ml3ts3m
	Tuna	Ml3ts3m	Emule	Akweibi

4.4. Concentration of Mercury in the Selected Fish Species from the Different Markets

Shown in Table 4.3 is the mercury concentration in the selected smoked fish (marine and freshwater species) from the three different markets. Generally, the concentrations of mercury in the marine smoked species were higher than those of the smoked fresh water species. Among the marine smoked fishes analysed, Brolovi from Adabraka and apataa from Madina market had the highest level of mercury, 0.347±0.003 μg/g and 0.327±0.006 μg/g respectively. Saflo from Adabraka market had the least mercury concentration (0.010±0.005 μg/g).

The mercury concentrations of the analysed smoked fish samples were all within the recommended allowable safe limit intake except apataa (0.327±0.006 μg/g) from Madina and Brolovi from Tema (0.214±0.023 μg/g and Adabraka (0.347±0.03 μg/g). The concentrations of mercury in these fish slightly exceeded the FAO/WHO recommended safe limit of mercury concentration in fish for pregnant women (0.2 μg/g). All the mercury concentrations from the different markets significantly differed from each other ($p<0.01$) except those in red fish and oheneba fish species ($p>0.05$).

Table 4.3: Concentration of Mercury (μg/g) in Commonly Consumed Fish Species from the Different Markets

Fish	Markets		
	Tema	**Madina**	**Adabraka**
Salmon	0.177 ± 0.009[a]	0.123 ± 0.006[b]	0.018 ±0.004[c]
Red Fish	0.095 ± 0.004	0.089 ± 0.005	0.098 ±0.005
Saflo	0.113 ± 0.008[a]	0.093 ± 0.011[a]	0.010 ±0.005[b]
Apataa	0.015 ± 0.005[a]	0.327 ± 0.006[b]	0.104 ±0.016[c]
Ohenena	0.181 ±0.010	0.190 ± 0.155	0.114 ±0.002
Bolovi	0.214 ±0.026[a]	0.087 ± 0.006[b]	0.347±0.003[c]
Herring	0.100±0.003[a]	0.056±0.017[b]	0.041±0.004[b]
Tuna	0.083±0.008[a]	0.073±0.005[b]	0.064±0.003[c]

Means with different superscripts along the same row for each fish species are significantly different (LSD) $p<0.05$; FAO 2002, Limit for total mercury is 0.2 μg/g for pregnant women.

4.5 Mean Concentration of Mercury in Fish From all the Markets

The mean concentrations of mercury were compared witthin the fish species regardless of market location to know which fish had higher mercury content. Results showed that brolovi had the highest mercury content (0.22 µg/g), followed by apataa (0.21 µg/g) and oheneba (0.16 µg/g) (Figure 4.3). The least mean mercury content was found in tuna (0.06 µg/g). Statistically all the mean mercury concentration did not differ from each other (p=0.108).

