AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

MPHIL THESIS

BURDEN, TRANSMISSION RISKS, AND IMPACT OF TOXOPLASMOSIS AMONG PREGNANT WOMEN IN MAMPONG MUNICIPALITY, GHANA

ASSOAH EBENEZER

NOVEMBER, 2024

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BURDEN, TRANSMISSION RISKS, AND IMPACT OF TOXOPLASMOSIS AMONG PREGNANT WOMEN IN MAMPONG MUNICIPALITY, GHANA

BY

ASSOAH EBENEZER
(8212090008)

A Thesis Submitted to the Department of Biological Sciences Education of the Faculty of Science Education, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development in partial fulfillment of the requirements for the award of a Master of Philosophy degree in Biology.

NOVEMBER, 2024

DECLARATION

Candidate's declaration

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Assoah Ebeneber

Signature: ……. Date: ……

Supervisors' Declaration

We hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development.

Dr. Denis Dekugmen Yar (Principal Supervisor)

Signature: ……. Date: ……

Papa Kofi Amissah-Reynolds (Co-Supervisor)

Signature: ……. Date: ……

ABSTRACT

Toxoplasmosis, if untreated during pregnancy, can cause complications such as spontaneous abortion, eye-ear defect, and in severe cases, death. This study assessed the burden of *Toxoplasma gondii* infection and its transmission risks among pregnant women. A cross-sectional study examined 201 consenting pregnant women, consecutively recruited at six health facilities in the Mampong Municipality, Ghana. Socio-demographic and clinical data were collected using a structured questionnaire and 5 ml of blood to determine the seroprevalence of *T. gondii* infection using a TOXO IgG/IgM One-Step Rapid Test Cassette. Multinomial logistic regression analysis used SPSS version 27 to determine the association of *T. gondii* infection with other communicable diseases, demographics, household factors, animal husbandry, and other environmental variables. The overall seroprevalence of *T. gondii* was 49.75%, with 40.30%, 2.49%, and 6.97% testing positive for IgG, IgM, and IgG and IgM, respectively. Prevalence of HBV, HIV, and syphilis were 14.61%, 0.61%, and 3.07%, respectively. Educational level, residential area, households with animals, animal husbandry practices, veterinary services, and hygiene practices were linked to toxoplasmosis. Drinking untreated water from rivers/streams/dams increases the risk of *T. gondii* infection three times [AOR=2.91 (1.07 – 7.92) p=0.037]. *T. gondii* infection was linked to miscarriage among the participants. The burden of toxoplasmosis among pregnant women in this study area was high, increasing the risk of *T. gondii* transmission to their fetuses. Although the prevalence of HBV and syphilis was very high, these were not linked to *T. gondii* infection. Pregnant women with tertiary education and living in urban areas had a reduced risk of *T. gondii* infection. Risk factors such as the presence of animals in households with extensive/semi-intensive systems and poor veterinary care services, drinking water from rivers/streams

significantly influenced the transmission of toxoplasmosis. *T. gondii* infection can be addressed as one of the significant factors of miscarriage in Mampong Municipality. Integration of toxoplasmosis into the routine ANC screening is critical to the prevention and control of pregnancy outcomes.

KEYWORDS: *Toxoplasma gondii* infection, Seroprevalence, HBV, HIV, syphilis and Pregnant women.

ACKNOWLEDGEMENTS

I thank the ALMIGHTY GOD for making this research work and my study a very successful one. Many are the people who have contributed greatly to the completion of this thesis. My earnest appreciation goes to my supervisors, Dr. Denis Dekugmen Yar and Papa Kofi Amissah-Reynolds, for their exceptional supervision, especially Dr. Denis Dekugmen Yar. Dr. Denis Dekugmen Yar was always available to advise, provide ideas, and support me to finish this thesis. I am also grateful to the heads and staff of all the health facilities in the study sites for their tremendous assistance. I would like to acknowledge all the selected public health final year students who helped in the data collection. I would also take this opportunity to thank all my lecturers who, in one way or another, helped make my study as well as this project a success. To all my friends and loved ones whose support and care helped me overcome setbacks in the course of this work as well as my entire graduate study, I say, a big thank you to you all.

DEDICATION

I dedicate this work to my dear mother, Ndaayaa Margaret Kwesi, and my lovely brother, Richard Assoah Sombeley, who inspired, supported me financially, and encouraged me throughout my study; I also to my entire family for their support in diverse ways in undertaking this research work.

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Kwame Nkrumah
University of Science
and Technology, Kumasi

College of Health Sciences
SCHOOL OF MEDICINE AND DENTISTRY

COMMITTEE ON HUMAN RESEARCH, PUBLICATION AND ETHICS

Our Ref: CHRPE/AP/717/23

11th August, 2023

Mr. Ebenezer Assoah
Department of Biological sciences
Akenten Appiah-Menka University
of Skills Training and
Entrepreneurial Development.

Dear Sir,

LETTER OF APPROVAL

Protocol Title: ***"The Current Status of Toxoplasma Gondii Infection and Co-Morbidity with Infectious Diseases among Pregnant Women in the Mampong Municipality of Ghana."***

Proposed Site: ***Mampong Municipality.***

Sponsor: ***Self-Sponsored.***

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

The Committee reviewed the following documents:

- A notification letter of 14th June 2023 from the Regional Health Directorate, Kumasi (study site) indicating approval for the conduct of the study in the Region.
- A notification letter of 22nd June 2023 from the Mampong Municipal Health Directorate (study site) indicating approval for the conduct of the study in the Municipality.
- 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 **11th August 2023** to **10th August, 2024** 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.

Thank you for your application.

Yours faithfully,

Rev. Prof. John Appiah-Poku.
Honorary Secretary
FOR: CHAIRMAN

Room 7, Block L, School of Medicine and Dentistry, KNUST, University Post Office, Kumasi, Ghana
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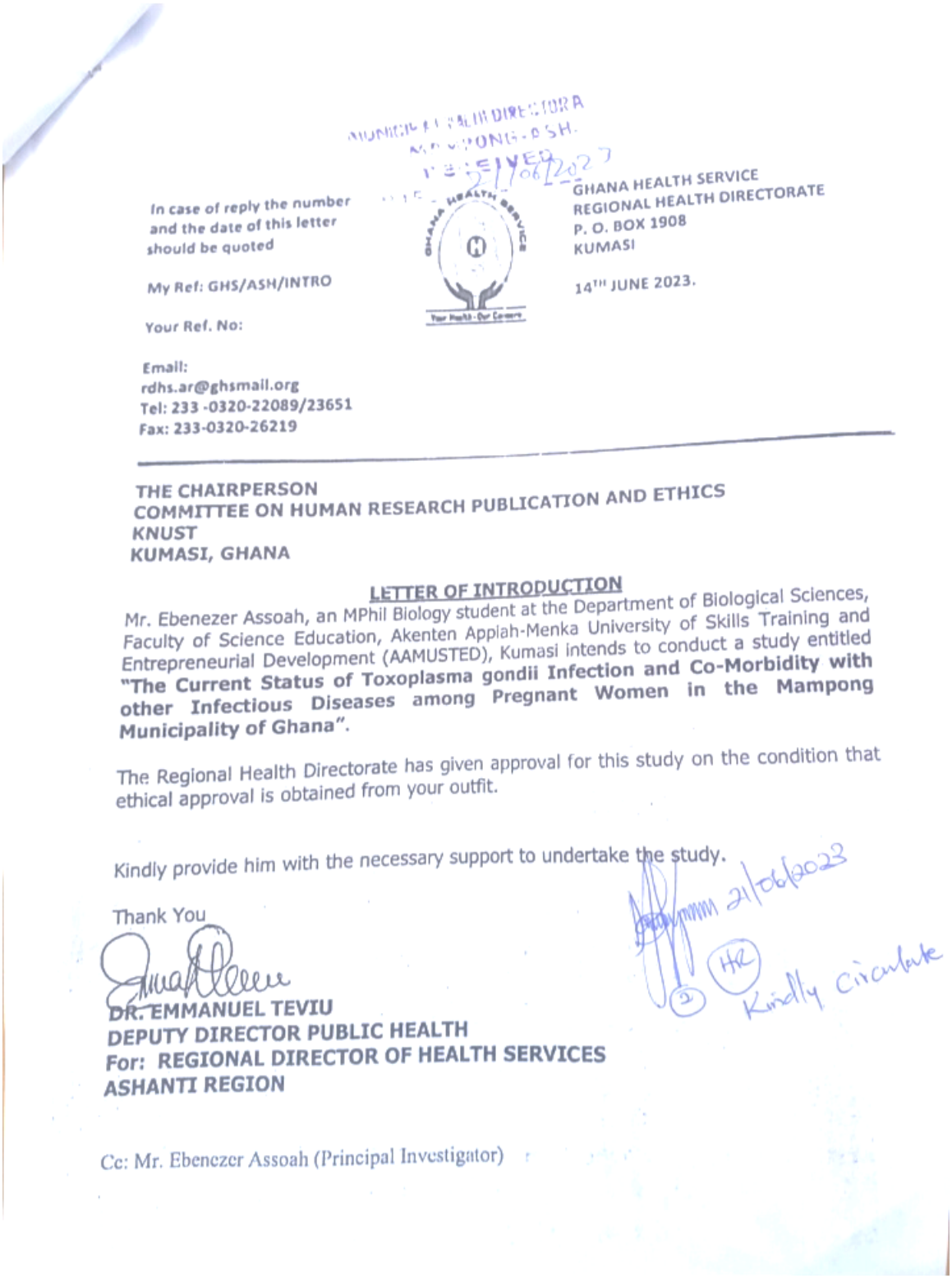
PROFESSIONAL EDITORIAL ASSISTANCE

Approval Letter from Regional Health Directorate



MUNICIPAL HEALTH DIRECTORATE
MAMPONG-ASH.
RECEIVED
21/06/2023

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

My Ref: GHS/ASH/INTRO

Your Ref. No:

Email:
rdhs.ar@ghsmail.org
Tel: 233 -0320-22089/23651
Fax: 233-0320-26219

GHANA HEALTH SERVICE
REGIONAL HEALTH DIRECTORATE
P. O. BOX 1908
KUMASI

14TH JUNE 2023.

THE CHAIRPERSON
COMMITTEE ON HUMAN RESEARCH PUBLICATION AND ETHICS
KNUST
KUMASI, GHANA

LETTER OF INTRODUCTION

Mr. Ebenezer Assoah, an MPhil Biology student at the Department of Biological Sciences, Faculty of Science Education, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED), Kumasi intends to conduct a study entitled **"The Current Status of Toxoplasma gondii Infection and Co-Morbidity with other Infectious Diseases among Pregnant Women in the Mampong Municipality of Ghana".**

The Regional Health Directorate has given approval for this study on the condition that ethical approval is obtained from your outfit.

Kindly provide him with the necessary support to undertake the study.

Thank You

21/06/2023
HR
Kindly Circulate

DR. EMMANUEL TEVIU
DEPUTY DIRECTOR PUBLIC HEALTH
For: REGIONAL DIRECTOR OF HEALTH SERVICES
ASHANTI REGION

Cc: Mr. Ebenezer Assoah (Principal Investigator)

Approval Letter from Municipal Health Directorate

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

Ghana Health Service
Mampong Municipal Health Directorate
P. O. BOX 424
Mampong – Ashanti

My Ref. No: MHD/MA/PF/PER/70
YOUR REF.NO
mamponghdirectorate424@yahoo.com

22nd June, 2023

Tel:0243123804

ALL HEALTH FACILITIES
MAMPONG-ASHANTI

RE: LETTER OF INTRODUCTION

I write to introduce to you Mr. Ebenezer Assoah from Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED)-Mampong, who is seeking to conduct a research in the Municipality on the topic **"The Current Status of Toxoplasma gondii Infections Disease and Co-Morbidity with other Infectious Diseases among Pregnant Women in the Mampong Municipality of Ghana".**

Kindly give him the necessary assistance he might need for a success research.

Thank you.

MR. JOSEPH DANSO YEBOAH
MUNICIPAL DIRECTOR OF HEALTH SERVICE

LIST OF ACRONYMS

Acronyms	Meaning
AAMUSTED	Akenten Appiah-Menka University of Skill Training and Entrepreneurial Development
ANC	Antenatal Care
AOR	Adjusted Odds Ratio
ART	Antiretroviral Therapy
CDC	Centres for Disease Control and prevention
CHRPE	Committee on Human Research, Publications, and Ethics
COR	Crude Odds Ratio
CT scan	Computerized Tomography scan
DNA	Deoxyribonucleic acid
EDTA tube	Ethylenediaminetetraacetic Acid tube
ELISA	Enzyme-Linked Immunosorbent assay
HBV	Hepatitis B Virus
HCC	Hepatocellular Carcinoma
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immunodeficiency Syndrome
HSS	HIV Sentinel Survey
IBM; SPSS	International Business Machines; Statistical Package for the Social Sciences
ICT	Immunochromatographic Test
IgG/M	Immunoglobulin G or M
KBTH	Korle Bu Teaching Hospital

KNUST	Kwame Nkrumah University of Science and Technology
MRI scan	Magnetic Resonance Imaging
MTCT	Mother-To-Child-Transmission
NHIS	National Health Insurance Scheme
PCR	Polymerase Chain Reaction
PI	Principal Investigator
RDT	Rapid Diagnostic Test
Ref	Reference
SHS	Senior High School
STI	Sexually Transmitted Infection
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Study Background

Globally, there is an upsurge in parasitic zoonoses, affecting approximately 4 billion people and resulting in more than 200,000 deaths annually (Algabbani, 2023; Hossain et al., 2023). In low-income nations in Asia, South America, and Africa, neglected parasitic diseases such as ascariasis, amebiasis, giardiasis, and toxoplasmosis remain a serious threat to public health, causing significant morbidity and mortality (Bekele, 2020).

Toxoplasmosis, caused by *Toxoplasma gondii*, is ubiquitous and, despite felids being the definite host, can infect all nucleated vertebrate cells, including humans (Augusto *et al.,* 2021; Yan *et al.,* 2016). *T. gondii* has three infective stages: tachyzoites in host tissue (transmitted via congenital transmission and blood transfusion), bradyzoites in tissue cysts (transmitted through undercooked or raw meat), and sporozoites in oocysts (transmitted through contaminated food and materials) (Attias *et al.,* 2020). Globally, toxoplasmosis is the fourth most important food-borne parasite (Sharma *et al.,* 2019; Torgerson & Mastroiacovo, 2013) and the fifth most neglected parasitic disease in humans (Jones *et al.,* 2014). About half of the human population is susceptible to *T. gondii* infection with the highest-burden occurring in developing nations like Ghana due to poor sanitation and lack of quality health services (Bigna *et al.,* 2020; Montazeri *et al.,* 2020; Tarekegn *et al.,* 2020).

Children and pregnant women are more susceptible to *T. gondii* infection due to immature or compromised immune systems (Gómez-Chávez *et al.,* 2020). Infection with *T. gondii* during the first trimester may cause congenital toxoplasmosis resulting in severe complications for both mother and the fetus. Toxoplasmosis, if untreated during pregnancy, can cause complications such as miscarriage, auditory impairment, eye defect, cognitive delay, and in severe cases, death (Bollani *et al.,* 2022; Curcio *et al.,* 2020). *T. gondii* infection is a precursor for other diseases in humans, such as cancer (Daher *et al.,* 2021), osteoporosis (Zhu *et al.,* 2022) and increased serum levels of low-density lipoprotein (LDL) (Raheem *et al.,* 2021; Xu *et al.,* 2020).

