KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

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COLLEGE OF SCIENCE

FACULTY OF BIOSCIENCES

DEPARTMENT OF BIOCHEMISTRY AND BIOTECNOLOGY

ASSESSING THE PREVALENCE AND RISK FACTORS OF NEURAL TUBE DEFECTS AT THE KOMFO ANOKYE TEACHING HOSPITAL, KUMASI

BY

YAA KONADU ANKWAH

(B ED. HOME ECONOMICS)

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A thesis submitted to the Department of Biochemistry and Biotechnology Kwame Nkrumah University of Science and Technology in partial fulfilment of the requirement for the award of

MASTER OF SCIENCE IN HUMAN NUTRITION AND DIETETICS (IDL)

DECLARATION

I hearby declare that the submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which, to a substantial extent, has been accepted for the award of any other degree or diploma at Kwame Nkrumah University of Science and Technology, Kumasi or any other educational institution, except where due acknowledgement is made in the thesis.

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(Supervisor)   Signature   Date

Certified by:

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(*Head of Department)*   Signature   Date

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ABSTRACT

Neural tube defect (NTD) is caused by folic acid deficiency, hereditary, lifestyle, environmental factors and chromosomal abnormalities, and among others it is a remarkable public health burden. However, the documented Ghana health literature is devoid of research studies on prevalence and causes of NTD in Kumasi Metropolis. This study therefore assessed the prevalence and risk factors of NTD at the Komfo Anokye Teaching Hospital (KATH) in Kumasi. The participants in this study were mothers of both live babies with and without NTDs born between the period of January, 2012 to December, 2016. The study collected both primary and secondary data from 65 mothers of babies born with NTD and 65 mothers of babies born without NTD at the Mother and Baby Unit (MBU) of KATH. The secondary data were collected from the medical records of the babies with NTD and their mothers while primary data were collected through administration of structured questionnaire. The data were analyzed quantitatively with the help of SPSS version 21.0. The study found out that the prevalence of NTD at KATH was 2.63 per 1000. The commonest type of NTD diagnosed was Meningocele. As mothers advanced in age the likelihood of neural tube defects significantly decreases. Mothers in urban communities had significantly less likelihood to give birth to babies with neural tube defects than mothers in rural communities. Single mothers had higher likelihood of giving birth to babies with neural tube defects than married mothers. Mothers with lower educational level had higher likelihood of giving birth to babies with neural tube defects. Folic acid intake before pregnancy (one year before pregnancy) reduced the likelihood of giving birth to babies with neural tube defects. Mothers in the test group were diagnosed of anaemia and eclampsia more than mothers in the controlled group. Gestational diabetic mothers exposed to smoke from firewood and anemic mothers living in dusty environment had highly significant likelihood of giving birth to babies with NTD. Pregnant women should be educated on nutrition and healthy life style at healthcare facilities as part of their antenatal. Pregnant women should also be made aware of their risk factors to help them know how to interact with the environment to prevent the occurrence of NTDs. Ministry of Health should further embark on massive folic acid intake education to help reduce the occurrence of NTDs.

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ABBREVIATIONS

AhRT	aryl Hydrocarbon Receptor
ARNT	aryl Hydrocarbon Receptor Nuclear Translocator
CHRPE	Committee on Human Research Publication and Ethics
DEENT	Dental Ear Eye Nose and Throat
GHS	Ghana Health Service
GSS	Ghana Statistical Service
GWCL	Ghana Water Company Limited
ICU	Intensive Care Unit
KATH	Komfo Anokye Teaching Hospital
KNUST	Kwame Nkrumah University of Science and Technology
MBU	Mother and Baby Unit
MTHER	Methylenetetrahydofolate Reductase
NCBDDD	National Center on Birth Defects and Development Disabilities
NTD	Neural Tube Defect

SPSS	Statistical Package for Social Sciences
UNICEF	United Nations Children’s Emergency Fund
VIF	Variance Inflation Factor
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

According to Berry *et al.* (2010), neural tube defect (NTD) is a congenital malformation which happens between the twentieth and twenty-eighth days after conception. The cells of the neural plate make up the sensory system of the foetus. In usual development of neural tube defects, they fold back onto themselves keeping in mind the end goal to make what is known as the neural tube, which at that point turns into the spinal cord and the back bone. After various changes, the predominant shaft in the end turns into the brain. The developing brain and spinal cord are then uncovered (contingent upon the area of the anomaly). The most well-known types of NTD are anencephaly and spina bifida (Manning & Archer 2011).

Crider *et al.* (2011) noted that NTD is a remarkable public health burden. Globally, 300,000 infants are born every year with NTD with 88,000 mortalities (WHO, 2015). In developing countries, NTD account for 29% of the neonatal deaths due to observable birth defects (Blencowe *et al.,* 2010). Ghana Health Survey (2016) revealed that the prevalence of NTD was 3.16 per 1000 births in Ghana. It is well noted that as mortality and mobidity from infectious illnesses are decreasing around the world, the contribution of birth defects to under-5 morbidity and mortality will keep on increasing proportionally (Blencowe *et al.,* 2010).

It is noted that one of the main causes of NTD is folic acid deficiency (Lo *et al.,* 2014; Ebrahimi *et al,* 2013). It is therefore suggested and accepted worldwide through clinical trials that sufficient peri-conceptional folic acid intake decreases the occurrence of NTDaffected pregnancy. This has resulted in obligatory folic acid fortification of staple cereals and grains in a lot of nations like Canada, United States, South Africa, Costa Rica and Chile to be administered to pregnant women (Lo *et al.*, 2014). Ebrahimi *et al.* (2013) added that countries that have adopted and effectively implemented obligatory folic acid fortification of cereals have experienced decrease in prevalence rate of NTD 5–6 for every 10,000 pregnancies. Aqrabawi (2005) noted that larger part of NTD can be cured with folic acid replacement.

Other causes of NTD are hereditary, life style, environmental factors and chromosomal abnormalities (Davalos *et al*., 2000). Mahadevan and Bhat (2005) indicated that a few opinions support the view that hereditary or genetic factors are causative agents of NTD. Mahadevan and Bhat (2005) noted environmental factors, parental occupation, maternal obesity and maternal nutritional status are cited as main causes of NTD. Duttachoudhury and Pal (1997) suggested that it had been established more than 4 decades ago that MFS or nutritional deficiency was a leading cause of NTD risk in developing countries like Ghana. This study therefore aims to determine the prevalence rate and risk factors of NTD at the Komfo Anokye Teaching Hospital.

1.2 Problem Statement

Neural Tube Defects (NTD) is a public health burden, causing mostly 29% of the neonatal death (Blencowe *et al.*, 2010). Health practitioners and governments over the world are looking for preventive mechanisms to the disease (WHO, 2015). One of the ways through which countries can fight this disease is increasing awareness on the disease. This has made a lot of nations like Britain, Canada, United States, Costa Rica, Chile and South Africa to devote much effort and resources in research to determine its prevalence rate and causes to increase public awareness to facilitate its prevention (Lo *et al.*, 2014). However, many developing countries such as Ghana don’t have information on NTD incidence as well as not having much data on prevalence of NTD, causes and where information exist prevalence measure differ broadly (Zaganjor *et al.*, 2016).

This is a clear indication that studies on NTD prevalence and causes in Ghana are largely lacking and such studies are needed to create much awareness of the disease to facilitate its prevention. Current literature shows no study has been done on prevalence and causes of NTD at Komfo Anokye Teaching Hospital.

1.3 Research Objectives

General objective

The general objective of the study is to determine the prevalence and causes of NTD at Komfo Anokye Teaching Hospital.

Specific objectives

- To determine the prevalence of neural tube defects at Komfo Anokye Teaching Hospital in the Kumasi Metropolis.
- To determine socio-economic factors of mothers associated with neural tube defects in the Kumasi Metropolis.
- To determine human and physical factors associated with neural tube defects in the Kumasi Metropolis.

1.4 Significance of the Study

The study is significant for Komfo Anokye Teaching Hospital (KATH), married couples in Kumasi Metropolis and researchers and students. Currently, KATH has little information about prevalence rate of NTD as a referral facility. This has the potency to impede effective planning for NTD treatment of the health care delivery system of the country. Through this study, health practitioners would be much informed about the prevalence rate and causes of NTDs. This would help in effectively planning for NTD treatment and education in Ghana.

People's awareness of a disease helps them to take actions that prevent the occurrence of the disease. Some couples give birth to children with NTDs because they are ignorant about the causes and prevention of the disease. This study would help couples to know the causes of NTDs and also how to take necessary actions to reduce its occurrence in Ghana.

This study would contribute to knowledge on prevalence and causes of NTD in Ghana. This would serve as good source of literature for any researcher in the medical and its related fields who want to conduct a study on NTDs elsewhere in Ghana.

1.5 Conceptual Framework

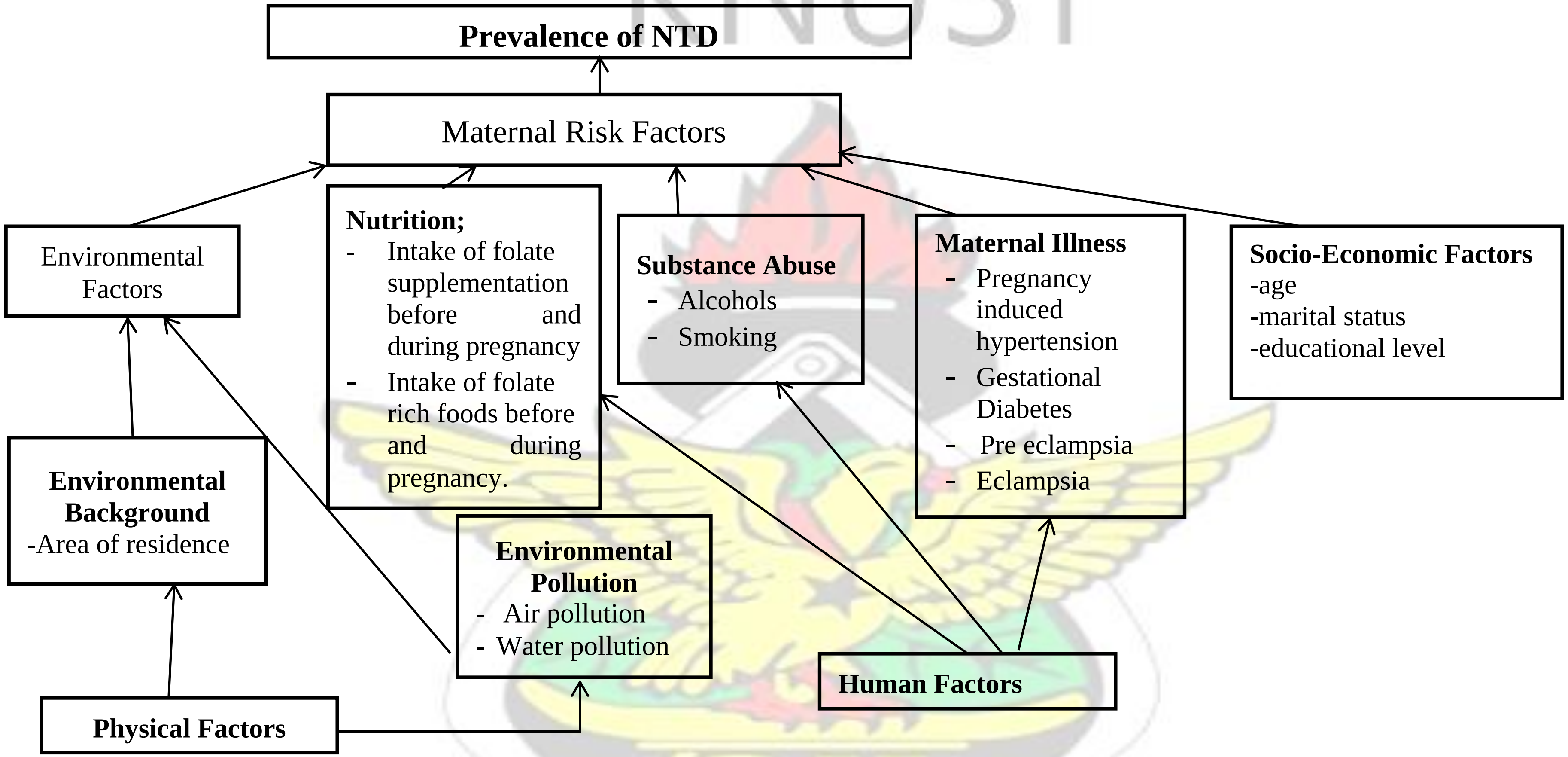

Figure 1.1: Conceptual Framework of Causes of NTD

Source: Adapted from Wang et al. (2010)

From Figure 1.1, Wang *et al*. (2010) noted that NTD is caused by maternal risk factors. The maternal risk is caused by four main factors, namely environmental exposures, nutrition, maternal illness and substance abuse (Wang *et al.*, 2010). Environmental exposure is made up of two factors, namely environmental background (area of residence) and environmental pollution (air and water pollution). Aside environmental background which is physical factor, all other factors constitute human factors. This study however added socio-economic factors to the model since literature has confirmed that some socio-economic factors such as age of mothers, marital status of mothers, and educational level of mothers and occupation of mothers influence the prevalence of NTDs.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Relevant literature on prevalence and risk factors of neural tube defects were reviewed in this chapter. The review specifically focuses on formation of NTDs, their prevalence, effects, causes and prevention. The review ends with summary of the chapter.