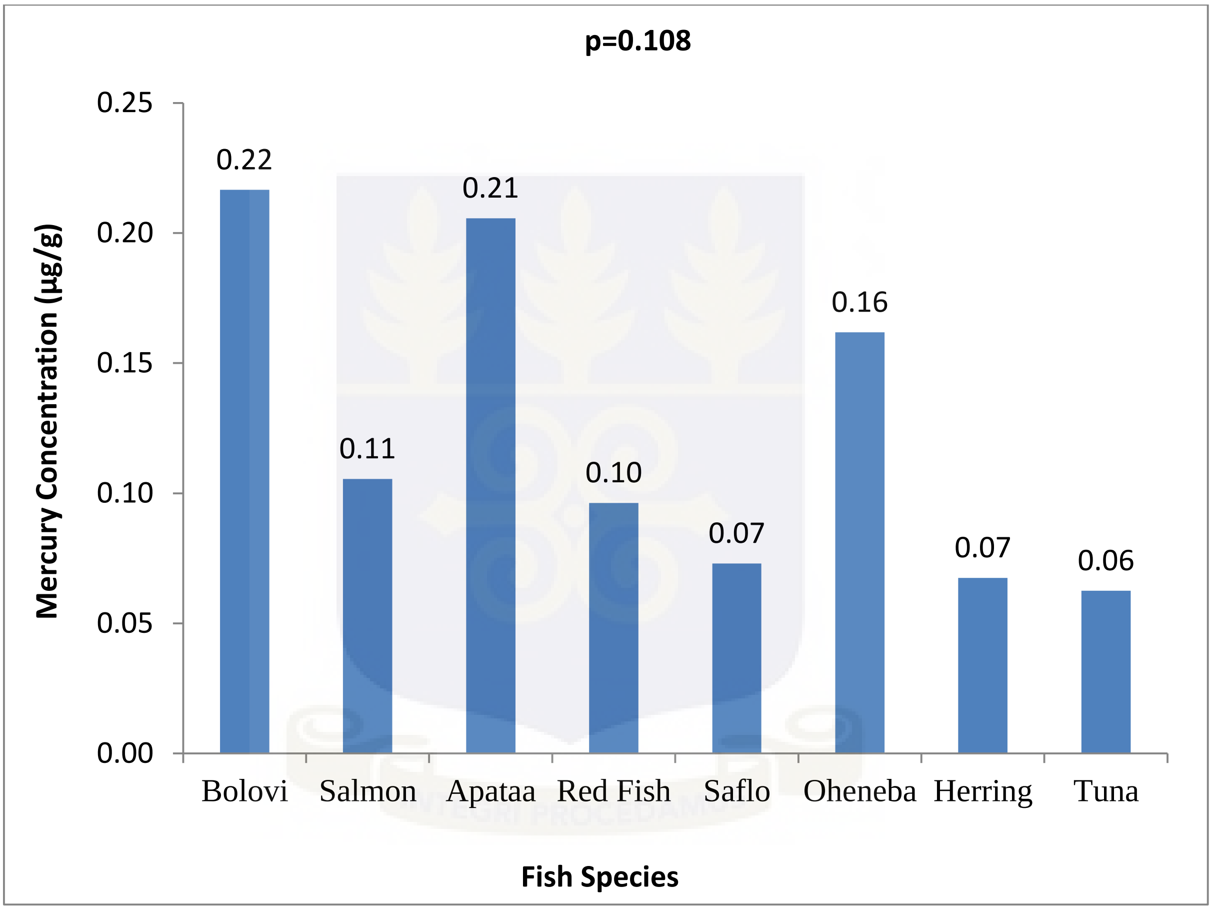

Figure 4.3: Mean Concentration of Mercury in Fish from all the Markets

4.6 Proximate Composition

The result of proximate analysis of the fish samples is shown in Table 4.4. The values show variant concentration/proportions of ash, moisture and protein content in the different markets. The highest Ash (%) content was recorded in red fish (19.263±0.587) from Tema while Tuna from Adabraka (2.760 ±0.073) had the least percentage of Ash in all the three market places. The least moisture percentage content was recorded in the oheneba fish sample in the three markets while saflo from Madina had the highest moisture content percentage (69.502±0.361). With respect to protein, the highest protein content (74.443±0.473) was recorded in herring from Tema and least in salmon (20.412±0.612) from Madina. The highest percentage of fibre (8.187±0.021) was recorded in Brolovi fish sample from Madina while saflo from Adabraka had the least percentage of fibre (0.300±0.010). The percentage of fat content was high in apataa from Adabraka (45.393±0.047) and least in Tuna from all the three markets.