The presence of *Toxoplasma* sp. in certain animals (cattle, goats, dogs, pigs, cats etc), along with the common phenomenom of human-animal interactions in many communities in Ghana, raises concerns regarding public health (Leeson, 2024). Most of these animals are not confined coupled with poor veterinary services and husbandry. These animals litter and defecate contaminating the soil and water bodies which may serve as playing grounds for children and sources of drinking water respectively, increasing the risks of *T. gondii* infection. In Ghana, there is a potential risk of transmission to humans through the consumption of meat from animals found to be infected, as well as through the ingestion of oocysts via contaminated soil, often from felid droppings. In this regard, some studies have reported *Toxoplasma gondii* seroprevalence ranging from 22.0% to 93.0% among pregnant women (Amissah-Reynolds, 2020b). Although toxoplasmosis infection is high in Ghana, the mode of the disease transmission is ill-defined. Hence, this study assessed the seroprevalence and transmission risks of toxoplasmosis.

1.2 Problem Statement

In Ghana, policies exist to test and treat congenital diseases such as viral hepatitis B, HIV/AIDS, syphilis, and malaria, aiming to reduce their impact on pregnancy and its outcomes. However, the prevalence of toxoplasmosis in Ghana, estimated at 80–90% (Rostami *et al.,* 2020), ranks among the highest globally, with possible dire consequences on pregnancy outcomes. In the Mampong Municipality, miscarriage rates are notably high, reaching up to 6.1% (Mampong-Municipal-Health-Directorate, 2024). The proximity determinants of these high miscarriage rates remain uncertain but could be linked to toxoplasmosis. Despite the reported high prevalence of toxoplasmosis in Ghana, the risks associated with the disease and its transmission during pregnancy are inadequately studied. Moreover, there is a lack of data on the comorbidity of *Toxoplasma gondii* infection with other congenital diseases commonly screened for during pregnancy. Research on toxoplasmosis and its transmission among pregnant women in the Mampong Municipality is also scarce. In addition, suboptimal animal husbandry practices and low vaccination rates among animals in rural communities within the Municipality increase human-to-animal contact, thereby heightening the risk of toxoplasmosis transmission. This study is therefore essential to investigate *T. gondii* infection and its co-infections with other infectious diseases among pregnant women in the study area. Given the rising incidence of adverse pregnancy outcomes in the Municipality and the myriad of potential contributing factors, there is a critical need for comprehensive research to address this gap.

1.3 Aim and Objectives

The main aim of the study was to examine the current status of *T. gondii* infection and co-morbidity with other infectious diseases (HBV, HIV, and Syphilis) screened during routine ANC among pregnant women in the Mampong Municipality.

1.3.1 Objectives of the Study

The study worked at the following specific objectives:

1. Determine the sero-prevalence and co-morbidity of toxoplasmosis with congenital diseases screened in pregnancy.
2. Examine the association of *T. gondii* infection with socio-demographics and its transmission risks in the population.
3. Assesse the association of toxoplasmosis on pregnancy outcomes.

1.4 Hypothesis for the Study

The study hypothesizes that, there is a high prevalent rate of *T. gondii* infection among pregnant women in Ghana of which the Mampong Municipality is not exception and that there is a significant co-morbidity with other infectious diseases such as HBV, HIV, and Syphilis. Additionally, it posits that *T. gondii* infection is associated with specific sociodemographic characteristics and certain risk factors, and that it has substantial impacts on pregnancy outcomes in the study population (Amissah-Reynolds, 2020a; Singh et al., 2021).

1.5 Justification

Globally, there is an upsurge of zoonotic diseases with high morbidity and mortality which are linked to pets, domesticated, and wild animals. The prevalence of

toxoplasmosis among pregnancy is on the increase (Rostami *et al.,* 2020). There is a direct link between humans and animals and the consequential transmission of zoonotic diseases (Leeson, 2024). Direct contact with pets like cats and animals which are hosts to *T. gondii* (Khademvatan *et al.,* 2014) or via exposure to contaminated environment are associated with the disease transmission (Symeonidou *et al.,* 2018).

In Ghana, there are policies for screening expectant mothers for a range of congenital diseases such viral hepatitis, HIV/AIDS, syphilis and malaria in order to lessen the morbidity and mortality among neonates. Some countries around the world have introduced national mandatory policy for prenatal serological screening for *T. gondii* with a significant decrease in maternal toxoplasmosis and congenital transmission among pregnant women. This policy, however, is yet to be introduced although high prevalence rates are reported in Ghana. Early detection of infections and administration of anti-*Toxoplasma* prophylaxis during pregnancy could prevent congenital transmission and reduce sequelae in neonates.

Currently, there is limited information on *T. gondii* transmission and risks of infections in Ghana, with most studies centered in the Greater Accra region (Amissah-Reynolds, 2020a). The expected outcome of this study would be an impetus for debate and dialogues for nationwide policy for testing and treating toxoplasmosis in pregnancy (Wehbe *et al.,* 2022). This, thus calls for concerted effort to provide up-to-date data that will complement nationwide surveillance of parasitic infections and policy formulation to improve pregnancy outcomes.

1.6 Significance of the Study

This study would provide a comprehensive current status of *T. gondii* infections among pregnant women in the Mampong Municipality of Ghana. In addition, the outcome of this study would provide empirical data for policy consideration for public health services and to devise effective control strategies and awareness for the prevention of toxoplasmosis in the country at large. The study outcome will contribute to existing literature.

1.7 Scope of the Study

This study encompassed cohort of pregnant women residing within the study area, specifically those attending regular antenatal clinics. Eligible pregnancies were required to fall within the gestational period of 2 to 40 weeks. Pregnant women who had not resided within the study area for a duration exceeding two months during their pregnancy were excluded to enhance the precision of inferences drawn within the municipality.

1.8 Thesis Organization

The study is divided into six main chapters. The first chapter addresses the background of the study, the problem statement, objectives, hypothesis for the study, justification, significance of the study, scope, organization and conceptual framework of the study. In the second chapter, relevant literature related to this research topic was thoroughly examined. Chapter three focuses on presenting the study area and the methodology employed to conduct the research. Moving on to chapter four, the study data is presented. Chapter five discussed the findings of the study. Lastly, in chapter six, the

summary of the results is presented, along with drawn conclusions based on the main findings and offering recommendations based on the study's outcomes.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter comprehensively reviews existing literature related to *Toxoplasma gondii* infection and its co-morbidity with congenital diseases among pregnant women. The review includes a summary of studies, other research findings, and theoretical frameworks that have explored various aspects of *T. gondii* and its infections. The aim is to establish a foundation of knowledge upon which the current study in the Mampong Municipality of Ghana is based.

2.1 Maternal and Neonatal Health in Ghana

Over the past few decades, Ghana has significantly improved in maternal healthcare (Adu *et al.*, 2023). Initiatives such as the National Health Insurance Scheme (NHIS) have increased healthcare access for all including pregnant women. Moreover, the country has seen improvements in antenatal care services, facility-based deliveries, and skilled birth attendants, that have resulted in a decline in maternal mortality rates (Adu et al., 2021). However, some challenges persist in maternal healthcare, despite a decline, Ghana's maternal mortality ratio remains unacceptably high (Ameyaw, 2021).

Factors such as limited access to quality healthcare in rural areas, delays in seeking care, inadequate emergency obstetric services, and cultural beliefs and practices continue to contribute to maternal deaths (Nyande *et al.*, 2022). A lack of access to neonatal care facilities and skilled healthcare providers in remote areas impedes efforts to reduce neonatal mortality (Ani-Amponsah *et al.*, 2021). Additionally, cultural

practices and traditional beliefs influence newborn care, sometimes leading to delayed care-seeking behaviours (Ani-Amponsah *et al.,* 2021). Infectious diseases, including toxoplasmosis, HBV, HIV/AIDS, and maternal syphilis, continue to pose significant threats to maternal and neonatal health in Ghana (Kuugbee *et al.,* 2023). Creating awareness and early detection of infections are critical strategies to improve maternal health and neonatal outcomes. Strengthening primary healthcare in rural areas, increasing healthcare worker capacity, and promoting maternal and neonatal health education are important in reducing adverse outcome of pregnancy.

2.2 Infectious Diseases in Pregnancy

Pregnancy is a transformative journey marked by joy, anticipation, and the promise of new life. However, it is also a time when a woman's immune system undergoes changes, making her more susceptible to infections. Infectious diseases during pregnancy can affect both the mother and her developing foetus (Jash & Sharma, 2022). Pregnancy is a remarkable physiological state marked by significant hormonal and immunological changes. These adaptations serve to protect the developing fetus but can also render the pregnant woman more susceptible to certain infections. The changes in immune function, particularly in the cellular and humoral immune responses, create an environment in which infections may thrive.

2.3 Toxoplasmosis and Pregnancy

Healthy individuals are mostly asymptomatic to toxoplasmosis and sometimes may experience mild, flu-like symptoms such as fever, headache, muscle pain, and swollen lymph nodes (Almashhadany *et al.,* 2024). However, during pregnancy, *T. gondii* infection can raise concerns because it can possibly be transmitted from the mother to

the developing fetus, potentially resulting in severe health complications for the unborn child (Deganich *et al.,* 2022). Developing effective control and prevention strategies, especially for vulnerable populations like pregnant women, requires understanding the burden of *T. gondii* infection, transmission routes, and associated factors.

2.3.1 The life Cycle and Transmission of *Toxoplasma gondii* Infection

Toxoplasma gondii has two life cycles: the sexual cycle occurs entirely in the small bowel of the feline family, including cats, as the definitive host, whereas the asexual cycle takes place in infected animals and humans (Attias *et al.,* 2020). Parasitism within the definitive host involves the excretion of sporulated oocysts through feline fecal matter. These oocysts undergo sporulation in the environment, typically spanning 1 to 5 days, rendering them infectious. Intermediate hosts, including humans become infected after ingestion of oocyst-contaminated soil, water, fruits and vegetables, and air (Shapiro *et al.,* 2019). Within these intermediate hosts, oocysts differentiate into tachyzoites, subsequently transitioning into tissue cyst bradyzoites. Felids acquire the infection by preying upon intermediate hosts housing tissue cysts or by directly ingesting sporulated oocysts (Attias *et al.,* 2020).

Human infection can occur through several pathways, with three primary transmission routes: **Vertical Transmission (Mother-to-Child Transmission);** This occurs when the parasite in its tachyzoite form is transmitted from an infected mother to her fetus during pregnancy (Figure 2.1, Number 11). **Ingestion of Tissue Cysts**; This route involves consuming infected meat containing the parasite in its bradyzoite form (Figure 2.1, Number 6). **Ingestion of Oocysts**; This occurs through the consumption of contaminated food (such as fruits and vegetables), water, or soil containing the parasite

in its oocyst form (Figure 2.1, Number 7) (Almeria & Dubey, 2021; Karakavuk *et al.*, 2021; Shapiro *et al.*, 2019). The *T. gondii* oocyst can contaminate substrates like soil, water and food when infected feline shed the parasites in their droppings (figure 2.1, number 7), these oocysts resist harsh conditions and persist in the environment for approximately 20 months at -20 to 35 degree celscius (Shapiro *et al.*, 2019). Pregnant women with acute *Toxoplasma* infection can transmit the parasite to their fetus (figure 2.1, number 11), leading to congenital toxoplasmosis (Deganich *et al.*, 2022). This transmission can result in severe complications for the developing fetus, making it a critical concern in maternal health. Although less common, *T. gondii* transmission through blood transfusion and organ transplantation has been documented (figure 2.1, number 8) (Guegan *et al.*, 2020).

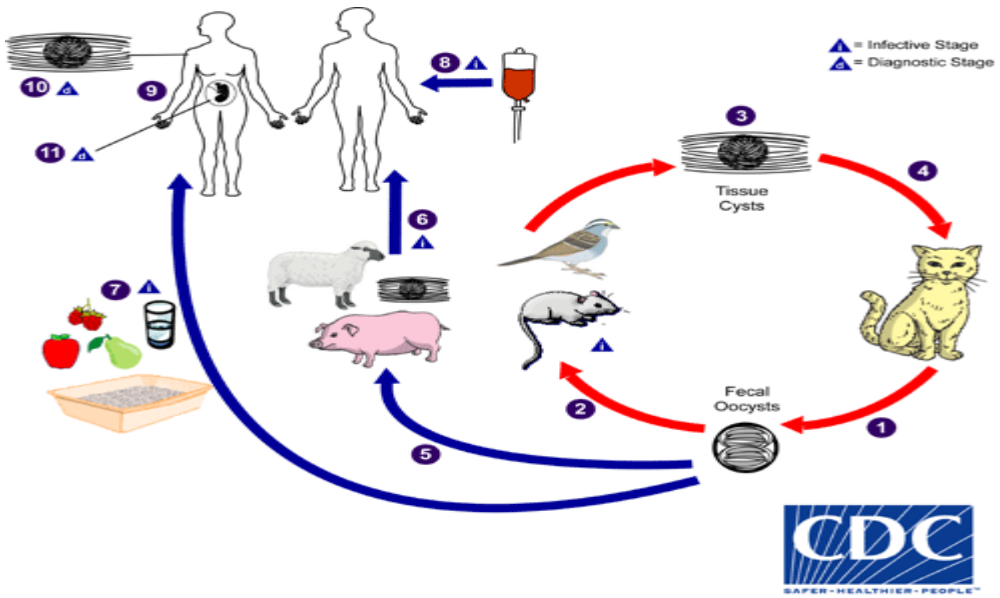


Figure 2.1 The life cycle of *T.gondii*

(source; CDC official website)

2.3.2 Effect of Toxoplasmosis on Pregnancy

Infection with *T. gondii* prior to pregnancy typically poses minimal to no risk to the developing fetus, with the exception of cases where women contract the infection within three months before conceiving (Adem *et al.*, 2023). The most significant concern is when a pregnant woman acquires toxoplasmosis for the first-time during pregnancy or experiences a reactivation of a previous infection. In such cases, the parasite can cross the placenta and infect the developing fetus, leading to congenital toxoplasmosis. Infections that happen in the first trimester tend to result in more serious complications than those occurring later in pregnancy (Picone *et al.*, 2020).

Congenital toxoplasmosis can have several complications on the fetus or the new born baby (Milne *et al.*, 2023). These complications can be grouped into three: neurological issues, eye problems and organ damage. The *T. gondii* can damage the developing brain, potentially resulting in intellectual disabilities, psychomotor and mental retardation, seizures, hydrocephalus, developmental delays, microcephaly, and epilepsy (Garweg *et al.*, 2022). Toxoplasmosis can affect the eyes, leading to inflammation of the retina (chorioretinitis), vision problems (including retinochoroiditis and strabismus), and, in some cases, blindness (Gomez-Marin & de-la-Torre, 2020). Toxoplasmosis can also elicit extracerebral manifestations, affecting organs such as the liver and spleen, thereby precipitating conditions like hepatomegaly, splenomegaly, and jaundice (Pal & Chetty, 2020). Additionally, toxoplasmosis-associated organ damage extends to intracranial calcifications and the development of petechiae (Tavares & Silva, 2020).

2.3.3 Prevalence of *Toxoplasma gondii* Infection

Infection rates of *T. gondii* exhibit significant disparities among different populations and geographical areas. This variation in the prevalence of toxoplasmosis can be explain by multitude of factors, including cultural practices, levels of hygiene, and exposure to environments contaminated with the *T. gondii* parasite (Ghenciu *et al.*, 2024; Van der Colf, 2020). Furthermore, specific demographic attributes, such as age, and immune status, can also exert an influence on the prevalence of *Toxoplasma gondii* infection (Guegan *et al.*, 2020).