2.2 Formation of Neural Tube Defects

NTDs are regular complicated inherent distortions of the CNS coming about because of neural tube closure failure amid embryogenesis. That is, they are a class of conditions where the brain or spinal cord is exposed during development at the initial stage. During pregnancy (mostly third week) specialized cells which are located on the back region of the embryo starts to convert to form the neural tube. When this formed neural tube is unable to close entirely, then a disease known as neural tube defects is occurred (Le *et al.*, 2010).

NTDs are made up of two main types, namely open and close NTDs where the open NTDs are mostly common (Sadler, 2005). Open NTDs happen when the spinal cord or the brain is uncovered during childbirth through skull defect or back bone defect. Le *et al*. (2010), have identified several types of NTDs such as hydranencephaly, schizencephaly, anencephaly, iniencephaly, encephaloceles, and spina bifida. Anencephaly (without brain) is a type of open NTDs which mostly happens between 23rd and 26th days of pregnancy. According to Saladin (2010), anencephaly happens when the dorsal part of the head of the NT opens leading to loss of some portion of the brain. This is the most server type of open neural tube defects and mostly results in infant death within few hours of birth (Saladin, 2010).

Encephalocele is a deformity of the bony skull that occurs when part of the brain herniates. According to the NCBDDD (2012), encephaloceles are portrayed by brain protrusions via the skull that are like sacs and secured with a tissue lining. They can be a furrow down the center of the upper part of the skull, between the nose and the forehead, or the ventral side of the skull. Encephaloceles is not as server as anencephaly and they are diagnosable since it is visible defect but some are detectable especially small encephaloceles in the nasal and forehead (_Yan *et al*., 2012).

Hydranencephaly and Iniencephaly are not common. Hydranencephaly occurs when cerebral hemispheres are lost and occupied with cerebrospinal fluid sacs while Iniencephaly occurs when head to the spine is bended, the neck is lost and the face skin links to the chest directly as well as the scalp links to the upper back. Spina bifida is made up of two types, namely Spina bifida cystica and Spina bifida occulta. This incorporates myelomeningocele and meningocele. According to Le *et al*., (2010), Myelomeningocele comprises herniation of the meninges and in addition to the spinal cord through the opening. Meningocele is not serious and is described by meninges herniation, yet not the spinal cord, through the spinal cord openings. In this deformity, if just cerebrospinal fluid and meninges herniates via the defect, it is alluded as meningocele, while a myelomeningocele straight forwardly affects the nerve roots as well as spinal cord. Spina bifida occulta means hidden split spine (Saladin, 2010) and originate from a gap in at least one vertebral arches in the lumbosacral portion, however the spinal cord and meninges remain altogether inside the vertebral canal. In this kind of defect, the meninges don't herniate via the opening in the spinal canal (Le *et al.*, 2010). It is a typical state happening in 10– 20% of generally healthy individuals. Pittman (2008) noted that the most common form of Spina bifida occulta is the one due to abnormality of part of the spine and the neural arch bones appear abnormal on the radiogramme.

From the above, open neural tube defects results in several disabilities in a child and these disabilities include skin anesthesia, hip, knees, and feet abnormalities, walk impairment, little or no bowel and weak bladder control (Thomson, 2009). Hence, the long-term medical costs of open neural tube defects are considerably high (Yi *et al*., 2011).

2.3 Prevalence of Neural Tube Defects

Among the open NTDs, anencephaly and spina bifida are the predominant general kinds of neutral tube defects, occurring in approximately 350 000 newborns globally (Wu *et al*., 2007). Though the occurrence of NTDs is still high, it has declined over the years due to many interventions like terminating pregnancies that are affected and folic acid replacements. This section reviews literature on prevalence of the disease across space (Developed countries, Africa and Ghana in particular).

2.3.1 Neural Tube Defects Prevalence in Developed Countries

The occurrence of NTDs has been on the decrease in United State of America and United Kingdom**.** For example, in United State (US), the prevalence rate is 4 in 10,000 live births (Au & Northrup, 2013). A study by the ICBDSR (2006) on spina bifida prevalence in 8 third world nations (Canada, USA, Italy, England, Germany, France, Japan and Russia) revealed that rate of prevalence from 2001 to 2003 among these nations was 3 to 4 in 10 000 stillbirths and live births with or without pregnancy termination. The survey further noted that prevalence rate in Germany was 7.41 while Japan had prevalence rate of 5.32 without pregnancies termination due to spina bifida.

According to European Surveillance of Congenital Anomalies (2012), the prevalence rate of neural tube defects is lower in European countries than other continents. Europe has lowest prevalence rate of 1.3 per 10,000 births while America has minimum prevalence rate of 3.3 per 10,000 births (European Surveillance of Congenital Anomalies, 2012; González-Andrade & López-Pulles, 2010).

2.3.2 Neural Tube Defects Prevalence in Africa

Nnadi and Singh (2016) found prevalence rate of neural tube defects in North –West Nigeria to be 2.2 per 1000 deliveries. Anyanwu *et al.*, (2015) conducted a similar study in Kano metropolis of North-Western Nigeria and found prevalence rate of 2.75 per 1000 live births. Kareem *et al*, (1992) found prevalence rate in the Middle Belt of Nigeria to 7 per 1000 birth. In Africa, Nigeria is reported to have the lowest prevalence rate of neural tube defect (5.2 per 10,000 births) whiles Algeria has the highest prevalence rate (75.4 per 10,000 births) (Houcher *et al.*, 2012). NTD prevalence is 0.47 per 1000 birth in Malawi, 1.74 per 1000 birth in South Africa, 3.48 per 1000 birth in Sudan (El Sheikh et al.2012).

2.3.3 Prevalence in Ghana

Alhassan *et al.*, (2017) conducted a study on NTD and hydrocephalus prevalence in the northern parts of Ghana. The study covered only and used data over the January 2010. The findings from the previous studies suggest that prevalence rate of neural tube defect differ across countries; and differ from region to region within the same country. Therefore, specific studies to determine the prevalence rate of the disease in regions of a country where no such studies have been done is inevitable. This informed the researcher to conduct this study in Kumasi Metropolis using Komfo Anokye Teaching Hospital as a case study.

2.4 Causes of Neural Tube Defects

The NTD causative factors are multifactorial and the causes can be grouped into environmental factors, nutritional factors, substance abuse and maternal illness (Wang *et al*., 2010).

2.4.1 Environmental factors and Neural Tube Defects

Environmental factors include all non-genetic factors that could cause neural tube defects. The factors of the environment include parity, maternal age, metabolic diseases and social class. Wlodarczyk *et al*. (2012) identified anticonvulsant drug valproic acid at the same time Maliva *et al*. (2006) identified fungal product fumonisin as teragens that cause neural tube defect. Other non-genetic risk causes comprise maternal fever as well as too much utilization of hot tubs (Moretti *et al*., 2005). Diabetes and maternal obesity are well-known risk determinants for NTD (Correa *et al*., 2003). Identifying the causative factors of diabetes-linked NTDs is hindered by the sophistication of the diabetic mellitus, though hyperglycemia solely is adequate for causing NTDs in culture of rodent developing foetus.

Neural tube defect may be caused by other factors such as excessive oxidative stress, changed the appearance of genes like *Pax3*, as well as neuroepithelial cell apoptosis (Reece, 2012). Present observations propose that start of apoptosis signal-regulating kinase 1 (ASK1) in hyperglycemic cases result in the triggering of the apoptosis intermediary caspase 8 by stimulating the FoxO3a transcription factor (Yang *et al.*, 2013).

Parents' characteristics such as occupation, mean income and educational attainment are noted to influence the occurrence of neural tube defect. The issues of occupation and environment or ambient environment have been critical in the study of causes of neural tube defects (Kim *et al*., 2017). Though no census has been reached as to whether occupational environment of parents, especially mother or any chemical substance is a key factor that causes neural tube, plays a role in the cause of NTDs. Occupations that are likely to cause neural tube defects include business or finance, healthcare practice, cleaning and maintenance (*Kim et al.*, 2017).

Matte *et al.* (1993) have empirically established the importance of parental occupation in the causative factors of NTD. They conducted research on congenial disorders and parental involvement in occupations in the health centre. This report originated from ABDCC study. A total number of 4915 babies and 3027 babies used as controls were used in the analysis. Mothers who were given occupations as nurses had statistically relevant challenges of bearing children with spina bifida or anencephaly. Depending on three cases, there was a relevant excess of NTDs in mothers who were exposed to X ray. Kim *et al*. (2017) further identified exposure to solvents, pesticides, ionizing radiation and mercury as likely causes of neural tube defects. Roeleveld *et al*. (1990) had little believe that parental exposure to organic solvent could cause neural tube defect but he supports that assertion that it could adversely affect brain development. Parental exposure to organic solvent becomes relevant when each type of neural tube defect is considered since some types of neural tube defect go with abnormalities in CNS with a variety of pathogenetic approaches (Taskinen, 1990). Thus in the opinion of Taskinen
(1990), parental exposure to organic solvent could cause neural tube defect.

2.4.2 Folic Acid Deficiencies

Folic acid deficiency in pregnancy is one of the causes of the NTDs. This folic acid deficiency can be maternal folate deficiency and paternal deficiency of folate. Requirements of folate rise during pregnancy to contain the MTG and foetal and embryonic development. Levels of MS and RBC decline as there is an active transportation of the folate to the foetus as shown by HCBFC (Wallace *et al*., 2008). The reasons for

RBC concentration of folate decline include rise in folate catabolism, inadequate intake, dilution secondary to rise in intravascular volume and increased demand (WHO, 2012). Talaulikar and Arulkumaran (2011) noted that FD results in MMA which is deadly when it is not treated.

Paternal and maternal sex cells are affected by the presence of teratogenicity at the conceptional stage. An example is the factor that affects exposure of the father to dioxins. A relative significance has been established between SFD and DE resulting in spina bifida (Chou, 2017). Waste obtained from industrial processes are called dioxins. This is the result of incomplete combustion. Distribution of dioxin in the environment is transboundary.

Accumulation of dioxins take place in the food chain with rising levels. Dioxins stay in the body for a long period because of their stable nature and ability to remain in fatty tissues. Mutation risks in sperms increases relevantly after exposure of preconception to dioxins. This leads to a higher risk of spina bifida (Chou, 2017) through mechanisms involving folate deficiency (Halwachs *et al*., 2010).

Depending on AhR/ARNT activation, PBM of exposure is epigenetic and results in FD as the causative factor of phenotypic neural tube defects. Even though this defect is distributed widely, it is more in the testicle of humans, thus making it one of dioxins' sensitive organs. There is therefore direct hindrance with spermatogenesis of man and fertility of man (Schultz *et al*., 2003). It therefore obvious from the above that increased contaminated food consumption can result genetic mechanism deregulation shown in FH. Because of inadequacy in consumption of alimentary folate, there is increase in global deficiency of folate in women and men. Eventually, the results are neural tube defects in newborn babies.

2.4.3 Genetic factors and Neural Tube Defects

Genes are smallest features in every body cell. Genes determines the body formation and growth which intends determines the characteristic of individuals. Therefore, genetic disorder leads to deformity in the body, causing much morbidity such as neural tube defects (Seidahmed *et al*., 2014). Disorders that are determined by changes in more than one gene are known as complex disorders. Some complex disorders are due to interaction of genes with environmental factors such as exposure to certain chemicals, medications, or maybe even diet (Griffiths *et al.*, 2012). If a person has the right combination of changed genes, the individual would have a disorder that is complex.

The findings of the Hungarian and British clinical trials (Czeizel & Dudás, 1992) conducted a lot of research on metabolism of folate to determine the biochemical and genetic foundations of NTDs. Folate deals with SCTs which are integral parts of the of a lot of processes (Rosenblatt, 1995). Steegers *et al.* (1994) conducted a study which was based more on cycle of metabolism where homocysteine goes through methylation to methionine. A lot of genes were examined.