Table 4.4: Proximate Analysis of Smoked Fish from the Different Markets

Fish	Markets		
	Tema	**Madina**	**Adabraka**
Ash (%)[b]			
Bolovi	14.767±0.776	15.110±0.726	16.037±0.708
Salmon	5.498±0.632[a]	5.194±0.110[a]	3.741±0.566[b]
Apataa	13.974±0.650	13.258±0.170	13.538±0.0.472
Red Fish	19.263±0.587[a]	13.082±0.444[b]	15.005±0.448[c]
Saflo	7.852±0.371[a]	8.443±0.168[b]	7.871±0.485[a]
Oheneba	17.992±0.598[a]	15.001±0.371[b]	13.761±0.501[c]
Tuna	3.745±0.048	4.165±0.095	2.760±0.073
Herring	9.939±0.308[a]	10.486±0.517[a]	11.996±0.182[b]
Moisture (%)[b]			
Bolovi	14.458±0.491[a]	6.829±0.857[b]	11.254±0.932[c]
Salmon	63.670±1.197[a]	58.450±1.614[b]	63.364±1.297[c]
Apataa	12.597±0.776	12.580±10.756	12.350±0.164
Red Fish	56.236±1.572[a]	61.840±0.139[b]	69.160±0.356[c]
Saflo	61.339±0.438[a]	69.502±0.361[b]	63.922±0.584[c]
Oheneba	7.600±0.532	9.521±0.017	8.301±0.371
Tuna	60.540±0.452[a]	66.701±0.001[b]	60.362±0.137[a]
Herring	15.664±0.293	45.897±0.270	12.328±0.071

Table 4.4 Proximate Analysis of Smoked Fish from the Different Markets (cont'd)

Fish	Markets		
	Tema	Madina	Adabraka
Protein (%)[b]			
Bolovi	51.698±0.492[a]	44.826±0.609[b]	61.800±1.152[c]
Salmon	48.178±0.538[a]	20.412±0.612[b]	23.398±1.225[b]
Apataa	29.919±0.541[a]	51.812±0.660[b]	49.327±0.690[c]
Red Fish	31.091±0.487[a]	35.244±0.583[b]	36.256±1.192[b]
Saflo	29.830±0.541[a]	28.132±0.513[a]	36.256±1.821[c]
Oheneba	36.665±0.529[a]	54.369±0.647[b]	63.747±1.367[c]
Tuna	26.223±0.015[a]	22.143±0.049[b]	25.816±0.015[a]
Herring	74.443±60.473[a]	60.473±0.004[b]	61.090±0.026[a]
Fibre (%)			
Bolovi	0.617±0.021[ad]	8.187±0.021[af]	0.560±0.030[ac]
Salmon	1.200±0.017[ed]	4.602±0.004[fa]	0.837±0.015[cf]
Apataa	0.863±0.015[df]	4.920±0.061[gf]	1.040±0.010[ag]
Red Fish	0.733±0.006[ef]	5.360±0.020[ga]	0.973±0.021[gs]
Saflo	4.763±0.038[fg]	1.086±0.003[sg]	0.300±0.010[sb]
Oheneba	0.957±0.015[fr]	1.250±0.100[ed]	1.513±0.015[ga]
Tuna	0.699±0.002[a]	0.788±0.003[b]	0.783±0.004[b]
Herriing	0.520±0.008[a]	1.285±0.013[b]	1.358±0.025[c]
Fat (%)			
Bolovi	26.380±0.407[ab]	26.210±0.165[ab]	20.957±0.060[ac]
Salmon	18.237±0.0473[df]	15.483±0.188[ad]	37.054±0.025[bc]
Apataa	22.530±0.061[ab]	20.033±0.025[ab]	45.393±0.047[ac]
Red Fish	18.723±0.075[ed]	25.920±0.192[ea]	24.650±0.050[ea]
Saflo	4.863±0.015[sd]	2.423±0.021[as]	6.033±0.031[af]
Oheneba	17.047±0.042[cd]	21.110±0.010[ds]	21.040±0.068[ds]
Tuna	4.066±0.052[ca]	5.313±0.024[as]	3.351±0.044[ef]
Herring	23.144±0.057[ta]	19.891±0.069[tr]	19.797±0.231[tr]

[b]Values shown are means ± standard deviations from three replicates, calculated on wet basis using analysis on variance (ANOVA) at $p<0.05$. On the same row for each fish species, values with different superscripts are statistically different from each other.

4.7 Awareness and Knowledge of the Effect of Mercury Toxicity of Fish on Pregnancy Outcomes

More than half (57.3%) of the participants have heard about mercury toxicity in fish and the main source of information was the media, radio (53.4%) and television (36.2%). The mean knowledge score was 2.22±2.33. More than half of the participants (65.5%) who had heard of mercury toxicity of fish had poor knowledge on its effect on pregnancy outcome with only 5.5% of them having good knowledge (Figure 4.4).