The prevalence of *T. gondii* infection varies widely across regions and populations (Blaga *et al.*, 2019). Numerous seroprevalence studies have been conducted to estimate the extent of exposure to the parasite mostly in pregnant women (Blaga *et al.*, 2019; Polanunu *et al.*, 2021). A study by Rostami *et al.*, 2020 as displayed in figure 2.2, shows a substantial variation of toxoplasmosis among pregnant women globally, which could be attributed to several factors, including geography, climate, dietary habits, and socio-economic conditions (Vueba *et al.*, 2020).

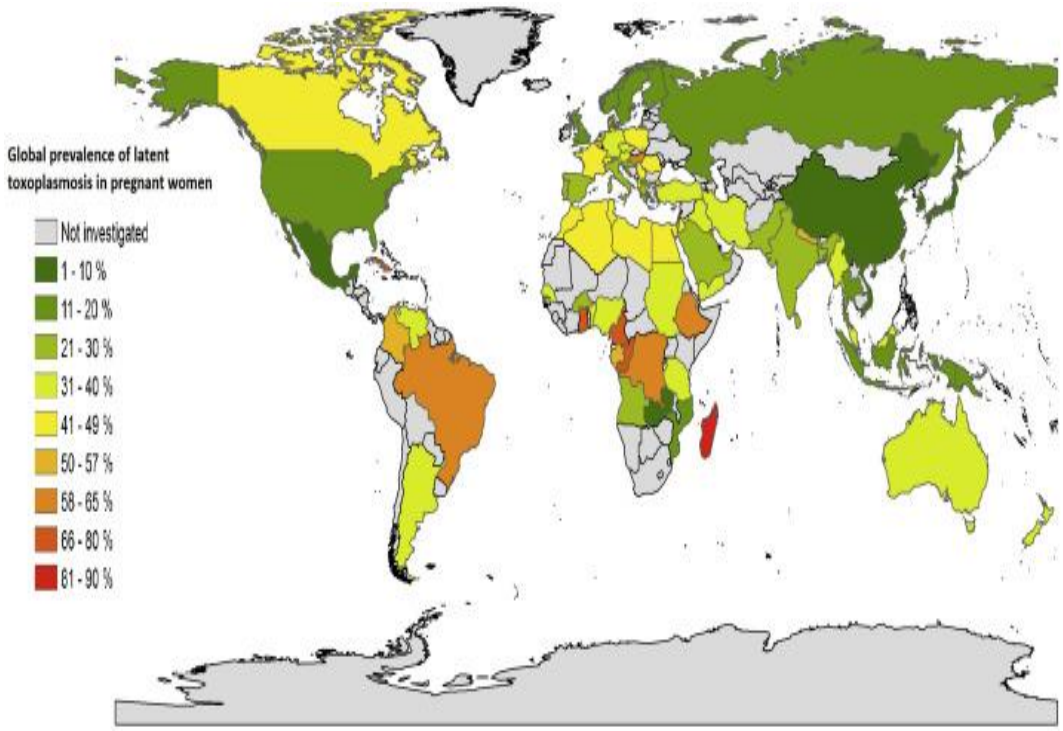


Figure 2.2: Map of global prevalence of toxoplasmosis in pregnant women (Rostami *et al.*, 2020)

A study conducted in the Democratic Republic of Congo by Doudou *et al.* (2014) in 781 pregnant women with an average age of 28 years old reported a seroprevalence of toxoplasmosis to be 80.3%, and 2.2% were positive for IgM. There was no statistically significant association between *T. gondii* infection and any risk factors assessed (Doudou *et al.*, 2014).

Gebremedhin *et al.*, (2015) investigated the prevalence of *T. gondii* infection across humans and animals in Ethiopia. They found high IgG seroprevalence rates among cats (87.72%), small ruminants (34.59%), and humans (74.73%). The infection was four times more prevalent in pregnant women than in non-pregnant women, and individuals with cat contact showed a threefold increase in prevalence compared to those without.

Urban residents exhibited a twofold higher prevalence than rural inhabitants. The authors concluded that public education on preventive strategies is essential to reduce the risk of transmission to humans. This study highlights the significance of zoonotic and environmental factors in *T. gondii* exposure (Gebremedhin *et al.,* 2015).

A report by Rocha *et al.* (2015), indicated that 240 pregnant women out of 338 representing 71% tested positive for *T. gondii* anti-IgG from the State of Tocantins, Northern Brazil (Rocha *et al.,* 2015). Research conducted by Teweldemedhin *et al.* (2019), in northern Ethiopia on 360 pregnant women indicated the overall prevalence for *T. gondii* to be 35.6%. However, 32.5% pregnant women were positive only for IgG, and 11 (3.1%) were positive both for IgM and IgG. There were no positive for only IgM. Factors such as age, educational level, habit of hand washing after contact with garden soil or domestic animals, presence of domestic cat, history of contact with domestic dog and consumption of raw vegetables were more likely to influence the prevalence of *T. gondii* among pregnant women in the study area (Teweldemedhin *et al.*, 2019).

Research in Ghana by Agordzo *et al.* (2019), reported the overall seroprevalence of 50.3% (n=151), with 49.7% (n=149) of the study participants seropositive for IgG and 1% (n=3) testing positive for IgM. Furthermore, the observed seroprevalence among pregnant women was 56.4% (n=62). With regard to settlement type, a seroprevalence of 55.6% was observed in the rural community, 50.6% in the peri-urban community and 47.1% in the urban community. The study identified cat ownership, contact with cat litter, contact with raw meat age as risk factors for infection (Agordzo *et al.*, 2019).

A study conducted by Rostami *et al*, (2020) on the "Global prevalence of latent toxoplasmosis in pregnant women: a systematic review and meta-analysis" within three decades (between 1988 to 2019) in a total of 311 studies on 1, 148 677 pregnant women from 91 countries were involve in the study. The study reported that the global prevalence of latent toxoplasmosis in pregnant women was 33.8%. South America had the highest pooled prevalence (56.2%) of latent toxoplasmosis in pregnant women, whereas the Western Pacific region had the lowest prevalence (11.8%). Their study concluded that, a high level of latent toxoplasmosis existed in pregnant women, especially in some low- and middle-income countries of Africa and South America, although the local prevalence varied markedly (Rostami *et al.,* 2020).

Olariu *et al.* (2020), conducted a research in Western Romania on 208 pregnant women reported 55.8% seroprevalence on *T. gondii*. The study identified certain risk factors associated with *T. gondii* seropositivity. These factors included lower levels of education, older age, owning pets (specifically cats and/or dogs), higher gravidity (number of pregnancies), and working in meat-related occupations. Notably, individuals who reported having pets exhibited a higher prevalence of *T. gondii* seropositivity compared to those who did not own any pets. Additionally, women with a history of spontaneous abortions were more likely to test positive for *T. gondii* antibodies compared to women without such a medical history (Olariu *et al.,* 2020).

A review by Nasiru Wana *et al.* (2020), on the "Prevalence of *Toxoplasma gondii* in Humans and Animals Reported in Malaysia from 2008 to 2018" reported prevalences of 59.7%, 57.4%, and 42.5% among healthy community members on Pangkor Island,

migrant workers in Malaysia, and pregnant women, respectively (Nasiru Wana *et al.,* 2020).

In Ghana, the focus of this current study was the Mampong Municipality. There has been limited investigations on the seroprevalence of *T. gondii* in the country, and no studies have been conducted in the Mampong Municipality. Among the few studies conducted in Ghana, a total of nine studies have explored toxoplasmosis among pregnant women. These studies encompassed 1,433 pregnant women across three regions (Ahafo, Ashanti, and Greater Accra). They were conducted in ten hospitals in nine districts. These studies reported varying prevalence rates ranging from 21.5% to 92.5% (Addo *et al.,* 2023; Agordzo *et al.,* 2019; Ayi *et al.,* 2009; Ayi *et al.,* 2016; Blay *et al.,* 2015; Kwofie *et al.,* 2016; Mensah *et al.,* 2019; Sefah-Boakye *et al.,* 2016; Singh *et al.,* 2021). Major risk factors associated with maternal toxoplasmosis include cat ownership and gravida status.

A chronological summary of the five prevalence studies on toxoplasmosis among pregnant women in Ghana is shown below:

Ayi *et al.,* conducted a study in 2009 at Korle Bu Teaching Hospital (KBTH) and Achimota Hospital in the Greater Accra region of Ghana, involving 159 pregnant women attending antenatal care. This study reported a seroprevalence of *T. gondii* infection at 92.5% (Ayi *et al.,* 2009). Blay *et al.* conducted research in 2015 at Korle Bu Teaching Hospital (KBTH) in the Greater Accra region of Ghana, involving 79 pregnant women. The study reported a seroprevalence of *T. gondii* infection at 76.0%. Additionally, the study examined congenital toxoplasmosis by testing placental tissue from 79 pregnant women, revealing a prevalence of 29.2% (Blay *et al.,* 2015).

In 2016, Sefah-Boakye *et al.* conducted research at Manhyia District Hospital in the Ashanti region of Ghana, with 110 expectant mothers attending antenatal care. The study reported a seroprevalence of *T. gondii* infection at 83.6% (Sefah-Boakye *et al.*, 2016). In 2016, A study conducted at KBTH in the Greater Accra region, involving 125 expectant mothers. The study documented a seroprevalence of *T. gondii* at 51.2% (Ayi *et al.,* 2016). A study was conducted on 100 pregnant women in their third-trimester at KBTH. Overall, 37.6 % of maternal blood, 39.5 % of umbilical cord blood, and 57.5 % of post-natal infant blood were positive for anti-*T. gondii* IgG. No anti-*T. gondii* IgM was detected in any of those samples (Kwofie *et al.*, 2016).

Mensah *et al.* (2019) conducted a study in the Ahafo region (Asunafo North District, Municipal Hospital Goaso) and the Ashanti region (Bosomtwe District, St. Michael Catholic Mission Hospital-Pramso) of Ghana, involving 266 pregnant women. The study revealed that 64.3% (171/266) of the participants tested positive for anti-*T. gondii* IgG, and 26.3% (70/266) tested positive for anti-*T. gondii* IgM antibodies (Mensah *et al.*, 2019).

Agordzo *et al.* (2019), conducted a study in three hospitals in the Ashanti region: Kumasi South Hospital, Agona Government Hospital, and Kuntanase Government Hospital, involving 110 pregnant women. The study revealed that the overall prevalence of toxoplasmosis among pregnant women was 58.2% (64 out of 110). Furthermore, 56.4% (n=62) of the pregnant women tested seropositive for IgG only, while 0.9% (n=1) tested positive for IgM only, and another 0.9% (n=1) tested positive for both IgG and IgM (Agordzo *et al.*, 2019).

In 2021, Singh *et al.* conducted a study involving 400 pregnant women in their first trimester of pregnancy at Kwame Nkrumah University of Science and Technology (KNUST) Hospital. The seroprevalence of toxoplasmosis was found to be 21.5% using the Rapid Diagnostic Test (RDT) and 57.3% using the Enzyme-Linked Immunosorbent Assay (ELISA) technique. Comparing the RDT results to those obtained with ELISA, it is evident that the specific RDT used in this study for diagnosing *T. gondii* infection exhibits low sensitivity (Singh *et al.*, 2021).

In 2023, Addo *et al.* conducted a cross-sectional study among 84 pregnant women attending antenatal care at Nkawie-Toase Government Hospital in the Atwima-Nwabiagya District of Ghana in 2020. Out of the participants, 47 expectant mothers (55.95%) tested seropositive for *T. gondii*, with 44 (52.38%) testing positive for IgG and 3 (3.57%) testing positive for IgM (Addo *et al.*, 2023).

2.3.3 Treatment of Toxoplasmosis

To reduce the risk of fetal transmission and mitigate the severity of the infection, the initiation of treatment with pharmacological agents, typically involving a combination of pyrimethamine and sulfadiazine, is warranted upon the detection of toxoplasmosis during pregnancy, particularly in its early stages (Dunay *et al.*, 2018).

2.3.4 Prevention of Toxoplasmosis among Pregnant women

Preventing toxoplasmosis in pregnant women is crucial for maternal and fetal health. Pregnant women must avoid consumption of raw or undercooked meat, as it may contain *T. gondii* (Belluco *et al.*, 2018). Properly cooking meat at safe temperatures is vital to eliminate the parasite. Adhering to food safety practices, like washing hands,

cutting boards, and utensils after handling raw meat, and preventing cross-contamination is essential (El-Sayed *et al.,* 2021). Animal droppings and cat litter boxes should be avoided, and if unavoidable, disposable gloves should be worn and hands washed with detergent after handling animal feces. The use of PPE's like hand gloves when gardening and proper hand washing afterwards aid in reducing toxoplasmosis because soil may harbour *T. gondii* (Stull, 2021). Pregnant women should desist from adopting new cat and avoid contact with stray livestock especially cats (Rasheed *et al.,* 2023).

2.3.5 Diagnosis

The greatest challenge in diagnosing toxoplasmosis is to establish the current infection and distinguish it from past infection. Toxoplasmosis can be diagnosed using several test techniques which are briefly explained below:

2.3.5.1 Clinical Evaluation

Toxoplasmosis can be diagnosed through clinical evaluation by healthcare professionals. While the condition is often asymptomatic, individuals with weakened immune systems such as pregnant women, older adults, and children may exhibit symptoms. These symptoms can include:

Flu-like symptoms: Fever, muscle aches, fatigue, headache, and sore throat. **Eye-related issues:** Blurred vision, eye pain, redness, and sensitivity to light. **Central nervous system (CNS) symptoms**: Confusion, seizures, coordination problems, and other neurological issues. **Gastrointestinal symptoms**: Abdominal pain, diarrhea, and nausea (Dubey & vectors, 2021). The healthcare providers will assess these symptoms,

medical history, and any potential risk factors, such as exposure to cats or undercooked meat.

2.3.5.2 Blood Tests (Serology)

Serology is the most common laboratory test for toxoplasmosis. It measures the presence of antibodies (IgM and IgG) against *T. gondii* in the blood. IgM antibodies are typically produced during an acute infection, while IgG antibodies persist for a longer time and may indicate a past infection or immunity (Teimouri *et al.,* 2020). After an acute infection, IgM antibody levels rise, peak at 1 to 2 months, and then decline faster than IgG antibodies (Vargas-Villavicencio *et al.,* 2022). IgG antibodies typically appear 1 to 2 weeks after infection, peak within 12 weeks to 6 months, and remain detectable for life (Elsheikha *et al.,* 2020). If both IgG and IgM are absent before or early in pregnancy, there's no previous infection risk. Detecting IgG without IgM suggests an past infection (Simon *et al.,* 2020). Positive results for both IgG and IgM are complex, possibly indicating either a recent infection or low IgM levels from a previous infection (Simon *et al.,* 2020). The IgG avidity assay evaluates the intensity of IgG attachment to *T. gondii*. There are several methods for serological testing of toxoplasmosis such as RDT, ELISA, PCR and etc.

2.3.5.3 Amniotic Fluid Analysis

When there is suspicion of congenital toxoplasmosis, an evaluation may involve the examination of amniotic fluid for the presence of *T. gondii* DNA (Varsa *et al.,* 2021). This diagnostic procedure, known as amniocentesis, entails the extraction of a small sample of amniotic fluid from the uterus using a needle. Detecting Toxoplasma DNA

in the amniotic fluid serves the dual purpose of confirming the diagnosis of congenital toxoplasmosis and assisting in the determination of suitable treatment strategies.