Au and Northrup (2013) first results showed that contribution of genetic factors to NTDs were not likely to be complicated. In addition, allele prevalence in some tribal groups correlated with NTD incidence. It was observed that, since the correlation is beyond perfection, other determinants should be involved. Similarly, even though the connection were to be causal, the variant of MTHFR would lead to a little division of NTD cases that are cured with folic acid intake.

2.5 Symptoms, Test and Diagnosis and Treatment of Neural Tube Defects

2.5.1 Symptoms

General symptoms include weakness or paralysis in the legs, urinary incontinence, bowel incontinence, a lack of sensation in the skin, accumulation of cerebrospinal fluid (CSF), leading to hydrocephalus, and possibly brain damage (Reece 2012).

2.5.2 Tests and diagnosis

Most cases of NTD are detected by a routine ultrasound scan during pregnancy. Testing for NTD can be done during pregnancy, but these tests are not 100 percent accurate (Wang *et al*., 2010). There are other tests for NTD and these include;

- **Maternal serum alpha-fetoprotein (MSAFP) test:** This is a blood test that assesses for alpha-fetoprotein (AFP), a protein that the fetus produces. AFP does not usually enter the mother's bloodstream. If it does, it usually means the fetus has abnormally high levels and probably a neural tube defect. This could indicate anencephaly, an incomplete skull and underdeveloped brain, or spina bifida. This is also not 100 percent accurate because sometimes, AFP levels are normal but the fetus has spina bifida (Wang *et al*., 2010). In other case, AFP levels are high but the fetus is healthy. If AFP levels are high, it is recommended that further tests such as ultrasound scan be done (Reece 2012).

2.5.3 Treatment

According to Kim et al. (2017) NTD treatment depends on several factors such as severity of the signs and symptoms.

2.5.3.1 Surgical options

- **Surgery to repair the spine**: This can be done within 2 days of birth. The surgeon replaces the spinal cord and any exposed tissues or nerves back into the newborn's body. The gap in the vertebrae is then closed and the spinal cord sealed with muscle and skin. If bone development problems occur later, such as scoliosis or dislocated joints, further corrective surgery may be needed (Kim *et al.*, 2017).
- **Prenatal surgery**: The surgeon opens the uterus and repairs the spinal cord of the fetus, usually during week 19 to 25 of pregnancy. This type of surgery may be recommended to reduce the risk of spina bifida worsening after delivery (Kim *et al.*, 2017).
- **Cesarian-section birth**: If NTD is present in the foetus, delivery will probably be by cesarean section. This is safer for the exposed nerves.
- **Hydrocephalus**: Surgery can treat a buildup of cerebrospinal fluid in the brain. The surgeon implants a thin tube, or shunt, in the baby's brain. The shunt drains away excess fluid, usually to the abdomen. A permanent shunt is usually necessary. Further surgery may be needed if the shunt becomes blocked or infected, or to install a larger one as the child grows (Wang *et al*., 2010).

2.5.3.2 Physical and occupational therapy

- **Physical therapy**: This is vital, as it helps the individual become more independent and prevents the lower limb muscles from weakening. Special leg braces may help keep the muscles strong.
- **Assistive technologies:** A patient with total paralysis of the legs will need a wheelchair. Electric wheelchairs are convenient, but manual ones help maintain upper-body strength and general fitness. Leg braces can help those with partial

paralysis. Computers and specialized software may help those with learning problems.

- **Occupational therapy**: This can help the child perform everyday activities more effectively, such as getting dressed. It can encourage self-esteem and independence.

2.5.3.3 Treatment for urinary incontinence

- **Clean intermittent catheterization (CIC)**: This is a technique to empty the bladder at regular intervals. The child or a parent or carer learns to place the catheter through the urethra and into the bladder to empty it.
- **Anticholinergics**: These drugs are normally prescribed for adults with urinary incontinence, but a doctor child may prescribe it for a child. They increase the amount of urine the bladder can hold and reduce the number of times the child has to pee.
- **Botox injection**: If the child's bladder contracts abnormally, known as a hyperreflexic bladder, the doctor may recommend a botulinum toxin (botox) injection to paralyze the muscles. If it works, treatment will be repeated every 6 months.
- **Artificial urinary sphincter (AUS)**: This surgically implanted device has a silicone cuff, surrounded by a liquid, a pump, and a balloon. It is attached to the urethra and the balloon is placed in the abdomen. The pump is placed under the skin of the scrotum in males and under the skin of the labia in females. When the child wants to urinate they press the pump, which temporarily empties the fluid from the cuff into the balloon, releasing the pressure on the cuff and opening the

urethra, allowing urine to be released. It may not be suitable for younger boys who have not yet reached puberty.

- **Mitrofanoff procedure**: The surgeon removes the appendix and creates a small channel, the Mitrofanoff channel, which ends at an opening, or stoma, just below the belly button. The child can place a catheter into the stoma to release urine and empty the bladder. Long-term use of antibiotics may be necessary to prevent urinary tract and kidney infections.

2.5.3.4 Treatment for bowel incontinence

Wang et al. (2010) identified treatment options for bowl incontinence to include the following;

- **Diet**: A healthy, balanced diet with plenty of fiber is essential to avoid constipation, but too much fiber can cause diarrhea. A food diary will help keep a record of suitable foods.
- **Anal plugs**: These are made of foam and inserted into the anus to prevent soiling. When the plug gets wet, it expands, blocking the passage of any feces and liquid. Anal plugs work for about 12 hours. They can be removed by pulling an attached string.
- **Enema**: Children who have not responded to treatments may benefit from enemas, which clean out the bowel for 2 to 3 days.
- **Surgery for bowel incontinence**: If none of these treatments are effective, the doctor may recommend surgery.
- **Antegrade continence enema (ACE)**: The appendix is used to create a channel between the bowel and the abdomen. This channel ends at an opening, or stoma, in the surface of the abdomen. If a catheter is inserted into the stoma, liquids can pass

through the catheter, into the stoma and into the bowel to flush out its contents through the anus.

- **Colostomy or ileostomy**: A colostomy involves diverting a section of the colon so that it connects to a stoma, which is attached to a pouch. The pouch collects stools. If the diversion is at the end of the small intestine, the procedure is called an ileostomy. A child with spina bifida may need help from a number of specialists, including a pediatrician, a neurosurgeon, a urologist, and an orthopedist.

2.6 Prevention of Neural Tube Defects (Folate Intake)

Due to multidimensional causes of NTD, one preventive measure may not be effective to substantially decrease the occurrence of NTDs. However, folate supplements and fortification are recommended to be effective in reducing the prevalence rate of the disease. Gedefaw *et al*. (2018) indicated that income level and prevalence of NTDs were negatively related with the poor having higher occurrence of NTDs. This is because poor families have poor diet; hence lower consumption of vitamins and folic acid (Gedefaw *et al.*, 2018). Therefore, increasing folate consumption can relevantly decrease the prevalence of NTDs. In view of this, there is the need for folate addition to enriched breads, flour, grain products and other cereals (Lawrence, 2013).

Due to the importance of folate intake in the prevention of NTDs, the following were recommended;

- All women of childbearing age should be receiving 0.4gm (400μg) of folic acid daily pre-conceptually for a month or two. (Talaulikar & Arulkumaran, 2011).
- Women at great risk of NTDs (women with previous neural tube defects-affected pregnancy, obesity, epilepsy and diabetes) should be receiving 5.5mg of FA

everyday pre-conceptually, starting 30 days prior to being pregnant and continuing via the initial three months of the conception (Talaulikar & Arulkumaran, 2011).

Supplementation and food fortification are the ways to provide folic acid to a lot of people. However, many pregnant women do not take in folic acid supplements due to unplanned pregnancy, lack of public awareness and high cost of food supplement. Rabius *et al*. (2012) showed that none of 220 pregnant women participants in his study in
Nigeria consumed folic acid supplements prior to conception (Rabiu *et al.*, 2012). According to Ogundipe *et al.* (2012), in Tanzania, 17.2% of pregnant women took folic acid supplement at the point their pregnancies during the period of 1999-2008.

Sayed *et a.l* (2008) have numerated four reasons why grain fortification is essential in Ghana and Africa as a whole in the fight against neural tube defects;

- In Ghana and Africa health infrastructure is very weak to the extent that many rural communities do not have access to quality healthcare. Due to the poor health infrastructure, a pregnant woman may not be aware of the state of her unborn baby whether the child has neural tube defects or not until the child is born. Moreover, there a few specialists to treat a neural tube defects; thus the best way to prevent or minimize the burden of neural tube defects is compulsory consumption of fortified grains for all women.
- In Ghana antennal care access is low due to surprise pregnancy, poverty and religious believe. Therefore, many pregnant women are not aware of the importance of folic acid intake. Therefore, education and consumption of fortified grains for women are sure ways of making all women to consume some amount of folic acid to prevent any possible neural tube defect.

- In Ghana, cultural believes make people to maltreat children with neural tube defects. This can lead to stigmatization of the child and the family, making them social outcast. To prevent this occurrence and to ensure social inclusion, fortification which leads to prevention of neural tube defects should be encouraged.
- The cost of medical treatment of neural tube defects is 30 times the cost of fortification in South Africa (Sayed *et al*, 2008).

Flour fortification started in 1996 in Oman. Before the flour fortification, Oman had prevalence rate of neural tube defects (Spina Bifida) to be 3 per 1000 birth. However, in 2006, the prevalence rate of Spina Bifida in Oman deceased substantially to 0.3 per 1000 births (Alasfoor *et al.*, 2010). Sayed *et al*. (2008) reported in South Africa that flour fortification had reduced prevalence rate of neural tube defects by 30.5% from 2003 to 2005.

In the United State, mandatory folate fortification did not significantly relate to the reduction in neural tube defects (Mosley *et al.*, 2009). This suggests that one intervention will significantly lead to reduction in neural tube defects. Other supplements such as vitamin B12 (Molloy *et al.*, 2009); 5-methyl THF (Czeizel *et al.*, 2011), formate (Momb *et al.*, 2013) and additions of purine precursors and thymidine (Chim *et al*. 2008) could reduce risk of NTDs. Lack of vitamin such as vitamin C is noted to be a cause of neural tube defects; hence intake of maternal diet and vitamins could help decrease the risk of NTDs (Sotres-Alvarez *et al*. 2013, Chandler et al. 2012).

2.6.1 Organizations in Support of Folate Fortification of Grains

Due the importance of fortification of grains in NTDs prevention, many organizations around the world have given it a support to be implemented in all countries. Some of these organizations include WHO, the USCDCP, UNICEF and the CCC.

Ghana and other African countries can also obtain help in fortification programmes from other organizations whose visions and missions are consistent with the fight against neural tube defects. These include;

- The Flour Fortification Initiative (FFI): gives resources for the fortification process at every stage of the programme. FFI provides information about why fortify grains, planning, and implementation and monitoring of fortification programme. (WHO, 2015)
- The IF for SBH: provides additional information about the prevention and support for those who have this defect from birth. IF has almost 50 members worldwide including four members in Africa. (WHO, 2015)
- FAM of Netherlands: it assists in legal and security order, sexual and reproductive health rights, water and food security in specified targeted countries.

2.7 Summary of Literature Review

NTDs are regular complex innate malformation of the CNS deriving from the closure failure of NT amid embryogenesis. Neural tube deformities can be open or closed, however, the most widely recognized among them is the closed neural tube defects. The most seen are anencephaly, schizencephaly, encephaloceles, iniencephaly, hydranencephaly, and spina bifida with spina bifida as number on the rundown.

The NTD prevalence differs across space and time. The prevalence rate is lower in the developed counties than developing counties. In the developed countries, Europe has lowest prevalence level of 1.3 in 10,000 births while America has minimum occurrence rate of 3.3 in 10,000 births (According to European Surveillance of Congenital Anomalies, 2012; González-Andrade & López-Pulles, 2010). In Africa, Nigeria has the lowest prevalence rate whiles Algeria has the highest prevalence rate of neural tube defect. In Ghana, the prevalence is not uniform; Alhassan *et al.* (2017) using data from Northern Region reported prevalence rate of 1.6 per 1000 births whiles Anyebuno *et a.l* (1993) using data from Bu Teaching Hospital in Accra reported 1.15 per 1000 births. However, prevalence rate of NTDs in the Ashanti region, Ghana and Kumasi Metropolis in particular is not known; making it difficult to fight against NTDs.

There are several causes of neural tube defects and these are broadly grouped into environmental causes, genetic and folate deficiency. It is recommended that folate intake (fortification and replacement) is better in ensure prevention of NTDs.

CHAPTER THREE

3.0 PARTICIPANTS AND METHOD

3.1 Introduction

This chapter deals with the general research design. It covers study methods and design, the profile of the study area, population of the study, sample size and sampling techniques, data collection methods, study variables, data analysis, ethical consideration, limitations of the study and assumptions of the study.