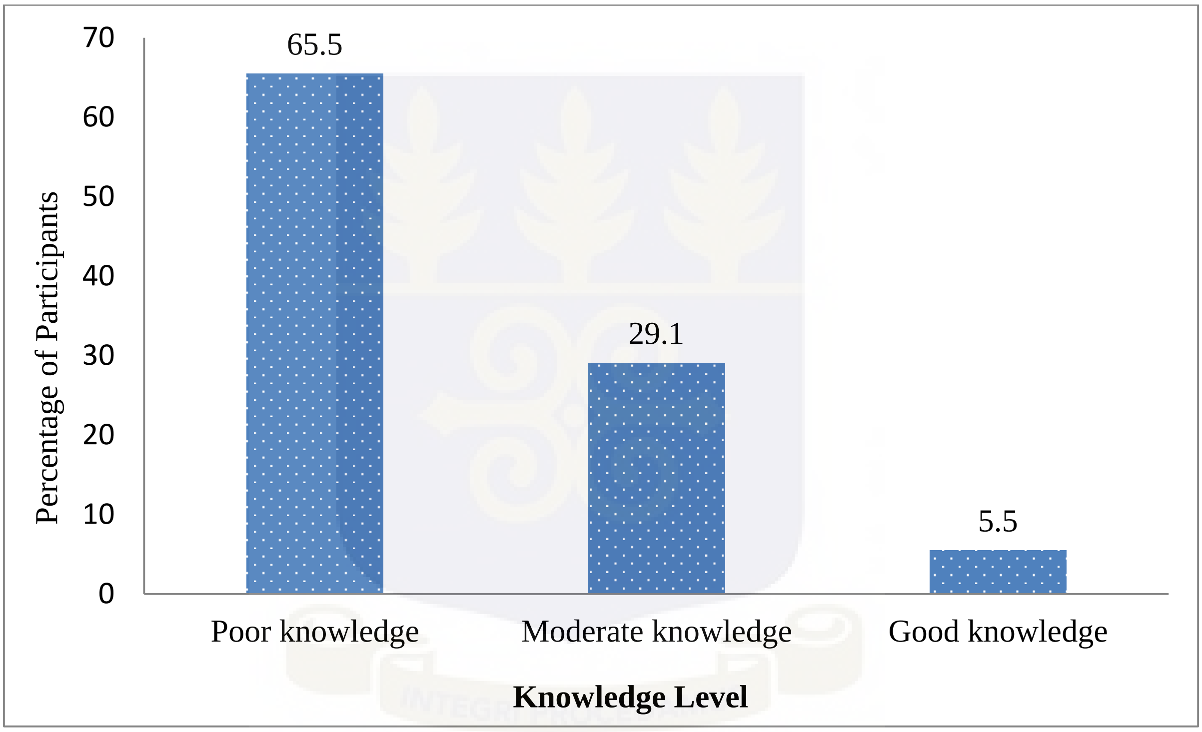

Figure 4.4: Knowledge Level of Mercury Toxicity of Fish

4.8 Human Risk Assessment of Mercury from Fish Consumption

Almost all the fish species had lower THQ values (THQ < 1), an indication of low adverse health risk associated with fish consumption in relation to mercury. However, the mercury concentration of apataa (1.42 µg/g) and brolovi (1.50 µg/g) from Madina and Adabraka markets respectively were high indicating adverse health risk from the consumption of these fish. Results of the calculated hazard quotients (HQ) are presented in Table 4.5 below.

Table 4.5: THQ Values of Mercury in Fish Species

Fish	Markets		
	Tema	**Madina**	**Adabraka**
Salmon	0.77	0.53	0.08
Red Fish	0.41	0.39	0.42
Saflo	0.49	0.40	0.04
Apataa	0.06	**1.42**	0.45
Oheneba	0.78	0.82	0.49
Brolovi	0.93	0.38	**1.50**
Tuna	0.36	0.32	0.28
Herrings	0.43	0.24	0.18

TQ<1, no adverse health risk, TQ>1, adverse health risk.