2.3.5.4 Tissue Biopsy

In instances of severe presentations or when conventional diagnostic approaches yield inconclusive results, a biopsy of affected tissue, such as lymph nodes or brain tissue, may be conducted to search for *T. gondii* (Sakr, 2023). Biopsy entails the extraction of a minute tissue sample, subsequently scrutinized under a microscope to identify the existence of *T. gondii*. This approach offers a more definitive diagnostic outcome and plays a pivotal role in directing suitable treatment interventions.

2.3.5.5 Imaging (MRI or CT)

In instances where toxoplasmosis has impacted the central nervous system, notably the brain, medical practitioners may employ MRI or CT scans for assessing organ damage. These imaging procedures offer intricate visual representations of the affected organs, facilitating the detection of any anomalies or lesions attributed to toxoplasmosis. Furthermore, these scans aid in gauging the extent of the damage and play a pivotal role in shaping treatment strategies for individuals with central nervous system involvement.

2.3.5.6 Ophthalmologic Evaluation

Toxoplasmosis can also impact the eyes, prompting an ophthalmologist to conduct an ocular assessment for distinctive lesions (Kalogeropoulos *et al.,* 2022). These lesions may induce symptoms such as blurred vision, ocular redness, and heightened sensitivity to light (Kalogeropoulos *et al.,* 2022). In cases of heightened severity, untreated

toxoplasmosis can result in lasting harm or even complete loss of vision (Gomez-Marin & de-la-Torre, 2020).

2.4 Hepatitis B Virus (HBV)

Hepatitis B virus (HBV) is a significant causal factors for chronic liver disease and the development of hepatocellular carcinoma (HCC) (Campbell *et al.,* 2021). HCC ranks as the fifth most prevalent form of cancer and is the third leading cause of cancer-related deaths globally (Liu & Liu, 2022). This indicates the critical need to identify early diagnostic indicators and therapeutic targets, especially those that are shared between both chronic infections.

Hepatitis B is primarily spread through contact with infected blood or other body fluids, such as semen and vaginal fluids. Common modes of transmission include unprotected sexual intercourse, sharing needles for drug use, and from mother to child during childbirth. HBV infection can be either acute or chronic. Acute infections are typically short-lived and the immune system can often clear the virus. Many people with acute HBV infection do not have symptoms, but some may experience symptoms such as jaundice, fatigue, and abdominal pain. Chronic HBV infection can lead to liver cirrhosis and liver cancer over time. Hepatitis B can be prevented through vaccination, which is recommended for all infants and individuals at risk. Safe sex practices and avoiding sharing needles or personal items that may come into contact with infected blood are also important prevention measures. Antiviral medications are available to manage chronic hepatitis B, but they may not cure the infection. The goal of treatment is to suppress the virus, reduce liver damage, and lower the risk of complications.

2.4.1 Prevalence of Viral Hepatitis among Pregnant Women

In 2016, Ahmad conducted a study to investigate the prevalence of hepatitis B (HBV) and hepatitis C (HCV) viral infections among pregnant women in Pakistan. A total of 10,288 pregnant women underwent screening for HBV and HCV using the immunochromatographic technique. The study revealed that the overall prevalence of HBV was 1.16%, with the highest prevalence occurring in January 2014 at 1.69%. Similarly, the overall prevalence of HCV infection among the pregnant women was 1.42%, with the highest prevalence of HCV infection (2.22%) recorded in March 2014 (Ahmad, 2016).

In 2014, Esan *et al.* conducted a study on the seroprevalence of hepatitis B and hepatitis C virus co-infection among 649 pregnant women attending antenatal care in Nigeria. The seroprevalence of HBV and HCV was found to be 44 (6.78%) and 9 (1.39%), respectively. The prevalence of HBV and HCV co-infection was 1 (0.15%) in the age group 31-35 (Esan *et al.*, 2014).

Frambo *et al.* (2014) reported a seroprevalence of HBV to be 9.7% among 176 pregnant women in Cameroon (Frambo *et al.*, 2014). In the year 2014, Bayo *et al.* conducted a study in Uganda and reported a seroprevalence of 11.8% for HBV among a total of 397 pregnant women attending routine antenatal care (Bayo *et al.*, 2014).

In Ghana, there have been limited studies on the prevalence of HBV and HCV especially among pregnant women, and no studies have been conducted in the Mampong Municipality. About nine (9) studies have been conducted in Ghana in exploring the prevalence of HBV and HCV among pregnant women. These studies

involved 10,413 pregnant women across five regions (Ashanti, Eastern, Greater Accra, Northern, and Volta). These studies reported varying prevalence rates, ranging from 2.4% to 10.6% (Anabire *et al.*, 2019; Antuamwine *et al.*, 2022; Bobie *et al.*, 2022; Cho *et al.*, 2012; Dortey *et al.*, 2020; Ephraim *et al.*, 2015; Helegbe *et al.*, 2018; Kwadzokpui *et al.*, 2020; Luuse *et al.*, 2016). These studies have been summarized in the table 1 below with the highest prevalence (10.6%) by Cho *et al.* (2012) and the lowest prevalence (2.4%) by Luuse *et al.* (2016).

2.5 HIV

Human immunodeficiency virus (HIV) is a viral infection that targets the immune system of the body. Acquired immunodeficiency syndrome (AIDS) represents the most advanced phase of the HIV disease. HIV affects white blood cells, which are vital components of the immune system (Obeagu & Obeagu, 2024). This therefore dwindles the body's ability to protect itself against several opportunistic infections such as toxoplasmosis (Obeagu & Obeagu, 2024).

2.5.1 Transmission Routes

The transmission of HIV occurs through the exchange of bodily fluids from an infected individual, including blood, breast milk, semen, and vaginal fluids (Kordy *et al.*, 2019). It must be noted that, HIV is not transmitted through common acts of affection like kissing or hugging, and sharing of food (Afzal *et al.*, 2023). HIV can be transmitted via vertical transmission or mother-to-child transmission (MTCT), thus infected mother can pass it on to the unborn child (Cardenas *et al.*, 2023).

2.5.2 Effects of HIV Pregnant Women

HIV-positive pregnant women are at a higher risk of experiencing health complications during pregnancy and childbirth (Cardenas *et al.,* 2023). These complications may include more frequent infections, anemia, and a weakened immune system. HIV weakens the immune system, which can lead to an increased susceptibility to opportunistic infections in pregnant women. These infections can complicate the pregnancy and pose risks to both the mother and the baby (Cabieses *et al.,* 2020). HIV infection during pregnancy can affect the developing fetus. The virus can cross the placenta and infect the baby, potentially leading to a range of health issues for the infant. HIV-positive pregnant women require specialized antenatal care to monitor their health and manage the risk of mother-to-child transmission. This often involves antiretroviral therapy (ART) to reduce viral load and the risk of transmission (Cabieses *et al.,* 2020). An HIV diagnosis during pregnancy can cause significant stress, anxiety, and emotional distress for expectant mothers. Coping with the stigma and discrimination associated with HIV can also be challenging.

2.5.3 Prevalence of HIV among Pregnant Women

Several factors influence HIV prevalence in pregnant women in Africa, including the prevalence of HIV in the general population, access to healthcare, and the availability of prevention and treatment programs. A study in Nigeria by Oladeinde *et al.* (2011) documented that the prevalence of HIV and anemia among pregnant women were 10.2% and 49.3% respectively (Oladeinde *et al.,* 2011). In a study conducted by Manyahi *et al.* in 2015, it was observed that the overall prevalence of HIV infection among pregnant women attending ANC clinics in Tanzania was 5.6%, while the prevalence of syphilis was 2.5% (Manyahi *et al.,* 2015). A report in Ghana by GHS

reported the prevalence of HIV among pregnant women in Mampong to be 2.8% (GHS, 2019).

2.6 Syphilis

Syphilis is a sexually transmitted infection (STI) caused by the bacterium *Treponema pallidum*. It can affect various parts of the body and progress through several stages if left untreated. Syphilis is a serious disease, but it is curable with appropriate medical treatment, usually antibiotics.

2.6.1 Stages of Syphilis

The first stage of syphilis typically involves the appearance of a single sore (chancre) at the site of infection (Chaudhry *et al.*, 2023). This sore is usually painless and may go unnoticed. It heals on its own within a few weeks. If left untreated, syphilis progresses to the secondary stage, which is characterized by a variety of symptoms, including skin rashes, mucous membrane lesions, fever, swollen lymph nodes, and flu-like symptoms (Chaudhry *et al.*, 2023). After the secondary stage, syphilis can enter a latent stage during which there are no apparent symptoms, but the bacterium remains in the body. Latent syphilis can last for years. In some cases, syphilis may progress to the tertiary stage, which can cause severe damage to organs such as the heart, brain, and nervous system. Tertiary syphilis can be life-threatening (Cornil, 2024).

2.6.2 Transmission Routes

Syphilis is primarily transmitted through direct contact with syphilis sores, known as chancres (Cornil, 2024). These sores can occur on the genitals, anus, lips, or inside the mouth. Syphilis can also be transmitted from mother to child during childbirth

(congenital syphilis) and, less commonly, through blood transfusions or by sharing needles with an infected person.

2.6.3 Diagnosis, Prevention and Treatment of Syphilis

Syphilis is diagnosed through blood tests that detect antibodies to the bacterium (Satyaputra *et al.,* 2021). A physical examination and evaluation of symptoms may also be necessary. Anyone diagnosed with syphilis should inform their sexual partners so that they can be tested and, if necessary, receive treatment (Satyaputra *et al.,* 2021). This is essential to prevent the spread of the infection. Syphilis is curable with antibiotics, typically penicillin. The type and duration of treatment depend on the stage of syphilis and the patient's medical history. Early treatment is essential to prevent the progression of the disease and complications.

Preventing syphilis involves practicing safe sex, which includes using condoms consistently and correctly during sexual activity (Purwoko *et al.,* 2021). Regular testing and screening for STIs are also important, especially for individuals at higher risk (Purwoko *et al.,* 2021). Pregnant women should be screened for syphilis during prenatal care because untreated syphilis can lead to congenital syphilis in infants. Early detection and treatment of syphilis during pregnancy are crucial to preventing harm to the baby.

2.6.4 Effects of Syphilis in Pregnant Women

Syphilis in pregnant women can have serious consequences for both the mother and the unborn baby (Uku *et al.,* 2021). The effects of syphilis during pregnancy depend on several factors, including the stage of syphilis and whether or not the infection is adequately treated. Syphilis can progress through different stages, and if left untreated,

it can lead to severe health problems in the mother, such as organ damage (including the heart and nervous system), neurosyphilis (affecting the central nervous system), and gummatous syphilis (destructive skin and tissue lesions) (Trovato *et al.,* 2021). The most significant concern of syphilis in pregnancy is the risk of transmitting the infection to the baby during pregnancy or childbirth (Trovato *et al.,* 2021). This is known as congenital syphilis. The risk of transmission to the baby depends on the stage of syphilis during pregnancy.

The highest risk of transmission occurs during the primary and secondary stages, but it can also occur during the latent stage. Congenital syphilis can result in a range of serious health problems for the baby, including: Stillbirth or death shortly after birth, Premature birth, low birth weight, and related complications, Anemia, Jaundice, Skin rashes, mucous membrane lesions, and bone abnormalities, Infection of the liver, spleen, and other organs, Damage to the eyes, ears, and central nervous system, Intellectual and developmental disabilities.

2.6.5 Prevalence of Syphilis among Pregnant Women

In a systematic review carried out by Hussen and Tadesse in 2019, it was reported that the combined prevalence of syphilis among pregnant women in sub-Saharan Africa stood at 2.9%. More specifically, in the East and Southern African regions, the prevalence of syphilis among pregnant women was comparatively higher, at 3.2% and 3.6%, respectively. Notably, the study did not find significant variations in prevalence based on region or time period (Hussen & Tadesse, 2019).

In 2019, Yideg Yitbarek and Ayele conducted a study involving 210 pregnant women during their initial ANC (Antenatal Care) visit in Northwest Ethiopia. They employed the VDRL test method to ascertain the prevalence of syphilis among this group. The findings of the study revealed a seroprevalence of syphilis at 1.9%. Notably, the study also identified a significant association between syphilis seroprevalence and women who reported having multiple sexual partners (Yideg Yitbarek & Ayele, 2019).

A cross-sectional study was conducted by Fikadu *et al.* in 2019 at Jimma University Specialized Hospital in Southwest Ethiopia. The study reported that out of the 181 expectant women conveniently sampled, only 2 out of 181 (1.1%) women were seropositive for syphilis (Fikadu *et al.,* 2019). A study conducted in the Kaduna Metropolis using a rapid diagnostic test kit to detect Syphilis antibodies reported that 8 out of the 300 pregnant women, representing 2.7%, were seropositive for syphilis (Dadah, 2021).

In a study conducted in Brazil by Benedetti *et al.* (2019), it was reported that the seroprevalence of syphilis among pregnant women was 4.4%, with 29 out of 661 participants testing positive. The study's findings indicated that the high prevalence of syphilis is attributed, in part, to the suboptimal quality of antenatal care services. Furthermore, the research revealed the presence of social and behavioral risk factors associated with syphilis in pregnant women (Benedetti *et al.*, 2019).

In a hospital-based cohort study conducted in Cape Coast Metropolitan Hospital, Ghana among pregnant women receiving antenatal care, discovered that out of the 2,640

pregnant women who delivered between 2016 and 2018, 107 of them, representing 4.1%, tested positive for syphilis (Kwamena *et al.,* 2019).

2.7 Co-Morbidity of Toxoplasmosis With Other Infectious Diseases

Toxoplasmosis is a significant opportunistic infection in individuals with weakened immune systems, such as those with advanced HIV/AIDS. HIV/AIDS can lead to a compromised immune system, making individuals more susceptible to toxoplasmosis, and toxoplasmosis can further weaken the immune system. Toxoplasmosis in HIV/AIDS patients often affects the brain (cerebral toxoplasmosis), leading to neurological symptoms. This condition is associated with high morbidity and mortality.

Co-infection may affect the clinical presentation and complications of either disease, and it can be particularly problematic in pregnant women, as both diseases can pose risks to the fetus. Co-morbidities or concurrent infections of these two diseases are relatively rare, as they do not share common modes of transmission or risk factors. However, it is essential to consider that co-infections with multiple pathogens can occur in some individuals, especially if they have multiple risk factors or compromised immune systems. The risk factors for contracting toxoplasmosis and syphilis are different. Toxoplasmosis is more commonly associated with exposure to contaminated soil, raw or undercooked meat, and cat feces, while syphilis is associated with unprotected sexual activity or congenital transmission from an infected mother.

There is a scarcity of publications on co-morbidities with other infections, however, below are the few discussed publications they are in relation to the subject. A study conducted by Mboera *et al.* (2019) in Tanzania reported that most deaths resulting from

toxoplasmosis affected the adult age category and were strongly associated with HIV/AIDS (Mboera *et al.,* 2019). In a study conducted by Sapmaz *et al.* (2019) titled "Relationship between *Toxoplasma gondii* seropositivity and depression in children and adolescents," it was noted that seropositivity was markedly more prevalent among patients with suicidal ideation compared to those without such ideation (Sapmaz *et al.,* 2019).