3.2 Study method and Design

The study employed retrospective case control study design to assess the risk factors of neural tube defects at Mother and Baby Unit (MBU) of Komfo Anokye Teaching Hospital (KATH) in the Kumasi Metropolis, Ashanti Region.

The study employed quantitative methods in data acquisition. Quantitative research design is whereby a researcher uses positivist claims to develop knowledge and collect data on predetermined instrument that yield statistical data (Creswell, 2003). The study adopted quantitative research design because it offers the opportunity to test hypotheses with statistical models (Grix, 2004) and to make predictions (Miller & Brewer, 2003). It is therefore a more scientific method of investigation because it aims at solving particular problems or testing theories and making predictions; thus between the qualitative and quantitative research design, the latter best fulfils these aims.

3.3 Profile of the Study Area

The study was carried out in Kumasi Metropolis of the Ashanti Region of Ghana. The metropolis is bounded by Kwabre District to the north; Antwima Kwanwoma Districts to the South. On the east of the Metropolis is Ejisu Juabeng Municipal and Atwima Nwabiagya District on the west of the metropolis. The unique centrality of Kumasi as a traversing point from all parts of the country also makes it a special place for many to migrate to. Kumasi has a population of 2,035,064 with a growth rate of 5.3% p.a (GSS, 2012).

The Metropolis has a number of Hospitals including KATH, Kumasi South Hospital, Suntreso Government Hospital, KNUST Hospital, Aninwaa Medical Center, Asafoagyei Clinic, Atasomanso Hospital, SDA Hospital and Bomso Clinic. The study was however conducted at KATH because it is the largest hospital and the only tertiary health institution in the Ashanti Region. The hospital has clinical and non-clinical directorates and these include Anaesthesia and Intensive Care Unit (ICU), Child Health, Dental, Eye,
Ear, Nose and Throat (DEENT), Diagnostics, Medicine, Obstetrics and Gynaecology, Accident and Emergency, Surgery, Oncology, Polyclinic, Pharmacy and Physiotherapy.

The vision of the hospital to “become a medical centre of excellence offering clinical and non-clinical services of the highest quality standards comparable to any international standards” making the study in the hospital more appropriate. The outcome of the study will help management to design educational programmes on prevention of neural tube defects in the metropolis, thereby helping the hospital to fulfill its vision with regards to eradication of neural tube defects.

3.4 Study Population

The study population was made up of mothers of babies born with NTD and the mothers of babies born without NTD between the periods of January, 2012-December, 2016 at the Mother and Baby Unit (MBU) of KATH. Within the period January, 2012December, 2016, number of birth recorded at the hospital was 51,755 with 136 NTD.

However out of the 136 cases, 77 of them were seeking treatment at the unit.

3.4.1 Inclusion criteria

Mothers of babies with NTD born in and referred to KATH within the period were included in the study. Also, mothers of babies without NTD born within the same period were used as control group for this study.

3.5 Sample size calculation

The study used Yamane (1967) formula started blow to calculate the sample size for the study. n= N/[1+ N(e^2)] Where; n= sample size;

N=total population of NTD patients for the period Jan., 2016-Dec., 2016 (77)

e= the level of precision. At the 95% confidence internal, e=0.05 From the formula, n= $77/(1+70(0.05)^2]$= 65

The study moreover adjusted for 10% non-respondent rate. The 10% adjusted nonresponse rate was calculated as [0.1 *65=6]. Therefore, from the Yamane formula and 10% adjusted non-response rate, the sample size is 71. However, due to difficulty of obtaining data from mothers in the test group, the sample size reduced to 65 mothers in the test group. Accordingly, 65 mothers in the controlled group were used. In all sample size was 130 mothers.

3.6 Sampling Techniques

The sampling was done in three phases. The first was to select the Mother and Baby Unit (MBU) where the study was carried out. The study purposively selected Mother and Baby Unit (MBU) at KATH. Komfo Anokye Teaching Hospital (KATH) is the largest hospital in the metropolis with highest number of birth per year in the metropolis; hence higher likelihood of occurrence of NTD at the hospital.

The second phase was to sample the respondents with NTD attending MBU at KATH. For the study period of January, 2012-December, 2016, the unit recorded 136 NTD cases but 77 were seeking treatment. The study systematically sampled the respondents. All the patients with NTD at the Unit were ranked numerically using KATH, MBU identification number as a guide. Based on the sample interval of 1, all patients on the lists from 1^{st} patient to the 77^{th} patient were automatically sampled for the study.

However, some patients within the range 1-77^{th} declined to participate since participation was not compulsory and some of the patients were not accessible. Therefore, the study replaced those patients with the next patients within or outside the range. However, due to difficulty of accessing the mothers in the test group, especially those who were not attending hospital as required the sample size for mothers in the test group reduced to 65.

The third phase was sampling of mothers in the controlled group. The study used convenience sampling to sample mothers in the controlled group. Convenience sampling was used based on accessibility to the mothers and willingness to provide accurate data for the study. At the end of this phase, 65 mothers attending Mother and Baby Unit (MBU) at KATH were selected to form the controlled group.

3.7 Data collection tools and techniques

The study relied on both secondary data and primary data. The secondary data were collected over the period January, 2012-December, 2016 from the medical records of the babies with NTD and their mothers. Important data not found in the medical records were sourced directly from the mothers through questionnaire administration. The mothers were either called on phone or visited in their homes to source the information needed. The study used structured questionnaire to gather the primary data because structured questionnaire helps to gather standardized responses from respondents and facilitate coding and statistical analysis of data.

The questionnaire was divided into four parts. Part A covered baby's information, Part B focused on socio-economic factors of mothers' information; Part C looked at the incidence of NTD; Part D covered human factors that influence NTD and these centered on nutritional intake (intake of folate supplementation during pregnancy), substance abuse (alcohol intake and smoking during pregnancy), maternal illness (pregnancy induced hypertension, gestational diabetes, pre-eclampsia, eclampsia) and environmental pollution (air pollution and water pollution). Part E centered on physical factors which focused on questions related to environmental background of the mother (that area of residence of the mother and the nature of house of occupancy).

Before the administration of questionnaire, the researcher sought permission from authorities of Mother and Baby Unit (MBU) at KATH. Questionnaires administration was scheduled on between 8th January, 2018 and 22nd January, 2018. Due to the large number of respondents and the data involved to be collected, the researcher trained two Research Assistants. They were trained on how to handle questionnaire before, during and after data collection; how to approach respondents and understanding of each question contained in the questionnaire to enable them to interpret the questions to the respondents for quality data.

The questionnaire was administered in two phases. The first phase was at the MBU at KATH within the period scheduled. However, after 22nd January, the number of respondents per the sampling technique was below 65, the researcher and the assistants contacted the required respondents on phone or visited them at their homes to respond to the questions. Each respondent was given at most 30 minutes to fill in the questionnaire. The respondents who could not write or read were assisted by the researcher or her assistants to write or read for smooth filling in of the questionnaire.

3.7.1 Pre-testing of Research Tool

The questionnaire for the study was pre-tested at the South Suntreso Government Hospital in Kumasi Metropolis. This facility has similar characteristics with KATH, hence responses to the pre-test questionnaire helped in shaping the design and the structure of the questionnaire.

The questionnaire was pre-tested on three NTD babies and their mothers at the chosen pre-test study hospital. The pre-test helped to correct all unclear questions, double barrel questions and irrelevant questions. It also helped to include in the questionnaire other questions which helped in providing the relevant data for addressing each research question.

3.8 Study Variables

Quantitative method was used in measuring the variables used in the study. The main variables used in the study were NTD, socio-economic factors, human factors and physical factors influencing NTD in the Kumasi Metropolis. The variables are defined in Table 3.1 below.

Table 3.1: Measurement of Key Variables in the Study

Study	Operational Definitions	Study Indicators Data	Sources of Variables
Maternal age	Age in years	below 20 years 20-25 years 26-30 years 31-35 years 36-40 years above 40 years	Questionnaire
Maternal education	Highest level of educational attainment	No formal education, basic education, secondary education and tertiary education	Questionnaire
Occupation	Occupation of the mother	unemployed trading farming public servant	Questionnaire
Marital status	Marital status of the mother	single married	Questionnaire

No. of pregnancies before diagnosis of NTD	Pregnancies that mother has had before given birth to a baby with NTD	numeric	Questionnaire
Number of children	Number of children of a mother before given birth to a baby with NTD	numeric	Questionnaire
Order of birth	The order of birth of a baby with NTD	numeric	Questionnaire
Human Factors influencing NTD	Timing of folate intake: Preconception 1=yes 2=no 1st Trimester 1=yes 2=no 2nd Trimester 1=yes 2=no 3rd Trimester 1=yes 2=no		Questionnaire
	Substance abuse: Preconception alcohol 1=yes 2=no intake 1=yes 2=no Alcohol intake during preg. 1=yes 2=no Preconception smoking 1=yes 2=no Smoking during pregnancy		Questionnaire
	Maternal illness: Medical Pregnancy induced records hypertension, 1=yes 2=no Gestational diabetes 1=yes 2=no Pre eclampsia, 1=yes 2=no Eclampsia 1=yes 2=no Others 1=yes 2=no		
	Environmental pollution: 1=yes 2=no Air pollution 1=yes 2=no Water pollution		Questionnaire

Physical factors influencing NTD	Environmental Background: Area of residence	1= urban 2= rural 3=sub-urban	Questionnaire
	condition of environment	1=smoking from refuse dump 2= smoking from industry chimney 3=smoking from firewood 4=dust etc	
	source of drinking water	1=well 2=GWCL 3=borehole	

3.9 Data Handling and Processing

At the end of questionnaire administration, questionnaires were checked for completeness. Questionnaires were sorted, numbered and kept in files under lock and key. Data were then being coded before entering into Statistical Package for Social Scientist (SPSS), version 21.

3.10 Data Analysis and Statistical Method

The data were analyzed and discussed according to arrangement of research objectives. Descriptive analyses were done using frequencies and percentages and results were presented using tables (frequencies and percentages). To test for statistical associations between NTD and all the maternal risk factors, this study used Chi-square test and Fisher's Exact Test. The study used 5% level of significance for all the test.

3.11 Ethical Considerations

Ethical clearance for the study was obtained from the Committee on Human Research, Publications and Ethics (CHRPE) of the Kwame Nkrumah University of Science and Technology (KNUST), School of Medical Sciences, KNUST with reference number

CHRPE/AP/586/17. In addition, clearance was obtained from the Mother and Baby Unit (MBU) at KATH. All the necessary permissions were sought from the relevant persons and authorities. Privacy and confidentiality of respondents were placed at the highest premium.

3.12 Study Limitations

The major limitation was the difficulty of getting data from mothers of the babies with NTD. This study is retrospective and obtaining data directly from mothers of babies with NTD who have stop attending the hospital for treatment of their babies was extremely difficult.

Despite this limitation, the researcher was able to source data from many of the mothers through alternative means such as telephone questionnaire administration.

CHAPTER FOUR

4.0 RESULTS

4.1 Introduction

The chapter presents result of the data collected from mothers of children with and without neural tube defects, seeking treatment at Komfo Anokye Teaching Hospital (KATH) in the Kumasi Metropolis. The chapter is divided into four sections. Section one focuses on child characteristics that formed the basis of this study; section two considers mother's characteristics and neural tube defects; section three focuses on human factors and neural tube defects and section four considers physical factors and neural tube defects.

4.2 Descriptive analysis

4.2.1 Data on Babies

This section is sub-grouped into three as prevalence of NTD; common NTD diagnosed and baby's characteristics.

4.2.1.1 Prevalence of Neural Tube Defects at KATH

The data collected on number of birth and NTD cases within the period of consideration is shown in Table 4.1. The result in Table 4.1 shows that the prevalence of NTD at KATH was 1:380.6 or 2.63 per 1000 birth.

Table 4.1: Prevalence of Neural Tube Defects at KATH

Period	Number Birth	of NTD cases	Prevalence of NTD	Prevalence per 1000 birth
2012-2016	51755	136	$\frac{136}{51755}$ $= 1:380\ 0r\ 0.263\%$	$1 = 380.6$ $x = 1000$ $360.6x = 1000$ $x = 2.63$

X is the number of NTD cases per 1000 birth

This study further considered common types of NTD at KATH and the results are summarized in Figure 4.1. The result in Figure 4.1 shows the most common type of NTD diagnosed at KATH was Meningocele (34.0%), followed by Spina bifida occulta (29.0%), Myclomeningocele (22.0%), and Encephalocele (15.0%).