CHAPTER FIVE

5.0 DISCUSSION

5.1. Widely Consumed Smoked Fish

The preference for the type of fish purchased for consumption is influenced by the economic and market factors in terms of cost and availability as well as the taste, culture, recreational habits and access to alternative food (Oken *et al*., 2012). Thus, how widely a particular fish is purchased and consumed may also be dependent on how long it can be preserved if smoked and the seasonal availability of the fish.

This study revealed that the eight widely consumed fish were herring, tuna, salmon, saflo, redfish (marine fish) and Oheneba, brolovi and Apataa (freshwater fish). Some of the reasons the pregnant women assigned for the selection of these fish species were; the taste, social and cultural acceptability, and their ability to remain intact in soup. This finding was similar to an earlier research by (Oken *et al*., 2012).

5.2 Frequency of Fish Consumption

Frequency of fish consumption varies depending on the taste, price, availability, flavour and their ability to remain intact in soup (Essuman, 1992). All the participants consumed fish at least once a week. This is similar to a report by Verbeke *et al* (2005) that more than half of Belgium population consumed fish at least once a week.

The frequently consumed fish reported by the respondents were herring, tuna and salmon; consumed 5-7 meals per weak. It is important to note that the highest frequency of fish consumption within the week was reported by the respondents to be 5-7 meals/week. Saflo and oheneba were the species that were not frequently consumed in a week. The difference in species frequency consumption may be due to difference in price, acceptability and taste.

5.3 Awareness and Knowledge of Effects of Mercury in Fish on Pregnancy Outcome

Knowledge of the effects of mercury in fish on pregnancy outcomes is essential to balance both the potential benefits and risk to the developing foetus (Selin, 2011). A study by Burch *et al.*, (2014) in South Carolina indicated that women who lived in areas of predicted high total levels of mercury in fish were more likely to have low birth weight babies. Preterm and low weight babies have a higher risk of infant morbidity and mortality and are also predisposed to disabilities and chronic diseases later in life (Morley, 2006).

In this study, more than half (57.3%) of the respondents were aware of mercury toxicity in fish. This finding is in agreement with previous reports by Damsky *et al*. (2009) and Verbeke *et al*. (2005) where more than half of the respondents (79.0% and 77.3% respectively) were aware of mercury toxicity in fish and attributed the awareness level to constant education of the public on safe eating guidelines on the effects of mercury toxicity in fish. Information about pollution and contamination of fish can have impact on consumers' perception, awareness and knowledge of fish (Verbeke *et al.*, 2005).

Although a significant number of participants were aware of mercury toxicity in fish, few had good knowledge of the effects of mercury toxicity of fish on pregnancy outcomes. These concords with previous results by Johnston *et al*. (2016), where most of the participants interviewed had no knowledge of local fish advisories with regard to mercury content in fish. The low level of knowledge in this study is contrast to the findings of Verbeke *et al*. (2005) who reported that fish consumers' awareness and knowledge of safety risks is higher than their awareness of a definite health benefit in their risk and health benefits of fish assessment among Belgium population.

5.4 Proximate Composition of Fish

Knowledge of the nutrient composition of fish is an important tool in understanding the links between fish consumption, access and nutrient intakes, and in formulating policies and programmes such as development of improved production technologies (Bogard *et al*., 2015). It also important to ensure they meet the dietary requirements and commercial specifications (Watchman, 2000; Annathai *et al*, 2014). The percentage range of the moisture content of the fish species was 6.8-69.5 with the range of individual nutrient content being; protein (20.4-74.4), fat (2.4-45.3), fibre (0.3-8.1) and Ash (2.8-19.2). Similar moisture content of smoked fish has been earlier reported by other authors (Nerquaye-Tetteh *et al*., 2002; Holma and Maalekuu, 2013; Longwe and Kapute, 2016). The low moisture content could be due to the fish been smoked before analysis since smoking has been reported to drastically reduce moisture content as result of dehydration process (Longwe and Kapute , 2016) and this may present low deterioration problems.