In a retrospective study on the prevalence of toxoplasmosis in pregnant women in Benin and its association with malaria, conducted by Dambrun *et al.* in 2022, the seroprevalence of *T. gondii* infection was found to be 52.6%. Notably, the study observed that the educational level of women appears to exert an influence on their serological status regarding toxoplasmosis, with women possessing limited or no formal education exhibiting a heightened level of immunity compared to those with higher levels of education. Remarkably, pregnant women who tested positive for toxoplasmosis tended to demonstrate a lower incidence of malaria infection during pregnancy (in terms of numerical prevalence) or at the time of delivery (in terms of presence). Furthermore, these individuals exhibited lower levels of IgG antibodies specific to *Plasmodium falciparum* Apical Membrane Antigen 1, in contrast to women who tested negative for toxoplasmosis (Dambrun *et al.,* 2022).

A study conducted by Safarpour *et al.* in 2020 documented the pooled prevalence of *T. gondii* infection among individuals with HIV. It revealed a prevalence of 3.24% by IgM and a pooled seroprevalence of *T. gondii* by IgG at 44.22%. The study also identified a correlation between *Toxoplasma* prevalence and factors such as gender, consumption

of raw meat, contact with cats, and knowledge about toxoplasmosis (Safarpour *et al.*, 2020).

2.8 *Toxoplasma gondii* Versus Sociodemographic Characteristics

Numerous studies have explored the connection between *Toxoplasma gondii* infection and sociodemographic factors in an effort to discern the impact of specific variables on the prevalence of *T. gondii* infection across diverse populations (Arshad, 2022; Owusu-Dommey *et al.,* 2020). Below are sociodemographic characteristics that have undergone investigation regarding their relationship with *T. gondii* infection:

2.8.1 Age

T. gondii infection has the potential to impact individuals across all age brackets, albeit some investigations have proposed that older individuals might exhibit a higher probability of prior exposure to the parasite during their lifespans (Owusu-Dommey *et al.,* 2020). This propensity can potentially be ascribed to factors such as increased engagement in outdoor activities and a heightened likelihood of consuming inadequately cooked meat, both of which are recognized as prevalent transmission pathways for this infection (Owusu-Dommey *et al.,* 2020). Additionally, it is noteworthy that advanced age may coincide with compromised immune systems, rendering older individuals more susceptible to *T. gondii* infections compared to their younger counterparts.

Notably, vulnerable populations encompass young children and pregnant women. In the case of young children, their immune systems are in the process of development, rendering them intrinsically more susceptible to *T. gondii* infections. Contrarywise,

pregnant women undergo alterations in their immune responses during gestation, potentially diminishing their ability to mount a robust defense against infections like *T. gondii* (Arshad, 2022). Consequently, it is imperative for these vulnerable cohorts to adopt enhanced precautionary measures aimed at averting exposure to the parasite and thus mitigating the likelihood of potential complications.

2.8.2 Gender

Research has shown varying outcomes, with some studies suggesting no significant gender-based differences in infection rates, while others have reported slightly higher rates in males or females (Lyons *et al.,* 2024). These differences may be related to behaviors or exposures associated with gender roles.

2.8.3 Geographic Location

The prevalence of *T. gondii* infection can vary significantly by geographical area (Ahaduzzaman *et al.,* 2022). It may be more common in areas with higher rates of oocyst contamination in soil, climate conditions conducive to oocyst survival, and differences in dietary habits and cultural practices (Ahaduzzaman *et al.,* 2022). This implies that areas where fresh and unpasteurized milk is consumed most may have a higher prevalence, or areas where their culture mandates them to eat fresh meat may have a higher incidence rate of toxoplasmosis. In addition, prevalence may be higher in regions that have more stray cats and rural areas where access to portable water is a challenge.

2.8.4 Socioeconomic Status

Some studies have indicated that individuals with lower socioeconomic status, including limited access to healthcare and poorer living conditions, may have a higher risk of *T. gondii* infection (Cabral Monica *et al.*, 2022). These factors can influence exposure to contaminated food or water sources.

2.8.5 Occupation

Certain occupational groups, such as farmers, veterinarians, and individuals working with animals, may have an increased risk of *T. gondii* exposure due to their close contact with potentially infected animals and contaminated environments(Cabral Monica *et al.*, 2022).

2.8.6 Dietary Habits

Consuming undercooked or raw meat, particularly from animals carrying *T. gondii*, can increase the risk of infection (Kuruca *et al.*, 2023). Dietary choices and food preparation practices can vary by culture and socioeconomic status.

2.8.7 Hygiene Practices

Poor personal hygiene practices, such as inadequate handwashing after handling raw meat or contact with soil, may contribute to *T. gondii* transmission (Karl *et al.*, 2022).

2.9 Conceptual Framework of Toxoplasmosis Burden and its Transmission Risks and Impact

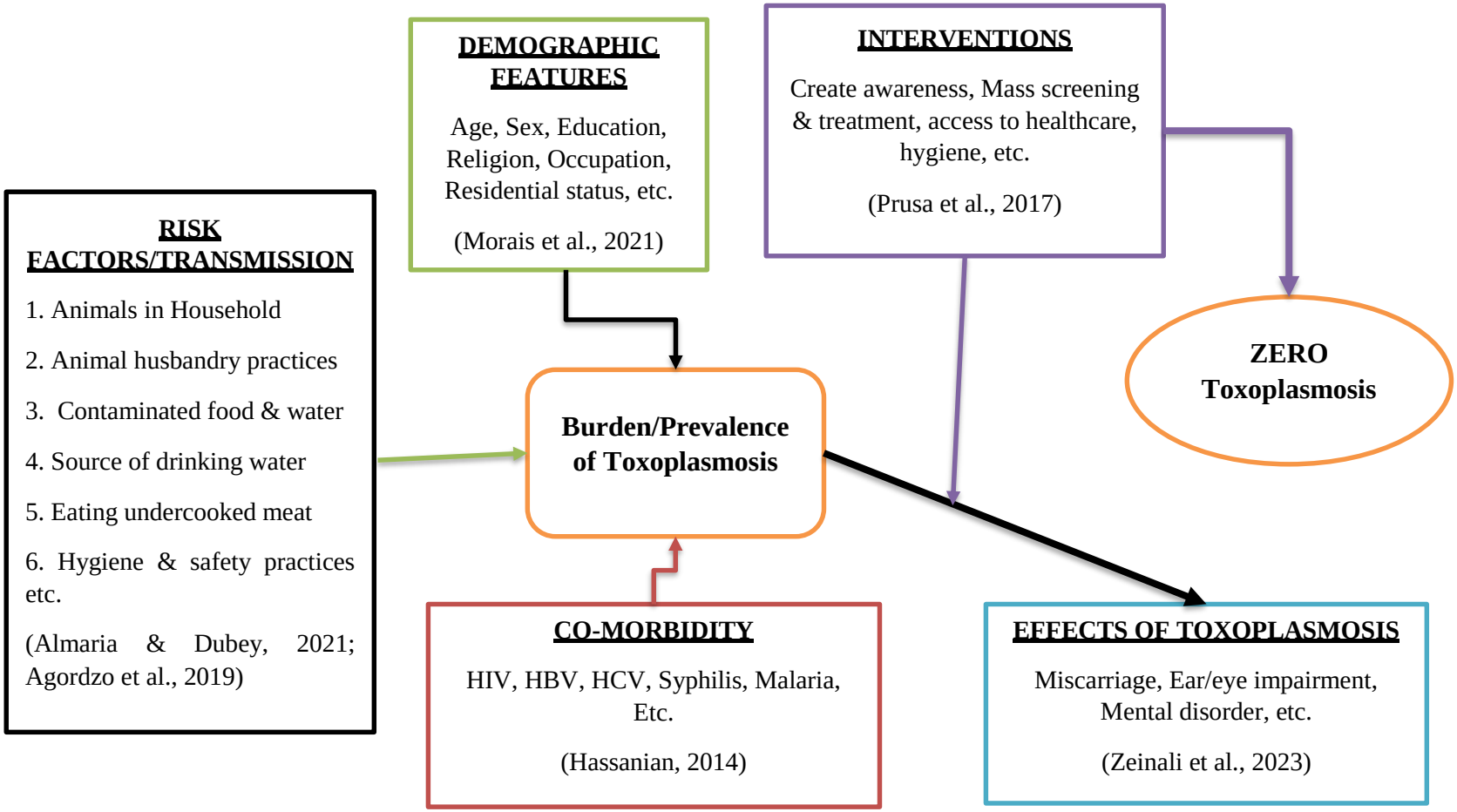


Figure 2.3: Conceptual framework of the Study Based on the Literature reviewed

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter of the thesis focuses on the study area and the methodology employed; is sectioned as follows: Study Design, Study Area, Study Site, Study Population, Inclusion and Exclusion Criteria, Sample Size Estimation, Sampling Techniques, Data Collection Tools and Techniques, Training of Research Assistants, Pilot Study, Data Collection Procedures, Blood Sample Collection, Sample Processing, Serological Testing, Data Management, Statistical Analysis, and Ethical Review and Clearance.

3.1 Design of the Study

This study employed a descriptive cross-sectional design to assess the current status of *Toxoplasma gondii* infection and co-infection with other congenital diseases among pregnant women in the Mampong Municipality over a period of ten months (from February to November 2023). This timeframe was chosen to capture variations in the population and reduce potential biases due to the sampling technique.

3. 2 Study Area

This study was conducted in the Mampong Municipality. Asante Mampong is the capital city of the Mampong municipal and is situated in the northern part of the Ashanti Region (GSS, 2021). Asante Mampong has a total land area of 2,345 km^2, which is made up of roughly 220 communities, most of which are located in rural areas (GSS, 2020). According to the 2021 Population and Housing Census in Ghana, 116,632 people are living in the municipality, with 56,965 males and 59,667 females (GSS,

2021). The municipality's average temperature is 28 °C, with a westerly wind moving at 5 km/h and relative humidity of 63 percent (Mampong-Municipal-Assembly, 2021). Mampong municipality is located in the transitional zone, which is inside the forest and the savanna region of Ghana (GSS, 2020; Mampong-Municipal-Assembly, 2021). The main economic activity in the Municipality is agriculture including animal farming which employs about 67.30% of the entire labor force of the Municipality. The majority of the working population is employed by an integrated system of markets, financial institutions, wholesalers and retailers, transportation companies, hotels and restaurants. Almost every household in Asante Mampong owns one or more domesticated animals commonly sheep, goats, poultry, cattle and dogs.

3.3 Study Site

This research was conducted within the confines of the Mampong Municipality, a geographical province situated in the Ashanti region of Ghana. The study's data collection took place across six (6) distinct healthcare facilities strategically selected within the municipality (**Figure 3.1**). These healthcare centres included: Mampong Government Hospital/Maternity Home; Calvary Health Service; Sister Phillipah Maternity Home; Krobo Health Centre; Asaam Health Centre and Kofiase Health Centre.

These healthcare institutions collectively served as the primary sites for data collection, where pregnant women were enrolled in the study to assess *Toxoplasma gondii* infection and its co-infection with various infectious diseases. The study was conducted at these sites because the majority of pregnant women in the municipality attend antenatal care (ANC) at these health centres. Additionally, various facilities with

differing statuses were taken into account to ensure balanced data. As a result, the study included both government and private health facilities, as well as facilities categorized as hospitals, health centres, or clinics. This approach consequently yielded a substantial dataset suitable for making inferences.

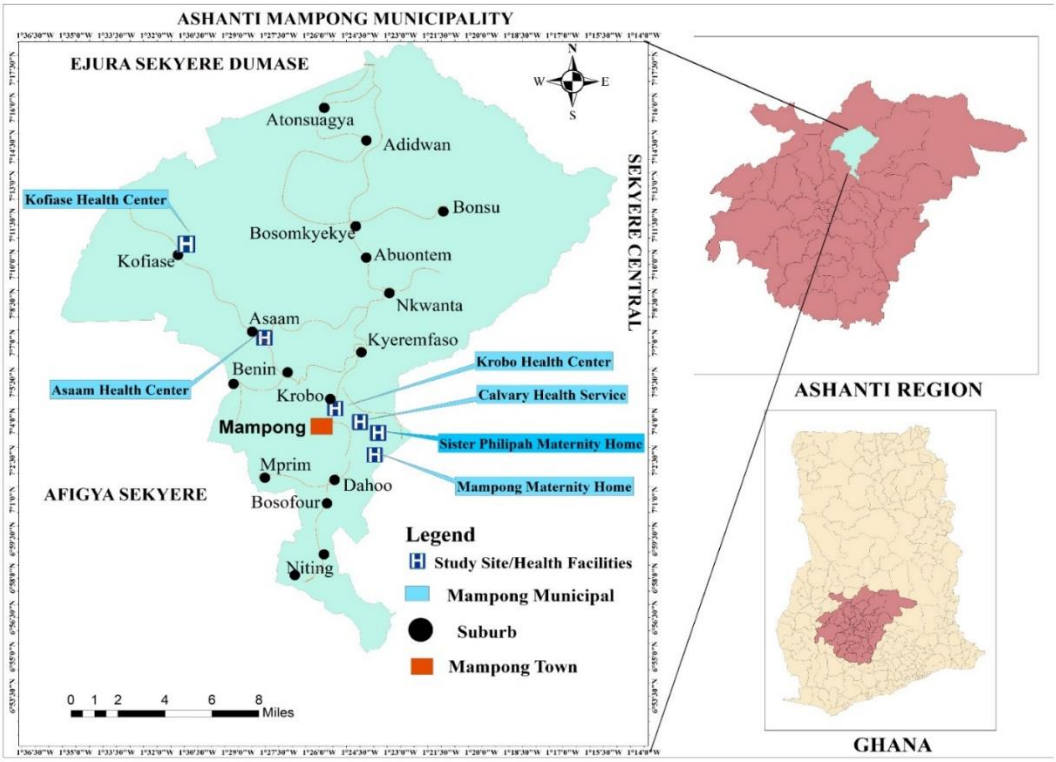


Figure 3.1 A Map of Asante Mampong Municipality Showing the Health Facilities

3.4 Study Population

The study population for this research consisted of pregnant women residing in the Mampong Municipality, located within the Ashanti region of Ghana. Specifically, data collection was conducted among pregnant women who sought healthcare services at six (6) different healthcare facilities selected within the municipality. Pregnant women visiting any of these six health centres for prenatal care and related services were included in the study population.

3.4.1 Inclusion and Exclusion Criteria

Pregnant women who have resided in the study area for more than two months and fell within the reproductive age range (15 to 49 years) were included. Participants who lived permanently outside the study area but attended ANC in the selected facilities were excluded.

3.5 Sample Size Estimation

A sample size of 200 was estimated using Cochran's Formula [$n = (Z^2pq)/e^2$] as previously described in (Sarmah *et al.,* 2013):

where n is the sample size

Z is the chosen critical value of the desired confidence level

p is the estimated proportion of an attribute present in the population (prevalent of *T. gondii* in Ghana)

q = 1 – p

and **e** is the desired level of precision or sampling error.

A review by Amissah-Reynolds, 2020 reported the prevalence of *T. gondii* in southern Ghana to be 92%. The degree of variability in the study population is 92% (p = 0.92), which is used at a 95% confidence level with ±5% precision (p = 0.92; q = 1-0.92 = 0.08; e = 0.05; z = 1.96), given an estimated sample size of 113.0967. However, a total of 200 sample size was targeted for this study to mitigate some possible biases due to the sampling technique. However, at the end of this study, a sample size of 201 was used for the analysis.

3.5 Sampling Techniques

In this study, a multi-stage sampling approach was utilized, incorporating both purposive and convenient sampling techniques. Firstly, a purposive sampling technique was used to select the study site while the study participants were conveniently sampled from these selected health facilities.