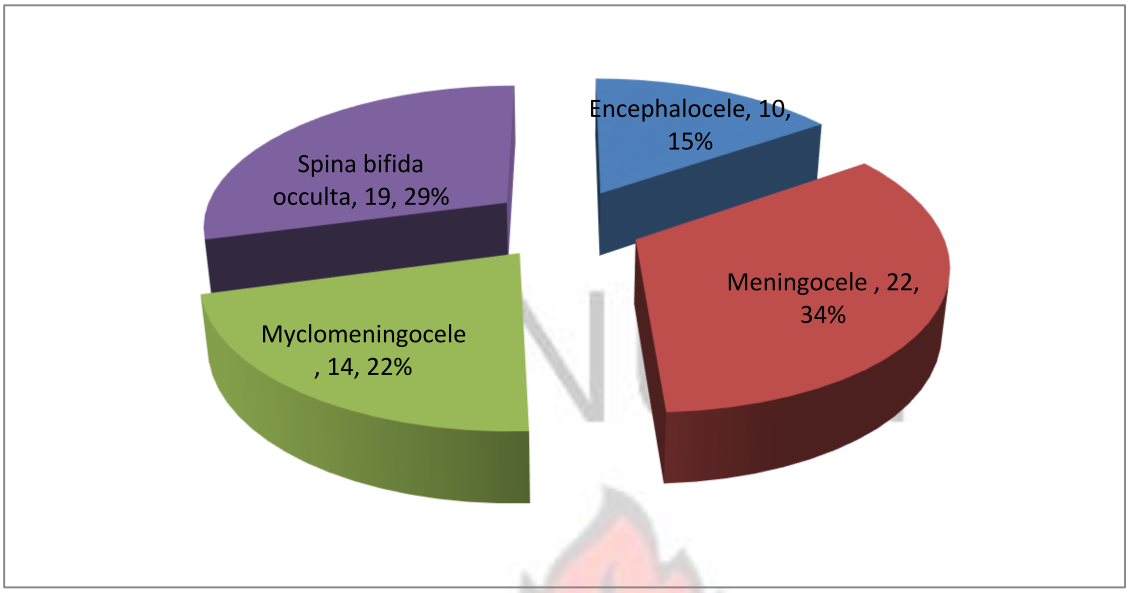

Figure 4.1: Common Types of Neural Tube Defects Diagnosed at KATH

The study reported on quality of life of children with NTD as shown in Figure 4.2. From Figure 4.2, the result shows that the number of children who were paralyzed was close to those who could walk. Those who could walk was 40.0%, those who required assistance to walk was 21.5% and those who were totally paralyzed was 38.5% of total number of babies with NTD.

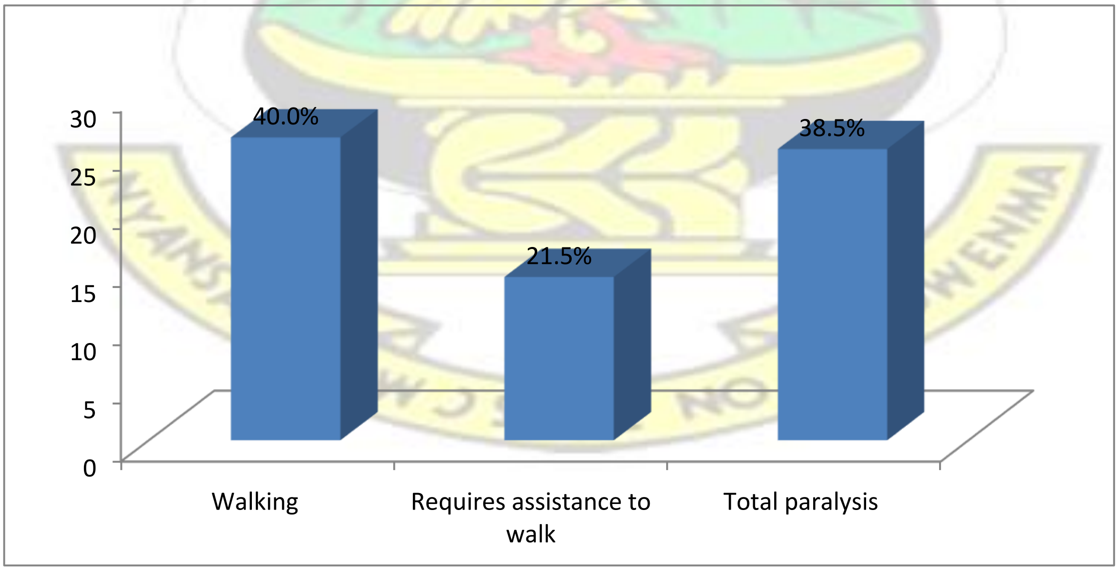

Figure 4.2: Quality of Life of Children with Neural Tube Defects

4.2.1.3 Baby's Characteristics

This section focuses on the characteristics of the babies of the mothers in test and control groups. The characteristics of babies sampled for the study were sex of the baby, age and weight at the time of diagnosis of the disease. The information is summarized in Table 4.2. The information in Table 4.2 shows that majority (64.6%) of the babies were at most one week when they were diagnosed of NTD. The male babies diagnosed of NTD were more than female babies. Out of 65 babies with NTD, 42 (64.6%) were males whilst 23 (35.4%) were females. The information in the Table 4.2 further shows that most (90.8%) of the babies in the case group had weight between 2-4 kg at birth with the remaining 9.2% having a weight in excess of 4kg. However, 27.7%, 61.5% and 10.8% of the babies in the controlled grouped were below 2 kg, 2-4 kg and above 4 kg respectively at birth.

Table 4.

1: Characteristics of Babies (both test group and control group)

Characteristics	Categories	Controlled Group		Case Group		Fisher's Exact test	Pvalue
		F	%	F	%		
Age at which NTD was detected	<1 wk 1 - 2wks >2wks	-	-	28 14 23	43.1 21.5 35.4		-
Gender	Males Female	41 24	63.1 36.9	42 23	64.6 35.4	0.033	0.999
Weight at birth	< 2 kg 2-4kg > 4 kg	18 40 7	27.7 61.5 10.8	0 59 6	0.0 90.8 9.2	71.865	0.000

4.2.2 Mother's Socio-economic Factors and Neural Tube Defects

The first objective of the study was to determine the association between mother's socioeconomic factors and NTD. Specific socio-economic factors of mothers considered were age, marital status, educational level, occupation, number of pregnancies before diagnosis, number of children before diagnosis and order of birth and the responses are summarized in Table 4.3.

The information in Table 4.3 shows that the maximum age of respondents was 40 years. Most of the respondents (both controlled and case groups) were between 20-30 years. However, more mothers in the case group were in the teens (below 20 years) than mothers in the controlled group. The number of mothers in test group was 21.6% higher than number of mothers in controlled group within the teen ages.

The Fisher's Exact test of association between age of mothers and NTD was statistically significant ($p<0.01$), suggesting that there is strong association between age of mothers and occurrence of NTD. Results further indicated that mothers in the case group relatively have larger family sizes. None of the mothers in the controlled group had 4 children but some mothers (29.2%) in the case group had 4 children.

From Table 4.3, majority of the respondents (77 mothers for both controlled and case groups) were married and the remaining (53 mothers) were single. However, the proportion of married mothers in control group (61.5%) exceeded that proportion of married mothers in the case group (56.9%) by 4.6%. The Fisher's Exact test result shows that the association between marital status of mothers and occurrence of NTD is not statistically significant (p=0.721).

Most of the mothers had JSS/MSL certificates, followed by Basic School Examination Certificates, no formal education, First Degree and Secondary School Certificate. None of the mothers in the case group had education beyond secondary level with 18 (27.7%), having no formal education, 21 (32.3%) having primary education, 20 (30.8%) having JHS/JSS education and 6 (9.22%) with secondary/SHS education. However, for the control group, the distributions of education level were JSS/MSLC (38.5%), Tertiary education (23.1%), Primary education (16.9%) Secondary education (10.8%) and no formal education (10.8%). The results further indicated that occurrence of NTD was associated with educational level of mothers and is statistically significant (p=0.021).

The results in Table 4.3 shows that most (49.2%) of mothers in the control group were public and civil servants with remaining of them as unemployed/house wives (12.2%), traders (27.8%) and farmers (10.8%). However, most (47.7%) of mothers in the case group were farmers with remaining as unemployed/house wives (20.0%) and traders (32.3%). From the Fisher's Exact test, occurrence of NTD is significantly associated with occupation of mothers (p = 0.031).

Table 4.

2: Association between Socio-Demographic Factors and Neural Tube Defects

	Categories	**Controlled Group**		**Case Group**		**Fisher's exact test**	**p-value**
		F	%	F	%		
Age at diagnosis	Below 20 yrs 20-30 yrs 31-40yrs			15 30 20	23.1 46.1 30.8	78.507	0.000
Marital status	Single Married	25 40	38.5 61.5	28 37	43.1 56.9	0.533	0.721
Educational level	No. formal edu Primary JSS/MSLC Secondary & Tertiary	7 11 25 7 15	10.8 16.9 38.5 10.8 23.1	18 21 20 6 0	27.7 32.3 30.8 9.2 0.0	11.341	0.021
Occupation	Unemployed Trader Farmer Public/civil servants	8 18 7 32	12.2 27.8 10.8 49.2	13 21 31 0	20.0 32.3 47.7 0.0	8.734	0.031
No. of children	1 2 3 4	31 19 15 0	47.7 29.2 23.1 0.0	21 12 13 19	32.3 18.5 20.0 29.2	7.007	0.068

4.2.3 Human Factors and Neural Tube Defects

This section of the chapter addresses the research objective two; "to determine human factors associated with neural tube defects in the Kumasi Metropolis". The human factors were grouped into four as medical history of the mothers, lifestyle factors of the mothers, folic acid intake and food intake by mothers during pregnancy.

4.2.3.1 Medical History and Life Style Factors of Mothers and Neural Tube Defects

The medical factors concentrated on medical history of the mother whilst life style factors considered alcoholic intake and smoking during pregnancy. The association between medical history of mothers and NTD and life style factors and NTD were tested with Chi-square Test and the results are shown in Table 4.4.

Results in Table 4.4 indicate three most common ailments among mothers (both controlled and case group) during pregnancy as gestational diabetes, pregnancy- induced hypertension and anaemia. However, mothers in the case group were diagnosed of anaemia and eclampsia more than mothers in the controlled group. Moreover, mothers in the controlled group were diagnosed of pregnancy induced hypertension, pre-eclampsia, gestational diabetes and severe hyperemesis than mothers in the case group. The Fisher's Exact test results show that among the ailments considered in the study, NTD is significantly associated with eclampsia (p=0.021), anaemia (p=0.005) and gestational diabetes (0.003).

Results in Table 4.4 shows that 40 mothers (both controlled and case groups) took in alcohol before and during pregnancy while 13 mothers (both controlled and case group) smoked certain amount of cigarette before and during pregnancy. However, results show that more mothers in the case group were into alcohol intake than controlled group. NTD is significantly associated with alcohol intake (p-value=0.023) and smoking (pvalue=0.035).

3: Association of Between Medical History, Life Style Factors and Neural Tube Defects

Factors	Categories	Controlled Group		Case Group		Fisher's Exact test	pvalue
		Yes	No	Yes	No		
Mothers' medical History	Pregnancy induced hypertension	14 (21.5%)	51 (78.5%)	12 (18.5%)	53 (81.5%)	0.201	0.827

Table 4.

during pregnancy	Pre-eclampsia	7 (10.8%)	58 (89.2%)	1 (1.5%)	64 (98.5%)	1.945	0.062
	Anaemia	7 (10.8%)	58 (89.2%)	21 (32.3%)	44 (67.7%)	8.922	0.005
	Gestational diabetes	21 (46.1)	44 (67.7%)	8 (12.3%)	53 (87.7%)	10.574	0.003
	Eclampsia	7 (10.8%)	58 (89.2%)	12 (18.5%)	53 (81.5%)	8.541	0.021
	Severe hyperemesis	13 (20.0%)	52 (880.0%)	11 (16.9%)	54 (83.1%)	0.204	0.822
Alcohol intake before and during pregnancy	---------------	0 (0.0%)	65 (100.0%)	26 (40.0%)	39 (60.0%)	8.142	0.023
Smoking before and during pregnancy	---------------	0 (0.0%)	65 (10.0%)	6 (9.2%)	59 (90.8%)	8.001	0.035

4.2.3.2 Folic Acid Intake and Neural Tube Defects

Having knowledge on folic acid as a mother is good but translating the knowledge into positive folate intake behaviour is more important in the lives of mothers during pregnancy. This section therefore assessed the folate intake behaviour of mothers and its association with NTD and the results are shown in Table 4.5.