Almost all the protein content recorded in the fish samples were far above the recommended protein range of 15-20% in fishes. It has been extensively reported that smoking as a processing and preservation method increases protein content in fish due to heat dehydration which concentrates proteins thus increasing the nutritional value of the processed fish species (Ahmad *et al*., 2011; Okereke *et al*., 2014). The high protein content recorded in this study is similar to the work of Nerquaye-Tetteh *et al*. (2002); Holma and Maalekuu, (2013); Olopade, Taiwo and Agbato, (2013), but contrary to the findings of Longwe and Kapute (2016). This is an indication of high quality protein which is good for human consumption. Among the fish species analysed, high percentage of protein content (74.4) was recorded in herring from Tema. This fish also had low moisture content. The lower the percentage of moisture in fish, the higher the crude protein content; low moisture content tends to concentrate nutrients in fish (Aberoumad and Pourshafi, 2010).

According to Ackman (1989) classification of fish according to fat content, almost all the fish studied belonged to high fat category (>8%). The high fat content could be attributed to the low moisture content documented in the fish species or the traditional practice of polishing the smoked fish with oil to make it attractive. Low moisture content has been correlated with high fat content in fish (Aberoumad and Pourshafi, 2010). The high fat content is similar to earlier work by Nerquaye-Tetteh *et al*., (2002) and Olopade *et al*., (2013) but different from other authors (Chukwu, 2009), Ahmad *et al*., 2011; Idah and Nwankwo,2013; Longwe and Kapute, 2016). This difference could be explained by oxidation and break down of crude fat into other components due to oxidation of poly-unsaturated fatty acids (PUFA) contained in the fish tissue to products such as peroxides, aldehydes, and temperature difference although this study did not account for the temperature used for smoking of the analysed fish species.

Ash content in fish is an indication of minerals which is generally influenced by size of fish and the feeding behaviour (Daramola *et al*., 2007). Ash content recorded for the fish species were high and above the 1 to 2% reported in fish (Annathai *et al*, 2014). This is in agreement with the work of Nerquaye-Tetteh *et al*. (2002) and Holma and Maalekuu (2013) who recorded high ash content in smoked fish in Ghana. Marine fish (salmon and saflo) had low ash content compared to the freshwater fish (oheneba, brolovi and apataa). On average, red fish from marine source had the highest ash content. This is in accordance with the report by Adewumi *et al*. (2014) that ash content in fish are generally higher in marine fish than in fresh water fish. The high ash content could also be explained by loss in moisture content during smoking which concentrates the minerals and the fact that whole fish including bones was homogenised and used for analysis. Fish bones have been reported to be an important rich source of minerals (Njinkoue *et al*., 2016).

5.5 Mercury Concentration in Fish

The neurotoxicity characteristic of mercury and other potential adverse effect it poses on human health have drawn the attention of researchers across the world including Ghana, where reported cases of pollution to water bodies are on the rise due to mining and its related activities, particularly that of illegal mining, which has become wide spread along fresh water bodies of the country**.**

Mercury content in fish is considered to be a good indicator of human exposure to methylmercury, a known neurotoxicant which forms about 95% of the total amount of mercury in fish (Li *et al*., 2009). In this study, mercury concentration measured in 5 marine fish species and 3 freshwater fish species was in the range of 0.01-0.0.347µg/g wet wt. All the mercury content of the fish species were below the permissible level of 0.5µg/g (general population) and 0.2 µg/g ww for pregnant women set by FAO (2002) except apataa and brolovi which slightly exceeded the limit set for pregnant women. On average the highest concentration of mercury was found in the fresh water fish (apataa and brolovi). By geographical and urbanization reasons, Accra and its environs are least known for mining activities. However, as the capital, it serves as the commercial hub for which most food commodities in different parts of the country are sold. Thus highest mercury levels observed largely on the fresh water fish (apataa and brolovi) could possibly be due to the fact that the source of these fish could have been polluted with mercury conceivably due to increased discharge of mercury in fresh water bodies by illegal miners. This agrees with previous reports by Shah *et al*. (2016) that fresh water fish have significantly higher mercury content than marine fish. Almost all the mercury concentration significantly varied between the sample locations but did not differ from each other statistically. This could be due to difference in concentration of metal pollutant in the aquatic habitat, fish feeding behaviour, geographic location and fish processing methods as asserted by Voegborlo and Akagi (2007).