3.6 Data Collection Tool(s) and Techniques

3.6.1 Data Collection Tool(s)

In this study, a structured questionnaire was utilized to collect data from the study participants. The questionnaires consisted of four sections: socio-demographic characteristics of the participants, their knowledge regarding zoonotic diseases and the associated modes of transmission, the levels of interaction between humans and their animal populations, prevention of disease transmission between humans and animals and routine ANC laboratory results. This instrument played a crucial role in gathering relevant and essential data for the study.

3.6.2 Training of Research Assistants

A group of final year Public Health students at AAMUSTED -Mampong Campus were recruited and trained as research assistants to assist in the data collection. They were trained for one week on how to administer the questionnaires for accurate responses and on how to extract data from the ANC records books.

3.6.3 Pilot Study

The data collection tools were pre-tested using Benim Health Centre and discrepancies identified in the tools were subsequently revised and updated. Research Assistants used

the pilot phase to test the data collection processes. Face-to-face data collection and completion of the questionnaires were learned practically before the onset of the main study.

3.6.4 Data Collection Procedure

A combination of face-to-face interviews and observational methods was employed to collect data from participants (**Figure 3.2**). Additionally, demographic characteristics, medical history, and clinical variables, including gestational stage, gravida, and results of routine screening tests for malaria, HBV, HIV, and syphilis, were meticulously extracted from the participants' antenatal care (ANC) record books.

Figure 3.2: Trained research assistants collect data while participants wait for their turn.

3.7 Blood Sample Collection and Handling

A phlebotomist stationed at the health facility's laboratory collected 5 mL of blood from each participant using venipuncture into EDTA tubes. The blood samples obtained

from pregnant women were used for routine antenatal care (ANC) screening tests and to detect the presence of *Toxoplasma gondii* antibodies and antigens.

After collection, the samples were immediately stored in a cool box maintained at a temperature of 2–8°C to preserve their integrity. The time taken from blood sample collection to the laboratory for processing did not exceed four hours. Upon arrival at the laboratory, the samples were logged, inspected for any signs of hemolysis. During transportation and handling, all samples were carefully monitored to prevent contamination and maintain their viability for accurate testing.

3.8 Laboratory Methods

3.8.1 Sample Processing

The blood samples collected were subjected to centrifugation at 1780 x g for 10 minutes at 4 °C to separate plasma for subsequent serological analysis. The plasma was promptly assayed for anti-*T. gondii* IgG and IgM antibodies using the immunochromatography Test (ICT) technique.

3.8.2 Serological Testing

The specific ICT used in this study was the TOXO IgG/IgM One-Step Rapid Test Cassette (WB/S/P) produced by Evancare Medical (Nantong) Co., Ltd., (China) (**Figure 3.3 and Figure 3.4**). This assay employs a lateral flow chromatographic immunoassay for the simultaneous detection and differentiation of IgG and IgM anti-*T. gondii* in human serum, plasma, or whole blood. Testing procedures strictly adhered to the manufacturer's instructions (Evancare, 2024).

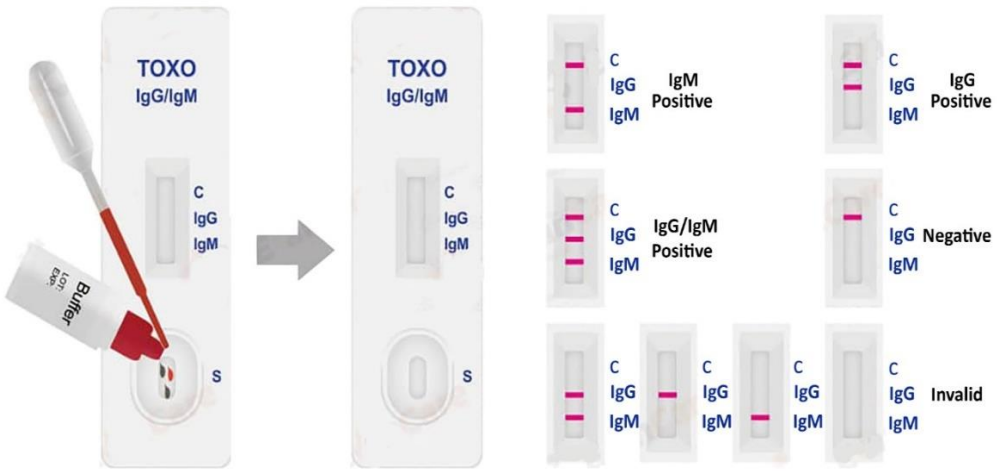


Figure 3.3 Procedure in the use of Toxo Rapid Test Cassette

Figure 3.4: PI (male) and team member (female) record *T. gondii* Test result, and IgG positive and negative rsults

3.9 Data Management Statistical Analysis

3.9.1 Data Management

The data collected from the field were checked for completeness and consistency by the team of scientists from AAMUSTED, Asante Mampong Campus (**Figure 3.5**). The data were entered into a Microsoft Excel (version, 2016) database and cleaned. Microsoft Excel 2016 spreadsheet was initially employed for data organization and preliminary processing. The clean dataset of the survey data and laboratory results was subsequently exported into IBM SPSS version 27.0 for comprehensive statistical analysis.

Figure 3.5: Data entry and Management by PI and team

3.9.2 Statistical Analysis

Descriptive statistics was employed to determine the frequencies and percentages of the variables. The prevalence of *T. gondii* and other routine ANC tests were analyzed using a chi-square goodness-of-fit test. Cross-tabulation of co-infection of toxoplasmosis with other routine ANC tests,transmission risks, and impact of toxoplasmosis were conducted to establish relationships among the variables. Chi-square test of

independence and logistics regression were used to determine comorbidity of toxoplasmosis with other routine ANC tests and the risks of *T. gondii* infections during pregnancy. A p-value of less than 0.05 and 95% confidence interval were considered as statistically significant.

3.10. Ethical Review and Clearance

Ethical clearance was acquired from the Committee on Human Research, Publications, and Ethics (CHRPE) at the Kwame Nkrumah University of Science and Technology (KNUST). The ethical clearance reference number is CHRPE/AP/717/23. Written permissions were obtained from the Ashanti Regional and Asante Mampong Municipal Health Directorate, and the study facilities. Participants were informed of the aims of the study and were told that their participation was solely voluntary. They were further informed of their right to withdraw from the study at any point when they deemed it necessary. A signed informed consent was obtained from each study participant before sample collection.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter presents the results of the study. The presentation of the results is based on the specific objectives and covers the following sub-headings: Demographic Characteristics of Pregnant Women, Obstetric History and Clinical Records of the Study Participants, Seroprevalence of *T. gondii* and Other Diseases Screened During Routine ANC, Co-morbidity of Toxoplasmosis and Other Diseases Screened at ANC, Association of *T. gondii* Infection with Sociodemographic Characteristics of the Study Participants, Transmission Risks of *T. gondii* Infection Among Pregnant Women, and Association of Toxoplasmosis and Health Indicators Among Pregnant Women in the Mampong Municipality.

4.1. Demographic Characteristics of Pregnant Women within the Mampong Municipality

In **Table 4.1**, 47.76% were aged 20 to 30 years, 15.43% were aged 15 to 19 years, 59.70% were married, and 20.90% were cohabiting. Most (85.57%) participants were Christians, 51.24% had basic education, whereas 8.96% had no formal education. Most (76.62%) were employed, 53.90% engaged in personal care & service works (such as hair-dresser, seamstress, makeup artists, and nail technicians, etc), 5.19% in food vending businesses, 45.27% were recruited from the Mampong Maternity Home, and 2.99% from the Asaam Health Centre.

Table 4.1: Demographic Characteristics

Demographic characteristics	Frequency	Percentages %
Age		
15 to 19	31	15.43
20 to 30	96	47.76
31 to 49	74	36.82
Marital Status		
Single	39	19.41
Married	120	59.70
Co-habitation	42	20.90
Religion		
Christian	172	85.57
Muslim	29	14.43
Educational Level		
No formal education	18	8.96
Basic (Primary and JHS)	103	51.24
SHS	40	19.90
Tertiary	40	19.90
Employment status		
Employed	154	76.62
Unemployed	47	23.38
Main occupation (Employed)		
Farmer	18	11.69
Service Professionals	20	12.99
Food vendor	8	5.19
Traders	25	16.23
Personal care & service workers	83	53.90
Health facilities		
Mampong Government Hospital	91	45.27
Calvary Health Centre	23	11.44
Sister Philippa Clinic	17	8.46
Kofiase Health Centre	53	26.37
Asaam Clinic	6	2.99
Krobo Health Centre	11	5.47

(Data Source: Field Data, 2023)

4.1.1 Obstetric History and Clinical Records of the Study Participants

In **Table 4.2**, 53.73% were in their third trimester, 23.38% were primigravida, 42.29% were ≥gravida III, 50% were in parity 2 to 5, 23.38% had experienced miscarriages, 1.41% had children with some form of disabilities, while 10.56% had children who were academically challenged, and 28.36% had experienced eye infections (chorioretinitis).

Table 4.2: Obstetric History and Clinical Records of Participants

Variables	Frequency	Percentages %
Gestational period		
First trimester(0-12wks)	25	12.44
Second trimester(12-24wks)	68	33.83
Third trimester(24-40wks)	108	53.73
Gravida/Number of pregnancies		
Gravida I	47	23.38
Gravida II	57	28.36
≥Gravida III	97	48.26
Parity/Number of children		
Parity 0	12	7.79
Parity 1	57	37.01
Parity 2-5	77	50.00
Parity 6-10	8	5.19
Had a child with auditory defect		
Yes	2	1.41
No	140	98.59
Had a child who academically challenged		
Yes	15	10.56
No	101	71.13
Not up to school-going age	26	18.31
History of miscarriage		
had a miscarriage in the past	36	23.38
No miscarriage	118	76.62
Ever had chorioretinitis in the past		
Yes	57	28.36
No	144	71.64

(Data Source: Field Data, 2023)

4.2 Seroprevalence of *T. gondii* and other Diseases Screened during Routine ANC

In **Figure 4.1 & 4.2,** th**e** prevalence of *T. gondii* infection among the participants was 49.75%, of which 40.30%, 2.49%, and 6.97% tested positive for IgG, IgM, and IgG/IgM, respectively.

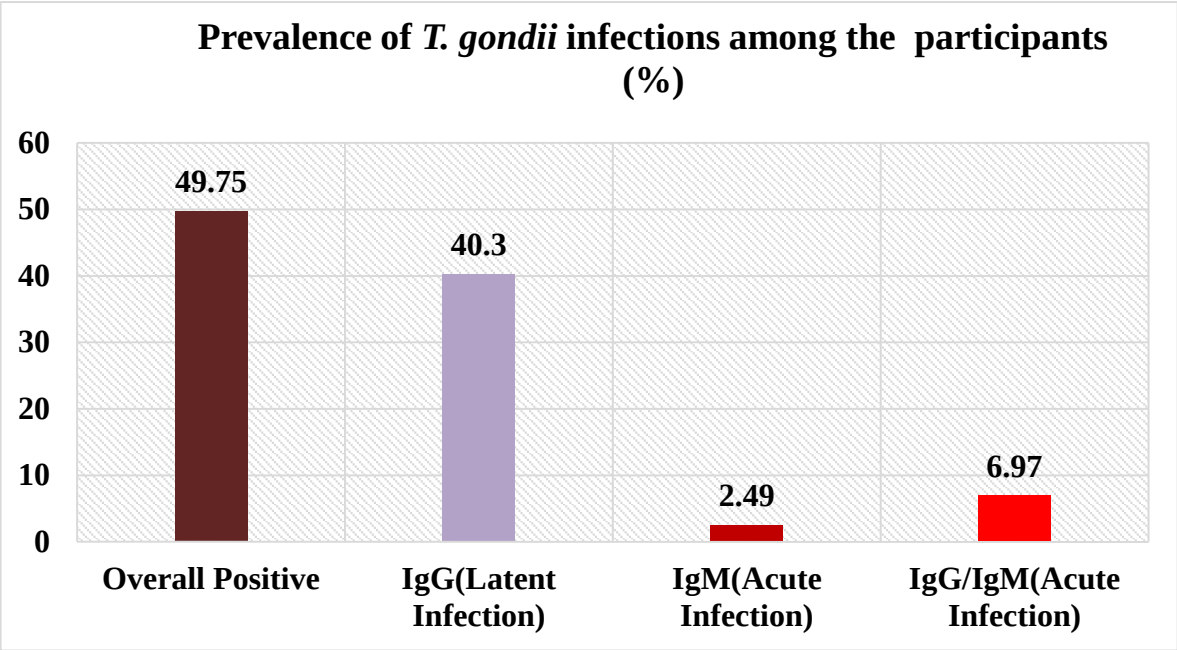


Figure 4.1 Seroprevalence *T. gondii*

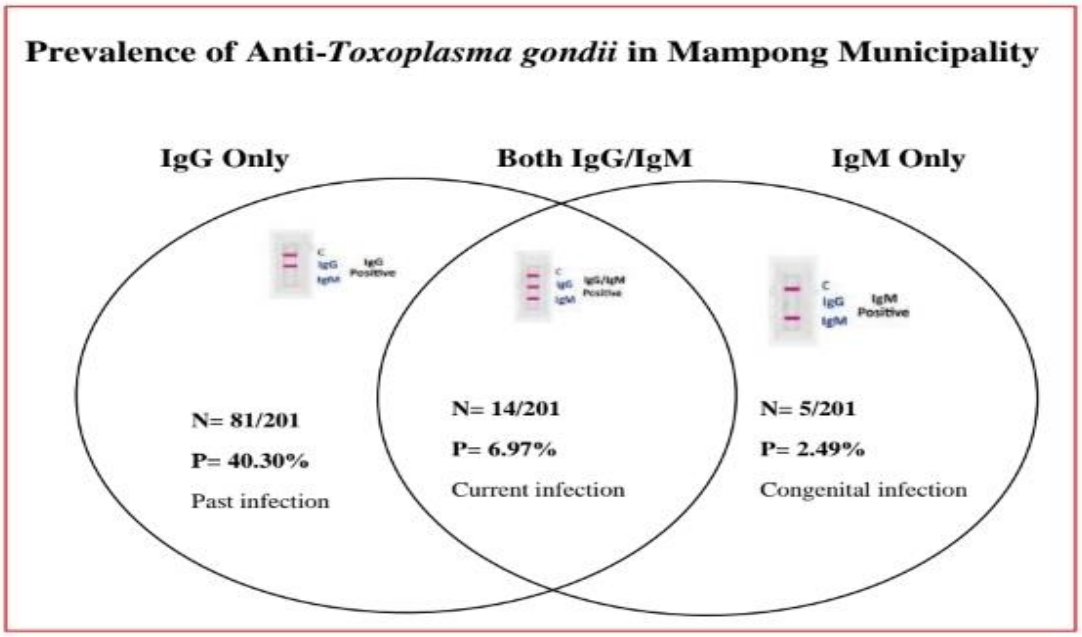


Figure 4.2: Prevalence of Anti-*T. gondii* in Mampong Municipality, Ghana

In **Table 4.3**, the prevalence of other diseases screened at the ANC was 14.61%, 0%, 0.61% and 3.07% for HBV, HCV, HIV and syphilis, respectively. There were variations in the sample sizes occasioned by the non-availability of routine screening tests at the ANC clinics for these routine ANC tests.