The results Table 4.5 shows that, mothers in the controlled group have positive folate intake behaviour than mothers in the case group. Out of 65 mothers in the controlled group, 31 (45.6%) took folic acid before conception whilst 7 (10.8%) of the mother in the case group took folic acid before conception. The results further show that all mothers in the controlled group took folic acid during pregnancy whilst 59 (90.8%) of the mothers in the case group took folic acid during pregnancy. The Fisher's Exact test shows that NTD was associated with both folic acid intakes before conception (p=0.000) and during pregnancy (p=0.028). However, the association between NTD and folic acid intake before conception was stronger than the association between NTD and folic acid intake during pregnancy.

4: Folate Intake Behaviour / Practice and Neural Tube Defects

variables	categories	Controlled Group		Case Group		Fisher's Exact test	p-value
Taking folic acid before conception	Yes	31	45.6	7	10.8	19.636	0.000
	No	34	54.4	58	89.2		
Taking folic acid during pregnancy	Yes	65	100.0	59	90.8	8.608	0.028
	No	0	0.0	6	9.2		

The study further asked the respondents key information about folic acid to determine their level of knowledge about it and the responses are given in Table 4.6. The study used Independence Samples T test to statistically test if there exist differences in knowledge about folic acid.

Table 4.6 shows that mothers in the controlled group knew the importance of folic acid more than mothers in the case group. Moreover, some good number of mothers in the controlled group could mention some specific importance of folic acid to them as mothers and their babies while mothers in the case group could not state any specific importance of folic acid. Moreover, mothers in the case group had less information on specific food source or items that are rich in folic acid. This suggests that the reasons for lower folic acid

Table 4.

intake among mothers in the case group were mainly lack of information on importance of folic acid and sources of food items rich in folic acid.

Table 4.5: Mothers' Knowledge about Folic Acid

Information	Categories	Controlled Group		Case Group		P-value
		F	%	F	%	
Do you know the importance of folic acid?	Yes No	58 7	89.2 10.8	44 21	67.7 32.3	0.015
What is your source of knowledge?	Hospital School Media	39 10 9	67.2 17.2 15.6	26 7 11	59.1 15.9 25.0	0.081
How often was folic acid taken during pregnancy	Daily	65	100.0	65	100.0	0.999
Nutritional counseling on folate intake	Yes No	22 43	33.8 66.2	12 53	18.5 81.5	0.011
Who counseled you on Dietician/ 14 63.6 7 58.3 0.274 **folate intake** Nutritionist 0 0.0 0 0.0						
	Doctor Nurse/Midwife	8	36.4	5	41.7	
Indicate some of the importance of folic acid		helps in cell development, brain development, prevent child disease like neural tube defect		It is good for pregnant women and their babies		

Indicate food items that are rich in folic acid	Kontomire, dried beans, dried nuts, citrus juice and fruit, lettuce, tomatoes, papaya, wheat bread	Kontomire, all dark green leafy vegetables	

4.2.3.3 Specific Food Intake and Neural Tube Defects

Apart from folic acid, pregnant women are supposed to eat some common locally produced food items beneficial to both the woman and unborn baby. This study thus assessed intake of these food items by the mothers and their associations with NTD and the results are given in Table 4.7. The results Table 4.7 indicates that majority of mothers in the controlled group ate dark green leafy vegetables 5-6 times per week while majority of those in the case group ate dark green leafy vegetables and took milk 2-4 times per week during pregnancy. Mothers in the controlled group ate tomatoes and citrus once a day while those in the case group take tomatoes 5-6 times per week and never ate citrus during pregnancy. However, both mothers in the controlled and case groups ate avocado, wheat bread, cabbage, beans, pea and lentils 2-4 times per week during pregnancy. Mothers in the case group ate milk/tea once a day whilst those in the controlled group ate milk/tea 2-4 times per week.

Both mothers in the controlled and case groups took beans, pea and lentils 2-3 times per week during pregnancy. Both mothers in the controlled and case groups ate okro, liver, papaya once in a week during pregnancy. Mothers in the controlled group ate lettuce once a week while those from the case group also take lettuce once a week. Both mothers in the controlled and case groups ate egg yolk 5-6 times per week during pregnancy.

The Fisher's Exact test results show that NTD is significantly associated with intake of all the food items in Table 4.7 except wheat bread and papaya. These results are consistent with some previous studies.

Table 4.6: Key Food Item Intake by Mothers during Pregnancy and their Association with Neural Tube Defects

Food items	Group	Never	Once a wk	2-4 per wk	5-6 per wk	Once a day	2-3 per day	WA	Fisher's Exact value	P-value
Dark green leafy vegetables	controlled	0 (0.0%)	0 (0.0%)	27 (41.5%)	38 (58.5%)	0 (0.0%)	0 (0.0%)	3.5846	38.144	0.000
	case	0 (0.0%)	0 (0.0%)	59 (90.8%)	6 (9.2%)	0 (0.0%)	0 (0.0%)	3.0932		
Milk and Tea	Controlled	0 (0.0%)	13 (20.0%)	20 (30.8%)	25 (38.5%)	0 (0.0%)	0 (0.0%)	2.9692	37.687	0.000
	Case	7 (10.8%)	11 (16.9%)	0 (0.0%)	19 (29.4%)	21 (32.3%)	21 (32.3%)	4.6615		
Beans, Pea and lentils	controlled	0 (0.0%)	7 (10.8%)	51 (78.5%)	7 (10.8%)	0 (0.0%)	0 (0.0%)	3.0000	16.293	0.000
	case	0 (0.0%)	0 (0.0%)	65 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3.0000		
Tomatoes	controlled	0 (0.0%)	22 (33.8%)	43 (66.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.6615	18.193	0.000
	case	0 (0.0%)	46 (70.8%)	19 (29.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.2923		
Okro	controlled	1(1.5%)	36 (55.4%)	28 (43.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.4154	44.575	0.000
	case	7 (10.8%)	58 (89.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.8923		
Liver	controlled	0 (0.0%)	51 (78.5%)	14 (21.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.2154	4.478	0.035
	case	0 (0.0%)	40 (61.5%)	25 (38.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.3846		

Avocado	controlled	4 (6.2%)	14 (21.5%)	47 (72.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.6615	8.755	0.007
	case	0 (0.0%)	27 (41.5%)	38 (58.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.5846		
Wheat bread	Controlled	21(32.3%)	4 (6.2%)	25 (38.5%)	0 (0.0%)	15 (23.1%)	0 (0.0%)	2.7538	4.270	0.237
	Case	19 (29.2%)	0 (0.0%)	28 (43.1%)	0 (0.0%)	18 (27.7%)	0 (0.0%)	2.9692		
Carrots	Controlled	19 (29.2%)	22 (33.8%)	43 (66.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.6615	17.488	0.000
	Case	13 (20.0%)	13 (20.0%)	39 (60.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.4000		
Papaya	controlled	0 (0.0%)	54 (83.1%)	11 (16.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.1692	2.622	0.181
	case	0 (0.0%)	60 (92.3%)	5 (7.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.0769		
Citrus	controlled	0 (0.0%)	0 (0.0%)	7 (10.8%)	5 (7.7%)	13 (20.0%)	40 (61.5%)	5.3231	40.409	0.000
	case	27 (41.5%)	12 (18.5%)	20 (30.8%)	12 (18.5%)	6 (9.2%)	0 (0.0%)	1.1538		
Lettuce	controlled	11 (16.9%)	39 (60.0%)	15 (23.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.0615	11.773	0.003
	case	26 (40.0%)	21 (32.3%)	18 (27.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1.8769		
cabbage	controlled	0 (0.0%)	9 (13.8%)	55 (84.6%)	1 (1.5%)	0 (0.0%)	0 (0.0%)	2.8769	13.510	0.002
	case	7 (10.8%)	12 (18.5%)	40 (61.5%)	6 (9.2%)	0 (0.0%)	0 (0.0%)	2.6923		

Egg yolk	controlled	0 (0.0%)	0 (0.0%)	26 (40.0%)	5 (7.7%)	20 (30.8%)	16 (21.5%)	4.3385	52.377	0.000
	case	0 (0.0%)	14 (21.5%)	32 (49.2%)	0 (0.0%)	6 (9.2%)	13 (20.0%)	3.5692		

4.2.4 Physical Environmental Factors and Neural Tube Defects

This section addresses the final objective of the study; "to determine physical environmental factors associated with neural tube defects in the Kumasi Metropolis". The physical environmental factors considered in this study were place of residence, condition of residence and source of drinking water and the findings are as summarized in Table 4.8.

The results in Table 4.8 show that most of the mothers in the controlled group lived in urban communities whilst most of the mothers in the case group lived in rural communities. Table 4.8 further shows that 17 (26.2%), 1(1.5%),7 (10.8%), 4 (6.2%), 6 (9.2%) of the mothers in the controlled group lived areas which most often experienced smoke from firewood, industrial chimneys, refuse dump sites, pollutants from sawmills and dust respectively. However, mothers in the case group lived in areas which most often experienced smoke from firewood (10.8%), industrial chimneys (1.5%), refuse dumps (10.6%) and dust (67.7%). Mothers in the case group who lived in dusty environment exceed the mothers in the controlled grouped who lived in dusty environment by 38 (58.5%).

The results in Table 4.8 indicates that mothers in the controlled group got their drinking water from bore holes (43.1%), well (10.8%) and Pipe borne water (46.1%) whilst mothers in the case group got their drinking water from borehole (78.5%) and GWCL (21.5%). In Ghana, water from most well and boreholes are not pure or contain pollutants which generate dioxins, hence leading to more likelihood of neural tube defect occurrence.

The Fisher's Exact tests show that NTD was not significantly associated with place of residence of mothers (p=0.176) but significantly associated with dusty environment, smoke from firewood (p=0.028), pollutant from sawmill (0.042) and dusty environment (p=0.000). Moreover, the Fisher's Exact test result revealed that NTD was significantly associated with source of drinking water for mothers (p=0.000).

Table 4.7: Environmental Factors and Their Association with Neural Tube Defects

Factors	Categories	Controlled Group		Case Group		Fisher's exact test value	P-value
		F	**%**	**F**	**%**		
Place of residence	Urban	36	55.4 26.1	26	40.0 40.0	3.522	0.176
	Rural	17	18.5	26	20.0		
	Sub-urban	12		13			
		Yes	**No**	**Yes**	**No**		
Condition of environment of residence of mothers	Smoke from firewood	17 (26.2%)	48 (73.8%)	7 (10.8%)	58 (89.2%)	8.608	0.028
	Smoke from industrial chimneys	1 (1.5%)	64 (98.5%)	1 (1.5%)	64 (98.5%)	3.322	0.106
	Smoke from refuse dumps	7 (10.8%)	58 (89.2%)	7 (10.8%)	58 (89.2%)	4.029	0.072
	Pollutants from sawmills	4 (6.2%)	61 (93.8%)	0 (0.0%)	65 (100.0%)		0.042
	Dusty environment	6 (9.2%)	59 (90.8%)	44 (67.7%)	21 (32.3%)	11.220	0.000
		F	**%**	**F**	**%**		
Mothers' source of drinking water	Bore hole	28	43.1	51	78.5	44.149	0.000
	Well	7	10.8	0	0.0		
	GWCL source (pipe borne water)	30	46.1	14	21.5		

4.3 Econometric Analysis

The study employed binary logistic regression to estimate the occurrence of neural tube defects. Before estimation, the study used Variance Inflation Factor and Tolerance level to test for serial correlation (Table 4.9).

Variance Inflation Factor (VIF) and Tolerance level tests (Table 4.9). indicates no problem of multicollinearity since all the values of VIF for independent variables and tolerance value were less than 3.00 and more than 0.4 respectively. According to Brien (2007) if VIF for independent variables is less than 3.00 with tolerance level above 0.4 then there is no multicollinearity problem.

Therefore, the binary logistic regression results are shown in Table 4.9. The results in Table 4.9 show that as mothers advanced in age the likelihood of neural tube defects significantly decreases. Therefore, mothers who are adults and have pregnancy experience are less likely to give birth to babies with neural tube defect. Mothers who were adults were 0.720 times less likely to give birth to babies with neural tube defects than mothers who were in their youthful age. Mothers with higher educational level (post-secondary education) had lower likelihood of giving birth to babies with neural tube defects. Mothers with post-secondary education were 0.181 times less likely to give birth to babies with neural tube defect than mothers with pre-secondary education. However, occupations, place of residence, marital of the mother do not matter in the likelihood of occurrence of neural tube defects.

The results show that mothers who took in folic acid before pregnancy (one year before pregnancy) had lower likelihood of giving birth to babies with neural tube defects than mothers who did not take in folic acid. They were 0.504 times less likely to give birth to babies with NTD.