The low mercury content of fish documented is in agreement with earlier reports in Ghana by Voegborlo and Akagi (2007) and Asare-Donkor and Adimado (2016). Other authors have documented low mercury content, other heavy metals and organic pollutants of fish below safety standards (Chen and Chen, 2006; Ahmad *et al*., 2015; Nyarko and Klubi 2013; Quarcoo Adotey and Ayitey, 2015; Looi, Aris, Haris, Yusoff and Hashim, 2016).

5.6 Health Risk Assessment

Human health risk assessment from fish consumption has been described by many parameters. In this study, the target hazard quotient (THQ), calculated as a function of ingestion rate and concentration of the metals in the fish samples was used to estimate human health risk associated with fish consumption. All the THQ values were less than 1 for all the fish species analysed except apataa and brolovi from Madina and Adabraka respectively. Thus, the assessment of non-carcinogenic THQ danger caused by the consumption of these fish with respect to mercury concentration will not threaten the health of fish consumers with the exception of apataa and brolovi from Madina and Adabraka respectively. This is consistent with the results of an earlier report (Nyarko and Kulbi, 2013; Malakootian *et al*., 2016; Looi *et al*., 2016) where all the smoked fish analysed were safe for human consumption. The high THQ values documented for apataa and brolovi is consistent with a recent study by Asare-Donkor and Adimado, (2016). The THQs values documented in their study were far above what is reported in this study. This is possibly due to the known source of the analysed fish samples (mining communities) compared with unknown source of smoked fish used in this study.

This study did not collect any biomarkers of mercury from the pregnant women, so we could not assess relationships between frequency of fish consumption and mercury burdens or clinical effects; however, our findings from the human health risk assessment show that consumption of certain fish species like apataa and brolovi may pose health risk to consumers especially pregnant women and the developing foetus.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The study showed that most widely consumed fish by the pregnant women were herring, salmon, tuna, brolovi, apataa, oheneba, saflo and kpala. Herring was found to be the fish consumed by majority of the participants with average frequency of consumption of 5-7 meals/week**.** The study revealed that the widely consumed smoked fish reported by the pregnant women were not the most purchased fish reported by the fish sellers form the 3 markets.

More than half (57.3%) of the participants were aware of fish contamination with the heavy metal, mercury but most of them had poor knowledge on mercury toxicity on pregnancy outcomes. Proximate analysis revealed rich source of protein and minerals. Fat and fibre content were high in the fish analysed. The high protein content makes the fish a good source of high quality protein essential for human consumption.

The mercury concentrations of the analysed smoked fish samples were all within the recommended allowable safe limit intake for pregnant women (0.2 µg/g ww) except apataa from Madina and Brolovi from Tema and Adabraka. All the fish species had lower target harzard quotients (THQ) values less than 1 (THQ < 1) except apataa and brolovi whose consumption may pose health risk to consumers especially pregnant women.

6.2 Recommendations

In order to encourage the consumption of fish and improve health and especially among pregnant women and young children who are vulnerable to mercury content in fish, the following recommendations are being suggested;

- Further studies should look into source of these fish and investigate whether processing methods could affect the mercury concentration. Biochemical parameters could also be checked to link fish consumption with biochemical (hair or blood) content of mercury.
- Regulatory bodies such as the Ghana Environmental Protection Agency should constantly monitor the environment and water bodies for pollution with heavy metals. Discharge of mercury into the environment by industries and pollution of water bodies by illegal miners should also be checked and prevented.
- There is the need for Ministry of health and Ghana health service to educate the public of potential harmful effects of mercury toxicity in fish on pregnancy outcomes.

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APPENDICES

APPENDIX 1

QUESTIONNAIRE

UNIVERSITY OF GHANA

DEPARTMENT OF NUTRITION AND FOOD SCIENCE

I am Mrs. Faustina Vimariba Tour, a postgraduate student of the Nutrition and Food Science Department of the University of Ghana, Legon. I am working on the Research topic 'Pregnant Women,s awareness and knowledge of mercury toxicity in smoke fish on pregnancy outcomes in the Greater Accra Region' Your response will be anonymous and only be used for research purpose. This survey will take

Key: *tick or write ( )……………………………………………………….. Where appropriate.*

Participant ID ………… Participant's Phone Number ………………

SECTION A: BACKGROUND CHARACTERISTICS

1. How old are you? …………………

1=14-19 year's 2= 20-39 years 3= 40-59 years

2. What is your highest level of education?

1= No formal education 2= primary 3= JHS/SHS 4=Tertiary

3. What is your occupation?

1= Trader 2= House Wife 3= Vocation 4. Formal work

4. What is your region of worship?

1= Christianity 2= Islamic 3= African Traditional Religion

SECTION B: MATERNAL CHARACTERISTICS

5. Where do you live?

1=Madina 2= Tema 3= Adabraka

6. Have you ever given birth?

1= Yes 2= No.