Table 4.3: Prevalence of *T. gondii* and other Diseases Screened at ANC

Variable	Frequency (N)	Percentage %
T. *gondii* test (N=201)		
Positive	100	49.75
Negative	101	50.25
Hepatitis B Test (N=178)		
Positive	26	14.61
Negative	152	85.39
Hepatitis C Test (N=41)		
Positive	0	0
Negative	41	100
HIV Test (N=165)		
Positive	1	0.61
Negative	164	99.39
Syphilis test (N=163)		
Positive	5	3.07
Negative	158	96.93

(Data Source: Laboratory records, 2023)
(Note: N= sample size for the individual test)

4.3 The Co-morbidity of Toxoplasmosis and other Diseases Screened at ANC

Table 4.4 shows toxoplasmosis co-infection with other diseases screened during ANC. The prevalence was 15%, 1%, and 4% with HBV, HIV and syphilis, respectively. However, bivariate and multivariate analysis did not show any statistically significant association between toxoplasmosis and the other diseases screened at ANC (**P-value > 0.05).**

Table 4.4: Co-morbidity of Toxoplasmosis and some Diseases Screened at ANC

Congenital Diseases	Toxoplasmosis Positive, N=100 (Co-morbidity Rate %)	X^2 (P-Value)
HBV Positive	**15(15.0)**	0.44 **(0.507)**
HIV Positive	**1(1.0)**	1.04 **(0.307)**
Syphilis Positive	**4(4.0)**	1.67 **(0.196)**

(Data Source: Laboratory records, 2023)

Note: Co-morbidity= (Number of positive for ANC diseases/Total number of positive for *T. gondii*) × 100%.

4.4 Association of *T. gondii* infection with sociodemographic characteristics of the study participants

Table 4.5 shows a significant association between the educational level and residential area of the study participants with *T. gondii* infection (χ^2=6.56, p=0.04) and (χ^2=10.97, p=0.004), respectively. Participants with tertiary education were less likely to be infected with *T. gondii* infections than those with the other level of education [AOR=0.39 (0.13 – 0.99) p=0.049]. Expectant mothers who reside in the peri-urban and urban areas were 0.13 and 0.10 times less likely to be seropositive of toxoplasmosis as compared with those residing in the rural areas [AOR=0.13 (0.02 –0.70) p=0.02; AOR=0.10 (0.02 – 0.78) p=0.03]. However, the chi-square test of independent analysis did not show any statistically significant association between toxoplasmosis and age, religion, housing type, or trimesters (**P-value > 0.05).**

Table 4.5: Association of *T. gondii* infection with sociodemographic characteristics of the study participants

Demographics	*T. gondii* Positive (%)	χ^2 (P- v)	COR (95%CI) p-v	AOR (95%CI) p-v
Age range				
15 to 19	18 (58.1)	1.71 (0.43)	Ref	Ref
20 to 30	49 (51.0)		0.68 (0.25, 1.34) 0.21	0.68 (0.26, 1.74)0.42
31to 49	33 (44.6)		0.77 (0.42, 1.42) 0.41	0.95 (0.47, 1.89)0.88
Religion				
Christians	89 (51.7)	1.89 (0.17)	Ref	Ref
Muslims	11 (37.9)		1.755 (0.78, 3.94) 0.17	2.1 (0.86, 5.26) 0.10
Education				
None	10 (55.6)	**6.56 (0.04)**	Ref	Ref
Primary	49 (47.6)		0.48 (0.16, 1.48) 0.20	0.39 (0.11, 1.30) 0.12
SHS	26 (65)		0.66(0.31, 1.40) 0.28	0.72 (0.33, 1.60) 0.42
Tertiary	15 (37.5)		0.32(0.13, 0.80) **0.015**	**0.39**(0.13, 0.99) **0.049**
Residential				
Rural	40 (67.8)	**10.97(0.04)**	Ref	Ref
Peri-urban	22 (44)		0.37 (0.17, 0.82) **0.013**	0.13 (0.02, 0.7) **0.02**
Urban	38 (41.3)		0.33 (0.17, 0.66) **0.02**	0.10 (0.02, 0.78) **0.03**
Trimester				
First	13 (52)	0.07 (0.97)	Ref	Ref
Second	34 (50)		1.12 (0.47, 2.69) 0.78	1.3 (0.51, 3.30) 0.58
Third	53 (49.1)		1.04 (0.57, 1.90) 0.91	1.1 (0.58, 2.12) 0.75
Gravidity				
Gravida I	25 (53.2)	1.14 (0.57)	Ref	Ref
Gravida II	25 (43.9)		1.46 (0.67, 3.16) 0.344	1.37 (0.54, 3.48) 0.50
>Gravida II	50 (51.5)		1.07 (0.53, 2.14) 0.85	0.99 (0.38, 2.62) 0.99

(Data Source: Laboratory records, 2023)

Note: *P-v = P-Value; Ref = reference; CI = confidence interval.*

4.5 The Transmission Risks of *T. gondii* infection among Pregnant Women in Mampong Municipality

4.5.1 Association between Consumption of animal products and *T. gondii* infection

Table 4.6 shows no statistically significant association between eating mutton, beef, raw meat, and drinking fresh milk from animal sources with the prevalence of toxoplasmosis among pregnant women in the Mampong Municipality (**P-value > 0.05).**

Table 4.6 Association between Consumption of animal products and *T. gondii* infection

Risk factors	*T. gondii* Test		χ^2 (P-value)
	Positive (%)	Negative (%)	
Which meat do you eat most?			
Mutton (sheep/goat)	20 (48.8)	21 (51.2)	
Beef	72(49.3)	74 (50.7)	0.33 (0.847)
Not applicable	8 (57.1)	6 (42.9)	
Consumption of meat			
Undercooked or raw	29 (53.7)	25 (46.3)	0.46 (0.497)
Well cooked	71(48.3)	76 (51.7)	
Drink or use unpasteurized milk for food			
Yes	26 (51)	25 (49)	0.04 (0.839)
No	74(49.3)	76 (50.7)	

(Data Source: Field Data and Laboratory records, 2023)

4.5.2 Association between Human-Animal Contact and *T. gondii* Infection

Table 4.7 Association between Human-Animal Contact and *T. gondii* Infection

Risk factors	*T. gondii* Test		χ^2 (P-value)	COR (95%CI) p-value	AOR (95%CI) p-value
	Positive (%)	Negative (%)			
Animal in household					
Yes	92 (58.6)	65 (41.4)	22.5 (0.001)	6.4 (2.78, 14.60) **0.001**	**3.9** (1.60, 9.48) **0.003**
No	8 (18.2)	36 (81.8)		Ref	Ref
Type of animals					
Pet (cat, dog, etc.)	51(56.7)	39 (43.3)		0.75 (0.29, 1.96) 0.55	0.96 (0.33, 2.81) 0.93
Poultry/birds	27(61.4)	17 (38.6)	0.5 (0.779)	0.91 (0.32, 2.62) 0.86	1.13 (0.35, 3.66) 0.84
Ruminant	14(63.6)	8 (36.4)		Ref	Ref
Level of confinement					
Extensive system	71(94.7)	4 (5.3)	92.1 (0.001)	166.9(42.6, 653.6)**0.001**	**431.7**(20.9, 8921.3) **0.001**
Semi-intensive	17(56.7)	13 (43.3)		12.3 (3.81, 39.65) **0.001**	**35.2** (3.37, 367.7) **0.003**
Intensive system	5(9.6)	47 (90.4)		Ref	Ref
Animal defecate					
Around compound	72 (60)	48 (40)		0.86 (0.24, 3.09) 0.81	0.47 (0.12, 1.89) 0.29
Animal pen or shelter house	14(53.8)	12 (46.2)	0.4 (0.807)	0.67 (0.16, 2.84) 0.58	0.54 (0.11, 2.67) 0.45
Don't know	7(63.6)	4 (36.2)		Ref	Ref
Contact with feces					
Yes	54(66.7)	27 (33.3)	11.9 (**0.001**)	3.4 (1.67, 6.78) **0.001**	**3.9** (1.81, 8.35) **0.001**
No	22(37.3)	37 (62.7)		Ref	Ref
Veterinary care					
Yes	22(50)	22 (50)		1.3 (0.47, 3.59) 0.61	1.4 (0.45, 4.10) 0.51
No	60(67.4)	29 (32.6)	6.37 (**0.041**)	2.7 (1.06, 6.86) **0.038**	**2.9** (1.10, 7.46) **0.031**
Don't know	10(43.5)	13 (56.5)		Ref	Ref
Cat in your house					
Yes	74(62.2)	45 (37.8)	2.14 (0.144)	1.7 (0.83, 3.65) 0.15	1.72 (0.74, 3.97) 0.21
No	18(48.6)	19 (51.4)		Ref	Ref
Gloves to handle feces					
Yes	2 (25)	6 (75)	14.7 (**0.001**)	0.07 (0.01, 0.38) **0.002**	**0.05** (0.002, 0.91) **0.043**
No	90(82.6)	19 (17.4)		Ref	Ref

(Data Source: Field Data and Laboratory records, 2023)

Note: Ref = reference; CI = confidence interval.

Table 4.7 shows that animal presence in households, level of confinement of the animals, human contact with animal faeces, lack of veterinary care of animals, and not wearing disposable gloves while handling animal faeces were significant risk factors contributing to toxoplasmosis among participants (χ^2=22.5, p< 0.001), (χ^2=92.1, p< 0.001), (χ^2=11.9, p=0.001), (χ^2=6.37, p=0.041) and (χ^2=14.7, p=0.001), respectively. Participants with animals in their households were 3.9 times more likely to be infected with *T. gondii* than those without animals in their households [AOR=3.90 (1.60 – 9.48) p=0.003]. Households with animals under extensive and semi-intensive system of keeping were 431.7 and 35.2 times more likely to contract toxoplasmosis as compared with intensive system [AOR=431.7 (20.90 –8921.3) p< 0.001; AOR=35.2 (3.37 – 367.70) p=0.003], respectively. Contact with animal faeces was 3.9 times more likely to be infected with *T. gondii* [AOR=3.90 (1.81 – 8.35) p=0.001]. Individuals in households with animals without veterinary care or vaccination were 2.9 times more likely to contract toxoplasmosis than those with vaccinated animals [AOR=2.90 (1.10 – 7.46) p=0.031]. Use of disposable gloves while handling the animals' faeces was 0.05 less likely to be infected with toxoplasmosis [AOR=0.05 (0.002– 0.91) p=0.043] compared with those without gloves.

4.5.3 Association between Sources of Water and Hygiene and *T. gondii* Infection

Table 4.8 shows that source of drinking water, not treating water before drinking, and animals drinking from the same water source as participants are the significant risk factors contributing to the high seroprevalence of toxoplasmosis among participants (χ^2=14.9, p= 0.002), (χ^2=6.3, p= 0.012) and (χ^2=7.9, p=0.005), respectively. Participants who indicated river/stream/well as their primary source of drinking water were 2.91 times more likely to be infected with *T. gondii* infections than other sources of drinking

water [AOR=2.91 (1.07 – 7.92) p=0.037]. Participants who treated water before drinking were 0.26 times less likely to be infected with *T. gondii* infection [AOR=0.26 (0.10 – 0.70) p=0.008].

Table 4.8 Association between Sources of Water and Hygiene and *T. gondii* Infection

Risk factors	*T. gondii* Test		X2 (P-value)	COR (95%CI) p-value	AOR (95%CI) p-value
	Positive (%)	Negative (%)			
Major source of drinking water					
Pipe	45(39.5)	69 (60.5)	14.9 (0.002)	0.61 (0.28, 1.34) 0.22	0.60 (0.27, 1.34) 0.21
Borehole	7(58.3)	5 (41.7)		1.3 (0.35, 5.01) 0.69	2.72 (0.60, 12.23) 0.19
River/stream/well	31(73.8)	11 (26.2)		2.7 (1.01, 6.99) **0.049**	2.91 (1.07, 7.92) **0.037**
Bottle/sachet water	17(51.5)	16 (48.5)		Ref	Ref
Treat water before drinking					
Yes	9(29)	22 (71)	6.3 (0.012)	0.36 (0.16, 0.82) **0.015**	0.26 (0.10, 0.70) **0.008**
No	91(53.5)	79 (46.5)		Ref	Ref
Animals drink direct from same water source					
Yes	19(76)	6 (24)	7.9 (0.005)	3.7(1.42, 9.74) **0.008**	2.2 (0.76, 6.40) 0.14
No	81(46)	95 (54)		Ref	
Wash fruit/vegetable before consumption					
Yes, always	76(50.7)	74 (49.3)	2.5 (0.288)	0.57 (0.18, 1.78) 0.33	0.92 (0.26, 3.20) 0.89
Sometimes	15(40.5)	22 (59.5)		0.38(0.11, 1.36) 0.14	0.62 (0.16, 2.49) 0.50
Rarely/never	9(64.3)	5 (35.7)		Ref	Ref

(Data Source: Field Data and Laboratory records, 2023)

Note: P-v = P-Value; Ref = reference; CI = confidence interval.

4.6 Association of toxoplasmosis and Health Indicators among Pregnant Women in the Mampong Municipality

Table 4.9 shows that pregnant women who have ever had a miscarriage are associated with high seropositivity of toxoplasmosis (χ^2=6.1, p= 0.014). Participants who indicated that they have ever had a miscarriage were 2.93 times more likely to be seropositive for toxoplasmosis than those who had never had a miscarriage [AOR=2.93 (1.20 – 7.04), p=0.016].

Table 4.9: Association of Toxoplasmosis and Health Indicators/Certain Outcomes among Pregnant Women in the Mampong Municipality

Variables	Toxoplasmosis Test		χ^2 (P-Value)	COR (95%CI) p-value	AOR (95%CI) p-value
	Positive (%)	Negative (%)			
Had a child with hearing loss					
Yes	1 (50)	1 (50)	0.00 (1.0)	1.0 (0.06, 16.3) 1.0	1.7 (0.10, 29.3) 0.72
No	70 (50)	70 (50)		Ref	Ref
Miscarriage history					
miscarriage in past	24 (66.7)	12 (33.3)	**6.1 (0.014)**	2.6 (1.20, 5.75) **0.016**	2.93 (1.2, 7.04) **0.016**
No miscarriage	51 (43.2)	67 (56.8)		Ref	Ref
Ever had chorioretinitis in the past					
Yes	34 (55.7)	27 (44.3)	1.26 (0.263)	1.4 (0.77, 2.58) 0.26	1.8 (0.82, 3.93) 0.14
No	66 (47.1)	74 (52.9)		Ref	Ref

(Data Source: Field Data and Laboratory records, 2023)

Note: Each of the responses above does not sum up to the total participants of the study, 201. This is due to the sensitive nature of the question, and it was made optional for the participants to choose to answer or not.

CHAPTER FIVE

DISCUSSION

5.0 Introduction

Physiological changes inherent to pregnancy induce immunosuppression in pregnant women, making them more susceptible to a spectrum of diseases. This augmented susceptibility is attributable to the body's innate response in prioritizing the protection and nurturing of the developing fetus, with the immune system reallocating resources accordingly. Moreover, it is imperative to perform comprehensive screenings for existing health conditions that might further undermine the maternal immune system during gestation. Routine medical examinations and screenings serve the purpose of detecting and managing latent health issues, ensuring the holistic well-being of maternal and fetal entities.

The study aimed to assess the current status of *Toxoplasma gondii* infection and co-infection with other diseases (HBV, HIV and syphilis) screened during routine ANC of pregnant women in the Mampong Municipality, Ghana. The key findings of the specific objectives are discussed in these thematic areas: seroprevalence of *T. gondii* and other diseases screened during routine ANC among pregnant women; co-infection of toxoplasmosis with other diseases screened during routine ANC among pregnant women; association of *T. gondii* infection on the sociodemographic characteristics of pregnant women; transmission risks of *T. gondii* infection and effects of toxoplasmosis in the study population.