The moderation of medical history of a mother and environmental conditions were included in the model. However, only interaction of Gestational Diabetes and Smoke from firewood and Anaemia and dusty environment had significant higher likelihood of causing neural tube defects. Therefore, mothers diagnosed of gestational diabetes and exposed to smoke from firewood were 9.685 times more likely to give birth to babies with neural tube defect. Moreover, mothers diagnosed of Anaemia and exposed to dust environment were 30.356 times more likely to give birth to babies with neural tube defects.

The Cox and Snell R- square and Nagelkerke R-square show that the explanatory variables together explained 38.8% and 57.1% respectively of the variables in occurrence of neural tube defect. This is a demonstration that the explanatory variables explain greater percentage of the variation in the dependent variable. The model as a whole is statistically fit for predictions (Omnibus χ^2=63.815; p=0.000).

Table 4.9: Logistic Regression Results

Variables	Coeff.	Wald Test	95% CI for EXP(B)		OR	Tolerance	VIF
			Lower	Upper			
Age of Mother	-0.328	7.360*	0.569	0.9913	0.720	0.413	2.421
Place of Residence (Urban)	-1.335	0.331	0.003	24.829	0.263	0.542	1.879
Marital status (single)	0.163	0.018	0.108	12.799	1.177	0.483	2.070
Educational Level (post-secondary education)	-1.709	5.211*	0.042	0.785	0.181	0.440	2.271
Occupation (unemployed)	1.260	0.650	0.165	75.484	3.527	0.411	2.433
Folic Acid Intake (before pregnancy)	-0.684	6.789*	0.301	0.844	0.504	0.421	2.375
Gestational Diabetes*Smoke from firewood	2.271	7.200*	1.844	50.866	9.685	0.449	2.227
Preg, Induced Hypertension*Smoke from Firewood	-0.331	0.069	0.061	8.486	0.719	0.894	1.118
Preg, Induced Hypertension*Smoke from Ind. Chimneys	-0.240	0.222	0.290	2.133	0.787	0.827	1.210
Preg. Induced Hypertension*Dusty Env.	0.137	0.016	0.385	3.416	1.147	0.715	1.399
Anaemia*Smoke from Ind. Chimneys	-0.099	0.035	0.317	-2.582	0.905	0.938	1.066
Anaemia*Dusty env.	3.413	6.908*	0.003	0.420	30.356	0.919	1.088
Gestational Diabetes*Dusty Env.	0.196	0.169	0.477	3.105	1.217	0.555	1.800
Constant	10.818	4.256*	-	-	49934.94	-	-

N=130

Cox and Snell R^2= 0.388; Nagelkerke R^2= 0.571 el Coefficient (Chi-
Omnibus Test of Mod re)= 63.812. 865; p= 0.0000

Dependent Variable=Occurrence of Neural Tube Defect; significance level=5%

CHAPTER FIVE

5.0 DISCUSSION

5.1 Baby's Information

The results showed that NTD was detected when most babies were at most one week. This is a clear indication that neural tube defects are detected quickly in the Komfo Anokye Teaching Hospital. This early detection of the disease helps to save the life of the babies with neural tube defects (Thompson, 2009). Male babies were diagnosed of NTD more than female babies. Out of 65 babies with NTD,42 (64.6%) were males whilst 23 (35.4%)The results on weights of babies with neural tube defects at the time of diagnosis suggests that the babies were not low birth weight (LBW) since LBW babies have weight at birth less than 2.5 kg. This is an indication that a baby at birth can have normal weight yet can be diagnosed of neural tube defects.

5.2 Prevalence of Neural Tube Defects at KATH

The prevalence of NTD at KATH was 2.63 per 1000 birth and is higher than Korle Bu Teaching Hospital in Accra and Tamale Regional Hospital in the Northern Region. The NTD prevalence in the Northern Region (Tamale Regional Hospital is 1.6 per 1000 births (Alhassan *et al*., 2017) and in the Korle Bu Teaching Hospital is 1.5 per 1000 births (Anyebuno *et al.*, 1993). The commonest type of NTD diagnosed at KATH was Meningocele, which is a type of Spina bifida. The study found out that number of children with NTD who were paralyzed is close to those who could walk.

KATH detected most of NTD cases within the first week of birth. Male babies were diagnosed of neural tube defects more than female babies. Most of the babies with NTD had normal weight at birth.

5.3 Socio-economic Factors of Mothers and Neural Tube Defects

The first objective of the study is to determine socio-economic factors of mothers associated with NTD. Key mother's characteristics considered in the study were age, occupation, level of education and marital studies. Among them, age of mothers and their occupations as at their last births emerged very crucial to neural tube defects. The study realized that mothers whose babies were diagnosed of neural tube defects were relatively younger (youthful) between 20-30 years than those whose babies were free from neural tube defects. However, the mothers in the case group had larger family size compared to mothers in the controlled. Therefore, though mothers in the case group were relatively younger, they had larger family size. This suggested that mothers in case group had little information or knowledge about family planning, leading frequent pregnancies and larger family size. Frequent child bearing, especially for a young mother has adverse health effect on her and fetus development during pregnancy.

Neural tube defect was significantly associated with occupation of mothers. From the study, most of mothers whose babies were free were public/ civil servants whilst most of the mothers whose babies were diagnosed of neural tube defects were farmers. The findings of this study are in lie with Sever's (1994) findings that farming is among the occupations that are associated with neural tube defect. Educational Level of the mothers was significantly associated with neural tube defect. The study revealed that mothers in the case group had educational attainment relatively lower than mothers in the controlled group. Most of the mothers in the case group were not having any formal education with the rest up to secondary education whilst most mothers in the controlled group had first degree (university education). This is an indication that mothers in the case group had less knowledge and information on causes of neural tube defects and its prevention.

Moreover, due to lack of adequate information on pregnancies and neural tube defects, some of the mothers in the case group were into practices such as smoking and alcohol intake that were not helpful for their health and development of foetus.

5.4 Human Factors and Neural Tube Defect

The study revealed that most of the mothers in the test group were anaemic as compared to those in the control. The study further reveled that mothers in the test group had lower folic acid intake relative to mothers in the control group before pregnancy. NTD was strongly associated with folic acid intake before pregnancy than during pregnancy. The reasons for lower folic acid intake among mothers in the case group were mainly lack of information on importance of folic acid and sources of food items rich in folic acid.

Talaulikar and Arulkumaran (2011) noted that folate deficiency is known to lead to maternal megaloblastic anemia, which may be fatal if left untreated. Folic acid deficiency can be maternal folate deficiency and or paternal folate deficiency. In this study, folate deficiency is mainly maternal since the study was about mothers. During pregnancy, folate requirements increase to accommodate embryonic and fetal development and maternal tissue growth. While folate is actively transported to the fetus as demonstrated by higher cord blood folate concentrations relative to maternal blood

(Ek, 1980), maternal serum and red blood cell concentrations of folate decline (Wallace, Bonham, Strain et al., 2008). The reasons for red blood cell concentration of folate decline include increased folate catabolism and clearance (Tamura & Picciano, 2006).

Talaulikar and Arulkumaran (2011) suggested that women at high risk of neural tube defects (women with previous neural tube defects-affected pregnancy, obesity, diabetes and epilepsy) should be receiving 5-5mg of folic acid daily pre-conceptually, stating a month before conception and continuing through the first trimester of the pregnancy.

The food items considered in the study are supposed to be eaten by pregnant women for improved health and some of them are relatively expensive foods in Ghana. For example, lettuce, liver and citrus are very expensive, making poor pregnant women unable to buy more as often as they should. Michie (1991) indicated that social class and prevalence of neural tube defects were negatively related with lower social class having higher prevalence of neural tube defects. This is because the lower social class has poor diet; hence lower consumption of vitamins and folic acid (Smithells et al, 1976). The occupation of the women in the case group is in line with assertion of Michie (1991). Women in the case group were basically farmers with relatively lower and unstable income, hence had lower conception of the food items such as green leafy vegetables, milk and tomatoes, citrus, avocado and wheat bread.

Dark green leafy vegetables are full of antioxidants. Green vegetables are rich in vitamin A which is good for building body's natural defenses; vitamin C for healthy skin and bones and vitamin K to help body heal itself quickly when necessary. In addition to these vitamins, dark green leafy vegetable is also rich in potassium and iron. The vegetable is also rich in Magnesium which is a mineral necessary for maintaining muscle health, as well as bone formation. These key nutrients in dark green leafy vegetables combined would help proper development of unborn baby, hence reducing the incidence of neural tube defect.

Another food items found to be consumed less by mothers in the case group relative to those in the control group is citrus fruits. Citrus is most commonly thought of as a good source of vitamin C. It contains others essential nutrients, including both glycaemic and non-glycaemic carbohydrate (sugars and fibre), potassium, folate, calcium, thiamin, niacin, vitamin B_6, phosphorus, magnesium, copper, riboflavin, pantothenic acid and a variety of phytochemicals (Whitney and Rolfes, 1999). These nutritional values of citrus food suggest that less consumption of its leads to nutritional deficiencies with resultant likely occurrence of neutral tube defects (Whitney and Rolfes, 1999).

However, mothers in the test group consumed more tea with milk or without milk more than mothers in the case group. High amounts of *tea* can cause *side effects* due to the caffeine in black *tea*. These *side effects* can range from mild to serious and include headache, nervousness, sleep problems, vomiting, diarrhea, irritability, irregular heartbeat, tremor, heartburn, dizziness, ringing in the ears, convulsions, and confusion. Studies in pregnant women have found that higher levels of tea consumption were associated with lower serum folate concentrations (Matsuzaki et al., 2008; Shiraishi et al., 2010). Because periconceptional folic acid intake reduces the risk of neural tube defects (MRC Vitamin Study Research Group, 1991; Czeizel and Dudas, 1992; Berry et al., 1999), tea consumption may put pregnant women at risk because of its possible antifolate properties. Studies have established that tea intake and neural tube defects are positively related and neural tube defects increased for tea drinkers compared with nondrinkers (Fedrick, 1974; Correa et al., 2000; Ye et al., 2011).

5.5 Physical Environmental Factors and Neural Tube Defect

Exposure to dioxins for examples adversely affects spermatozoid folate deficiency leading to spina bifida (Hatch & Stein, 1987). Dioxins are mainly unwanted byproducts of a wide range of industrial processes. In terms of dioxin release into the environment, uncontrolled waste incinerators (solid waste and hospital waste) are often the worst culprits, due to incomplete burning. The study found that most mothers in the test group lived in environments that are dusty, smoky (smoke from industrial chimney, refuse dumps and firewood) and these were more likely to contaminate foods eaten by them and their families; hence creating dioxins in human body. Once the human body has absorbed dioxins, they persist for a long time because of their chemical stability and their ability to accumulate in fat tissue. After preconceptional exposure to dioxins, the risk of mutations in spermatozoids is significantly increased, leading to an increased risk of spina bifida (Hatch & Stein, 1987) through mechanisms involving folate deficiency (Halwachs, Lakoma, Gebhardt, Sch¨afer, Seibel & Honscha, 2010).

The results further show that most mothers in the test group had their drinking water from well and bore holes. In Ghana, water from most well and boreholes are not pure or contain pollutants which generate dioxins, hence leading to more likelihood of neural tube defect occurrence.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusions

The prevalence of NTD among the subjects was higher compared to earlier findings from Korle Bu Teaching Hospital and Tamale Regional Hospital in Ghana. The study concludes that Meningocele is the commonest type of NTD diagnosed at KATH.

The study further concludes that mothers in their teens and have little or no formal education are more likely to give birth to babies with NTD. Though conditions of environment in which mothers live and their medical history are critical to occurrence of NTD, each individual effect is not statistically important in NTD occurrence. However, interaction of medical history and environmental conditions are significant in NTD occurrence. This study concludes that mothers diagnosed of Gestational Diabetes and are exposed to smoke from firewood and those diagnosed of Anaemia and lived in dusty environment are more likely to give birth to babies with NTD.

6.2 Recommendations

The study, on the basis of the findings recommends the following;

- The study observed that prevalence of NTD is high. Therefore, the study recommends that there should be an aggressive effort by KATH, Ministry of Health and Ghana Health Service in dealing with NTD at KATH.
- Embarking on massive folic acid intake education. Ministry of Health should embark on education on folic acid intake by women in their reproductive age. The education should focus on the importance of folic acid intake by women before and

during pregnancy and sources of food rich in folate. This education would help motivate folic acid intake and consumption of food rich in folate among pregnant women, thereby reducing the incidence of NTD in Ghana.