If yes, How many …………………

NB IF No skip to Question 10

7. Have you ever had still birth? 1 .Yes. 2. No

8. Have you ever had preterm baby? 1. Yes 2.No

If yes, how many ………………………

9. Have you ever had an underweight baby? 1. Yes 2. No

If yes, how many …………………………

SECTION C: FISH CONSUMPTION PATTERN

10. Do you add fish during food preparation?

1=Yes 2=No

11. Which type of fish do you consume, Select as many as you consume? 1= Smoked

2= Fresh 3=Fried 4= Dried

12. If smoked, which fish do you consume most?

Fish species	Tick [√] the fish consumed
Akaw	
Polo	
Herrings	
Oheneba	
Mud Fish	
Mletsem	
Yenyinanyimnyim	
Brolobi	
Kpala	

Odai	
Tsile	
Onyeike	
Tuna	
Emule	
Saflo	
Tuna	
Salmon	
Others specify	

13. How often do you consume the fish the following fish in a week?

Fish species	Number of times per week
Saflo	
polo	
Red fish	
Herrings	
oheneba	
Mud Fish	
Mletsem	
Yenyinanyimnyim	
Brolobi	
Kpala	
Odai	
Tsile	
Onyeike	
Tuna	
Emule	
Akaw	
Tuna	
Salmon	
Others Specify	

SECTION D: AWARENESS LEVEL OF MERCURY IN SMOKED FISH AMONG PREGNANT WOMEN

14. Have you heard of mercury toxicity in Fish?

1=Yes 2=No

15. If yes, please indicate source of information.

1= church 2= market 3. Newspaper 4. Radio 5.TV 6. Others, specify ……………………

16. Which fish did you hear contain mercury? List

1= 2= 3= 4= 5=

SECTION E: KNOWLEDGE LEVEL OF EFFECTS OF MERCURY IN SMOKED FISH ON PREGNANCY OUTCOMES AMONG PREGNANT WOMEN.

17. Please indicate how much you agree or disagree with each of the following as effects of mercury in smoked fish.

Effect of mercury in smoked intake	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't Know
	1	2	3	4	5	6
Low birth weight						
Pre term babies						
Under weight babies						
Still Birth						

KEY INFORMANT INTERVIEW GUIDE

UNIVERSITY OF GHANA

DEPARTMENT OF NUTRITION AND FOOD SCIENCE

INTRODUCTION:

This questionnaire is designed by Mrs. Faustina Vimariba Tour who is a final year Nutrition and Food Science student of University of Ghana, Legon. Your cooperation is needed for it completion, which is a partial requirement to fulfil an Mphil Nutrition and Food Science. The topic is ***'Pregnant Women,s awareness and knowledge of mercury toxicity in smoked fish on pregnancy outcomes in the Greater Accra Region'***.

I would like to have a discussion with you to find out the smock fish that is usually available in the market and those customers buy the most

Also I would like to assure you of the confidentiality of your responses, and that it will be used for the intended purpose.

1: Predominant fish most widely purchased fish

A.Which of these fishes is predominant in the market in order of ascendancy

Fish species	Market	Community
Tuna		
Salmon		
Herrings		
Tilapia		
Mud Fish		
Cat fish		
Others specify		

B. Which of these fishes is widely purchased in the market in order of ascendancy

Fish species	Market	Community
Tuna		
Salmon		
Herrings		
kpala		
Mud Fish		
Others, specify		

APPENDIX 2

Fish used for the Analysis results

BROLOVI

APATAA

OHENEBA

SAFLO

HERRINGS

SALMON

RED FISH

TUNA