- All pregnant women should be aware of their health conditions. The study recommends that all pregnant women should be aware of their medical history. This information would help women know how to interact with the environment since certain ailment when interacted with certain conditions of the environment increase the chances of giving birth to baby with NTD. The study recommends that pregnant women diagnosed of Gestational Diabetes should not live in smoky environment and pregnant women diagnosed of Anaemia should not live in dusty environment in order to reduce their chances of giving birth to babies with NTD.
- Healthcare facilities should pay more attention to vulnerable pregnant women (single, poor, uneducated pregnant women). Most of these women, per their condition and societal stigmatization indulge in acts such as smoking and drinking which are harmful to foetal development, leading to NTD. Proper counseling of these pregnant women on dangers of smoking and drinking would go a long way to help most of them to stop these acts and reduce the incidence of NTD.
- Drinking unpolluted water. It was observed that pregnant women whose source of drinking water is borehole had higher chance of giving birth to babies with NTD than those whose source of drinking water is Pipe borne water. This study therefore recommends to all pregnant women to drink from purer sources or drink unpolluted water. They can buy and drink purified water from sources accredited by Food and Drug Authority.
- Positive life style. It was observed that women in the case group were into alcoholism and smoking before or during pregnancy. This study recommends that

Ministry of Health should embark on massive education on dangers associated with alcoholism and smoking. This would go a long way to reduce smoking and alcohol intake, thereby reducing the occurrence of NTD.

- Nutritional intake. It was observed that women in the case group do not eat dark green leafy vegetables as often as possible. The study recommends that all healthcare facilities like KATH should highlight on dietary folate intake during nutrition education at antenatal care services. This would help increase intake of dark green leafy veggies among pregnant women, thereby helping to reducing occurrence of NTD.

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APPENDIX

The econometric analysis was done with binary logistic regression. The model measures the probability that a mother gives birth to baby with neural tube defect or not. Therefore, the model has a qualitative dependent variable with binary or dichotomous responses. According to Gujarati (2003) in models where the dependent variable, is qualitative, the objective was to find the probability of something happening. Thus, in this study the probability that a mother gave birth to a baby with neural tube defect was specified as:

$$P_i = \Pr(y_i = 1) = \frac{e^{X\beta}}{1 + e^{X\beta}}$$

And the probability that a mother does not give birth to a baby with neural tube defect was also expressed as

$$(1 - P_i) = \Pr(y_i = 0) = \frac{1}{1 + e^{X\beta}}$$

Thus, the odds ratio i.e. the ratio of the probability that a mother gave birth to a baby with neural tube defect to the probability that a mother does not give birth to a baby with neural tube defect was written as:

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{X\beta}}{1 + e^{-X\beta}}$$

The logarithm of the ratio P_i and $(1 - P_i)$ was the log-odds ratio and the log-odds ratio was a linear function of the explanatory variables. That is:

$$\log \frac{P_i}{1 - P_i} = \beta_0 + \sum_{j=1}^{k} \beta_j x_{ij}$$

The Logistic model had features which include:

1. As P goes from 0 to 1, the logit L goes from $-\infty$ to $+\infty$. That is, although the probabilities (of necessity) lied between 0 and 1, the logits were not so bounded.

2. Although L was linear in the explanatory variables, the probabilities themselves were not.

3. If L, the logit, was positive, it meant that when the value of the regressor (s) increases, the odds was that the regressant equals 1 (meaning some event of interest happened). If L was negative, the odds are that the regressant equals 1 decrease as the value of explanatory variables increase

Based on the above formulations, the model was therefore stated mathematically as:

From Model 1;

OCNT=occurrence of neural tube defect. A mother whose child had neural tube defect was coded as 1 and 0 otherwise;

AM=age of mother. Mothers were categorized into youth and adult. Adults were coded as 1 and 0 otherwise.

PRM=Place of residence of mother. Categorized into urban and rural. Urban was coded as 1 and 0 otherwise.

MSM= categorized into single and married; singled coded as 1 and 0 otherwise. ELM= educational level of mother. Categorized into pre-secondary education and post basic education. Pre-secondary education was coded as 1 and 0 otherwise.

OCM= occupation of mother. Categorized into unemployed and employed. unemployed coded as 1 and 0 otherwise

FAM= folic acid intake one year before pregnancy. Coded as 1 if mother took in folic acid for a year period before pregnancy and 0 otherwise.

GD*SF= interaction of gestational diabetes and smoke from fire wood

PIH*SF= interaction of pregnancy induced hypertension and smoke from fire wood

PIH*SIC= interaction of pregnancy induced hypertension smoke from industrial chimneys

PIF*DE= interaction of pregnancy induced hypertension and dusty environment

A*SIC= interaction of anaemia and smoke industrial chimneys

A*DE= interaction of anaemia and dusty environment

GD*DE= interaction of gestational diabetes and dusty environment

E*SF= interaction of eclampsia and smoke from fire wood ε=

error term

Before estimating the model, the study performed Pearson's correlation coefficient matrix to test for correlation between each independent variable and the dependent variable and Variance Inflation Factor (VIF) for test for collinearity problem.

KWAME NKRUMAH UNIVERISTY OF SCIENCE AND TECHNOLOGY

COLLEGE OF SCIENCE

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY

PREVALENCE AND RISK FACTORS OF NEURAL TUBE DEFECTS AT KOMFO ANOKYE TEACHING HOSPITAL – KUMASI

The information obtained from this questionnaire is solely for research purposes and all responses are confidential. Please kindly provide answers to all the questions to the best of your ability.

Sample number**: …………………………………**

Date__ __/__ __/__ __   Time**: __ __/ __ __**

SECTION A: BABY'S INFORMATION

1. Age at diagnosis: [   ] weeks
2. Gender: [   ] Female   [   ] Male
3. Weight at diagnosis: [   ][   ].[   ] (kg)

SECTION B: SOCIO DEMOGRAPHIC DATA OF MOTHER

4. Age of mother at diagnosis: [   ] (years)
5. Place of residence [ ] Urban [ ] Rural [ ] Sub-urban
6. Marital Status: [ ] Single [ ] Married [ ] Widowed [ ] Divorced
7. Education Level [ ] None [ ] Primary [ ] JSS/MSLC [ ] Secondary [ ] Tertiary
8. Occupation: [ ] Unemployed [ ] Trader [ ] Farmer

[ ] Senior Civil Servant [ ] Others specify ....

9. Number of pregnancies before diagnosis: [ ]

10. Number of children before diagnosis: [ ]

11. Birth order: [ ] (of child with NTD)

SECTION C: INCIDENCE OF NEURAL TUBE DEFECTS AMONG NEWBORNS

12. Type of anomaly: [ ] Hydrocephalus [ ] Encephalocele [ ]Anencephaly [ ] Meningocele [ ] Myelomeningocele [ ] Iniencephaly [ ] Spina bifida

13. Management outcome [ ] Alive [ ] Died

14. Quality of life of child (If alive) [ ] Walking

[ ] requires assistance to walk

[ ] total paralysis

[ ] N/A

SECTION D: PHYSICAL / ENVIRONMENTAL FACTORS OF MOTHERS

15. Mothers medical history during pregnancy

[ ] Pregnancy Induced Hypertension [ ] Pre Eclampsia [ ] Anaemia

[ ] Gestational Diabetes [ ] Eclampsia [ ] Severe Hyperemesis [ ] N/A

16. Did you take in alcohol before and during pregnancy? [ ] Yes [ ] No

17. Did you smoke before and during pregnancy? [ ] Yes [ ] No

18. Did you reside in an environment with any of the following before and during pregnancy?

[ ] Smoke from firewood [ ] Smoke from industrial chimneys

[ ] Smoke from refuse dumps [ ] Pollutants from sawmills

[ ] Dusty environments [ ] Others: ……………………

[ ] N/A

19 What was your source of drinking water?

[ ] Bore hole [ ] Well [ ] GWCL Source

SECTION E: NUTRITIONAL KNOWLEDGE

	Question	**Response with Likert Type Scale (each correct response would be rated 1, wrong rated 0)**	**Score**
20.	What is folic acid?	Drug / Medicine [0] Nutrient / Supplement [1] Don't know [0] **(TOTAL Score of correct responses)**	
21.	Tick some food sources rich in folic acid	Yam [0] Wheat bread [1] Papaya [1] Plantain [0] Citrus fruits [1]	
		Liver [1] Gari [0] Sweet potatoes [0] Beans and groundnuts [1] Water [0] Tomatoes [1] Lettuce [1] Cabbage [1] Kontomire [1] Rice [0] Egg yolk [1] Garden eggs [0] Okro [1] Milk [1] Don't know [0] **(TOTAL Score of correct responses)**	

22.	What are some of the importance of folic acid?	Helps in the neural development of the baby in the womb [1] Provides energy [0] Prevents infections [0] Enhance the production of the red blood cells [1] Prevents pregnancy related complications [1] Don't know [0] **(TOTAL Score of correct responses)**	
23.	What is your source of knowledge?	School [1] Hospital [1] Media [1] Others .... [0] [1] Don't know [0] **(TOTAL Score of correct responses**)	
24.	At what point did you acquire this knowledge?	Before pregnancy [1] During 1st month of pregnancy [1] After the 1st month of pregnancy [0] After delivery [0] Don't know [0] **(TOTAL Score of correct responses**)	
		GRAND TOTAL SCORE	

SECTION F: FOLATE INTAKE BEHAVIOURS / PRACTICES

25. Did you take folic acid tablet before conception? [ ] Yes [ ] No 26.

Did you take folic acid tablet during pregnancy? [ ] Yes [ ] No

27. If yes to question 26, it was prescribed by whom?

[ ] Midwife [ ] Doctor [ ] Traditional birth attendant

[ ] Other: ……………………………………………………………………

28. If yes to question 26, how often did u take it?

[ ] Every other day [ ] Daily [ ] Twice daily

[ ] 3 times daily [ ] Other: ……………………………

29. Are you currently taking folic acid supplements? [ ] Yes [ ] No

30. Have you had any nutritional counselling on folate intake? [ ] Yes [ ] No

31. If yes to question 30, by who? [ ] Dietician / Nutritionist [ ] Doctor

[ ] Nurse/midwife [ ] Others: ………………………….

32. If yes to question 30 when was the nutritional intervention given?

[ ] Before pregnancy [ ] During the 1st month of pregnancy

[ ] After 1st month of pregnancy [ ] At diagnosis

[ ] After diagnosis of child's condition

33. How frequent do you take foods rich in folic acid like the following? **(Please tick appropriately)**

	FOOD AND AMOUNT	**AVERAGE USE PER WEEK**						
	HIGH FOLATE FOODS	**Never**	**Once/a week**	**2-4/ week**	**5-6 / week**	**Once a day**	**2-3/ day**	**>3/ day**
1	Dark green leafy vegetables							
2	Milk							
3	Beans, peas and lentils							
4	Citrus							
5	Okro							
6	Liver							
7	Avocado							
8	Wheat bread							
9	Carrots							
10	Papaya							
11	Tomatoes							
12	Lettuce							
13	Cabbage							
14	Egg yolk							
15								
16								

34. Is your food intake of the above-mentioned foods different from your consumption before conception of your child with NTD or non NTD? [ ] Yes [ ]

THANK YOU

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF HEALTH SCIENCES
SCHOOL OF MEDICAL SCIENCES / KOMFO ANOKYE TEACHING HOSPITAL
COMMITTEE ON HUMAN RESEARCH, PUBLICATION AND ETHICS

Our Ref: CHRPE/AP/586/17 — 18th December, 2017.

Dr. Christopher Larbie
Department of Biochemistry
and Biotechnology
College of Science
KNUST-KUMASI.

Dear Sir,

LETTER OF APPROVAL

Protocol Title: ***"Prevalence and Risk Factors of Neural Tube Defects at Komfo Anokye Teaching Hospital – Kumasi."***

Proposed Sites: ***Directorate of Child Health, Komfo Anokye Teaching Hospital.***

Sponsor: ***Principal Investigator.***

Your submission to the Committee on Human Research, Publications and Ethics on the above named protocol refers.

The Committee reviewed the following documents:

- A notification letter of 7th December, 2017 from the Komfo Anokye Teaching Hospital (study site) indicating approval for the conduct of the study in the Hospital.
- A Completed CHRPE Application Form.
- Participant Information Leaflet and Consent Form.
- Research Protocol.
- Questionnaire.

The Committee has considered the ethical merit of your submission and approved the protocol. The approval is for a fixed period of one year, beginning 18th December, 2017 to 17th December, 2018 renewable thereafter. The Committee may however, suspend or withdraw ethical approval at any time if your study is found to contravene the approved protocol.

Data gathered for the study should be used for the approved purposes only. Permission should be sought from the Committee if any amendment to the protocol or use, other than submitted, is made of your research data.

The Committee should be notified of the actual start date of the project and would expect a report on your study, annually or at the close of the project, whichever one comes first. It should also be informed of any publication arising from the study.

Yours faithfully,

Osomfo Prof. Sir J. W. Acheampong MD, FWACP
Chairman

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