5.1 Seroprevalence of *T. gondii* and other Diseases Screened During Routine ANC

5.1.1 Prevalence of *T. gondii*

The overall seroprevalence of *T. gondii* among pregnant women was 49.75%, consistent with previous studies in Ghana which reported between 50% to 56% seroprevalence of *T. gondii* infection among pregnant women in health facilities (Addo *et al.,* 2023; Agordzo *et al.,* 2019; Ayi *et al.,* 2016). Meanwhile, other studies in Ghana reported over 76% seroprevalence of *T. gondii* infection among pregnant women in hospitals (Ayi *et al.,* 2009; Blay *et al.,* 2015; Sefah-Boakye *et al.,* 2016). The seroprevalence in this current study, however, is much higher than previous studies in Ghana and Ethiopia which reported 21.5% (Singh *et al.,* 2021) and 35.6% (Teweldemedhin *et al.,* 2019) respectively. However, this seroprevalence is fairly similar to a study in Western Romania that reported 55.8% of pregnant women (Olariu *et al.,* 2020) but differ from a study in Brazil which reported a 71% prevalence among pregnant women (Rocha *et al.,* 2015).

The disparity in the prevalence of *T. gondii* infections reported in these studies could be attributed to several factors such as geographical areas, including cultural practices, levels of hygiene, exposure to environments contaminated with the *T. gondii* parasite, climate, dietary habits, and socio-economic conditions (Blaga *et al.,* 2019; Vueba *et al.,* 2020).This study has demonstrated that the presence of animals in households, their levels of confinement, exposure to their faeces, and veterinary care practices were significant risk factors for toxoplasmosis. It further showed that *T. gondii infection* was associated with the educational level and residential areas of the respondents (Dambrun *et al.,* 2022).

In this current study, 40.30% of participants tested positive for *T. gondii* IgG, which is an indication of previous infection or exposure to the parasite in the past. Meanwhile, 2.49% and 6.97% tested positive for IgM and both IgG and IgM, respectively. This further showed that nearly 10% of the study participants were currently infected with *T. gondii* parasites, of which about 3% were naïve immunity to the parasite and could more likely infect the unborn baby. This assertion is supported by other studies in Ghana (Agordzo *et al.,* 2019; Mensah *et al.,* 2019) which have reported IgM among pregnant women and is suggestive that in Ghana, there is a high risk of vertical transmission of *T. gondii* parasites with its attendance consequences (Agordzo *et al.,* 2019; Kwofie, 2012). Contrary to this, however, a study in Ethiopia that reported no IgM among pregnant women (Teweldemedhin *et al.,* 2019).

5.1.2 Prevalence of Hepatitis B Viral Infection

In this current study, the prevalence of hepatitis B infection among the participants was 14.61%. This rate is much higher than previous studies in Ghana which reported between 2.4% to 10.6% infections among pregnant women (Anabire *et al.,* 2019; Antuamwine *et al.,* 2022; Bobie *et al.,* 2022; Cho *et al.,* 2012; Dortey *et al.,* 2020; Ephraim *et al.,* 2015; Helegbe *et al.,* 2018; Kwadzokpui *et al.,* 2020; Luuse *et al.,* 2016). These disparities in HBV prevalences among pregnant women in Ghana could be attributed to the differences in the locations, cultural, and behavioural characteristics of the participants (Wakjira *et al.,* 2022).

The prevalence of HBV infection in this current study is twice as high as that of a systematic review in 2020, which reported 7.44% among pregnant women but was comparable with 14.30% among adolescents in Ghana (Abesig *et al.,* 2020).

Additionally, this value is higher than a national prevalence of 8.48% (Nartey *et al.,* 2022) and the national average of HBV infections of between 8.0% -12.0% in the general population (Abesig *et al.,* 2020; Nartey *et al.,* 2022). The high prevalence of HBV infections in this current study could be linked to the age of the participants, as most of them were between the ages of 15-49 years, which is a predictor of HBV positivity in Ghana (Nartey *et al.,* 2022).

Although Ghana initiated a national expanded program for hepatitis B immunization in 2002 (Abesig *et al.,* 2020) in response to the World Health Organization (WHO) target of eliminating HBV infection by 2030, this appears unattainable due to low awareness and knowledge of HBV infection in Ghana (Abdulai *et al.,* 2016; Dun-Dery *et al.,* 2017). Hepatitis B Virus infection is a significant public health challenge in Ghana, particularly among pregnant women, as evidenced by this current study relative to other studies which reported 9.5% in Nigeria (Ajuwon *et al.,* 2021) and 2.41% among blood donors in Pakistan (Mehmood *et al.,* 2020).

The high prevalence of HBV infections among pregnant women in this current study is suggestive of low uptake of HBV vaccine and presents a high risk of mother-to-child transmission (MTCT), which is the main route of HBV infection in Ghana. The main risks of HBV are attributable to sexual and other behavioural characteristics (Abesig *et al.,* 2020; Wakjira *et al.,* 2022). Therefore, it is imperative to enhance education efforts to raise awareness about HBV immunization and implement policies for free testing and vaccination to facilitate the eradication of HBV infection in Ghana.

5.1.3 Prevalence of HIV

In this current study, the prevalence of HIV among pregnant women was 0.61%, which is much lower than 1.89%, 1.91% and 1.66% reported in the Asante Mampong municipal, Ashanti region and the nationwide among the adult population, respectively (Ghana HIV fact sheet, 2022). The current study result is at variance with 2.8 % reported among pregnant women in the Asante Municipality in an HIV Sentinel survey (Ghana National AIDS Control Programme, Ghana Health Service 2019 Sentinel Survey). The low HIV prevalence in this current study could be attributable to several factors, including the small sample size, the duration of data collection, study sites, improvement implementation of HIV policies, etc. (Boah, Yeboah, Kpordoxah, Issah, & Adokiya. Although the prevalence of HIV in this current study is low compared to other previous studies reported in Ghana and other African countries, zero prevalence is the expected goal among mothers.

5.1.4 Prevalence of Syphilis

In this current study, the seroprevalence of syphilis was 3.07% among pregnant women at health facilities in the Asante Mampong municipality. This current result is fairly comparable to the 4.1% reported among pregnant women at the Cape Coast Metropolitan Hospital (Kwamena *et al.,* 2019) and 3.7% among gold miners in Konongo (Adjei *et al.,* 2014). This current result is higher compared to 0.4% previously reported in the general population at the national and in the Asante Mampong municipality (Ghana National AIDS Control Programme, Ghana Health Service 2019 Sentinel Survey). The syphilis result in this study was much higher compared to HIV in the same population, although both are sexually transmitted. However, it has been shown that HIV is predominant among urban dwellers, whereas syphilis is most

associated with rural residents (HSS 2015). What could have accounted for these distributions is not well defined. However, it is suspected that differences in access to healthcare services, education on prevention methods, number of sex workers, migration and stigma surrounding each disease may play a role in the varying prevalence rates between urban and rural populations.

The discrepancy in the prevalence may be attributed to several factors, including sexual behaviours, lifestyle factors, etc. Several studies have reported syphilis among pregnant women 2.5% in Tanzania (Manyahi *et al.,* 2015), 1.9% in Ethiopia (Yideg Yitbarek & Ayele, 2019) and 4.4% in Brazil (Benedetti *et al.,* 2019). The compulsory routine screening for syphilis among pregnant women, early detection and treatment, sex education, free voluntary testing, etc., is vital to prevent the progression of the disease and complications, especially among pregnant women and their babies.

5.2 The Co-infection of Toxoplasmosis and other Diseases Screened at ANC

Co-infections of toxoplasmosis with HBV, HIV, and syphilis screened at ANC were 15%, 1%, and 4% respectively. However, these diseases were not associated with toxoplasmosis (Safarpour *et al.,* 2020). This finding suggests that within the scope of this study, toxoplasmosis may not be linked to HBV, HIV, or syphilis infections. This findings may however be limited by the sample size and other potential confounding variables (Safarpour *et al.,* 2020).

Meanwhile, in related studies in Benin and Tanzania, toxoplasmosis was reported to decrease malaria incidence in pregnancy (Dambrun *et al.,* 2022) and increase death rates among people living with HIV (Mboera *et al.,* 2019). Other studies have

documented an association between toxoplasmosis and some diseases such as suicidal ideation among children (Sapmaz *et al.,* 2019). This study's findings highlight the need for large-scale studies to better understand the relationship between toxoplasmosis and other communicable diseases.

5.3 Association of *T. gondii* Infection With Sociodemographic Characteristics of the Study Participants

In this study, *T. gondii* infection was significantly associated with participants' educational level and residential area. Participants with tertiary education were 3 times more likely to be protected from the risks of *T. gondii* infections compared to other levels of education. This assertion is augmented by a study which showed that pregnant women with limited or no formal education exhibited heightened immunity relative to their counterparts with higher educational levels (Dambrun *et al.,* 2022). Individuals with tertiary education may have higher socioeconomic statuses and access health information and other resources, potentially reducing their risk of *T. gondii* infection. Factors such as hygiene practices, dietary habits, exposure to contaminated environments with *T. gondii* oocysts, etc., increase the risk of disease transmission across diverse populations (Marín-García *et al*., 2022; Thebault *et al.*, 2021). In this study, pregnant women residing in peri-urban and urban areas had at least an 85% reduced risk of getting toxoplasmosis compared to those residing in rural areas. This suggests that urban and peri-urban environments have typically improved sanitation and hygiene, social amenities, pets and animal husbandry practices, etc., compared with rural settings, thus reducing the risks of *T. gondii* infection. However, age, religion, housing type or trimesters in this study were not linked to toxoplasmosis, although age > 30 years was associated with *T. gondii* seropositivity (Deshmukh *et al.,* 2021).

5.4 The Transmission Risks of *T. gondii* Infection among Pregnant Women in Mampong Municipality

Animals in households, levels of confinement, exposure to their faeces, and veterinary care practices were significant risk factors for toxoplasmosis. The presence of animals in the participants' households increased their risk of *T. gondii* infection by 4 times, indicating that animals are hosts to *T. gondii* and can be transmitted to humans via direct contact with contaminated fur, saliva, or faeces (Udainiya *et al.,* 2024). This assertion is corroborated by previous studies that linked domesticated cats and dogs to an increased risk of *T. gondii* infections (Iddawela *et al.,* 2017; Opsteegh M., 2012). This study further revealed that extensive and semi-intensive systems of animal husbandry increase the risk of transmitting *T. gondii* infection by several folds compared to the intensive system. This suggests that animal-rearing systems could influence the transmission of *T. gondii* infections.

In extensive systems, animals might hunt or scavenge for food, which may potentially be infected with *T. gondii* and thus become infected themselves, whereas animals that are intensively managed may receive regular veterinary care. Meanwhile, the absence of veterinary care increases the risk of *T. gondii* by 3 times. These infected animals may contaminate the environment with their feces posing a risk to humans. Meanwhile, in this study, contact with animal faeces increased the risk of *T. gondii* infection 4 times. This implies that droppings and litter from animals in the environment coupled with poor hygiene practices can facilitate the transmission of *T. gondii* to humans (Deshmukh *et al.,* 2021). However, the use of personal protective equipment in handling animals' faeces highly reduced the risks of *T. gondi*i infection.

Consumption of animal products was not associated with toxoplasmosis, contrary to a study (Safarpour *et al.,* 2020) that linked the consumption of meat and other animal products to the infection (Ertug *et al.,* 2005). Also, drinking water sources were significant risk factors for toxoplasmosis, increasing risk by 3 times among the study participants akin to a study in Brazil by (Doline *et al.,* 2023) that linked toxoplasmosis with sources of drinking water. In this study area, residents of rural communities relied largely on rivers, streams, or wells, which are also used by livestock, contaminating them with their faeces that may harbour *T. gondii* oocysts. Thus, the usage of these water sources for drinking and domestic purposes may expose members of the communities to the tachyzoite and bradyzoite forms of the parasite which persist in water, increasing the likelihood of accidental ingestion. However, treating water before drinking decreases the risk of *T. gondii* infection by 26%. This study suggests that toxoplasmosis is significantly linked to water sources in this study area.

5.5 Association of Toxoplasmosis and Miscarriage among Pregnant Women in the Mampong Municipality

This study revealed that *T. gondii* infection was significantly associated with a higher risk of miscarriage among participants. Participants who were seropositive for toxoplasmosis had three times increased risk of having a miscarriage, linking toxoplasmosis with pregnancy outcomes. Pregnancy can alter a woman's immune response, making her more susceptible to *T. gondii* infection, which increases the risk of miscarriage. This assertion is augmented by several studies that linked *T. gondii* infection with spontaneous abortion (Kalantari *et al.,* 2021; Shojaee *et al.,* 2018; Zeinali *et al.,* 2023).

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

6.1 Introduction

This chapter presents a summary of the major findings of the study which assessed the current status of *Toxoplasma gondii* infection and co-infection with other diseases (HBV, HIV and syphilis) screened during routine ANC of pregnant women in the Mampong Municipality, Ghana. The chapter includes a summary of the research findings, study limitations, conclusions from the results obtained, and recommendations for further studies.

6.2 Summary of the Key Findings

The overall seroprevalence of *T. gondii* among pregnant women was 49.75%, with 40.30%, 2.49%, and 6.97% testing positive for *T. gondii* IgG, IgM, and IgG and IgM, respectively. Additionally, the prevalence of HBV, HIV, and syphilis infections among the participants was 14.61%, 0.61%, and 3.07%, respectively. Co-infections of toxoplasmosis with HBV, HIV, and syphilis screened at ANC were 57.7%, 100%, and 80%, respectively.

Notably, educational level and residential area were linked to *T. gondii* infection. The presence of animals in households, animal husbandry practices, hygiene and safety practices, veterinary services, and drinking untreated water were risk factors for *T. gondii* infection. Conversely, using personal protective equipment reduced the risk of

T. gondii infection. There was a relation between spontaneous abortion and *T. gondii* infection in the study population.

6.3 Study Limitation

Conceivably, relying on self-reported information from participants introduces the possibility of recall bias, as participants may selectively report information, leading to inaccuracies in the collected data. To help reduce this bias, participants were assured of strict confidentiality regarding the collected data, and their anonymity was guaranteed.

In addition, conducting the study solely within healthcare facilities with a smaller sample size and utilizing non-random techniques to recruit participants may limit the generalizability and accuracy of the findings to the broader population, making it difficult to draw inferences.

However, despite these limitations, the outcomes of this study were not affected. Therefore, the findings are very relevant for policymakers aiming to improve maternal and neonatal healthcare services.

6.4 Conclusion

The burden of toxoplasmosis among pregnant women in this study area was high, increasing the risk of *T. gondii* transmission to their fetuses. Although the prevalence of HBV and syphilis was very high, these were not linked to the transmission of *T. gondii*. Pregnant women with tertiary education and living in urban areas had a reduced risk of *T. gondii* infection. Risk factors such as the presence of animals in households with extensive/semi-intensive systems and poor veterinary care services, drinking water

from rivers/streams significantly influenced the transmission of toxoplasmosis. Infection with toxoplasmosis significantly increases the risk of miscarriage in pregnancy. Integration of toxoplasmosis into the routine ANC screening is critical to the prevention and control of pregnancy outcomes.

6.5 Recommendations

6.5.1 Government, Ministry of Health and Ghana Health Service

- Should integrate toxoplasmosis into the routine antenatal care services screening to prevent and control maternal and congenital transmission.

6.5.2 Municipal Health Directorate:

- Should immediately initiate community engagement to create awareness and educate the population on toxoplasmosis.

- Should provide potable water and advise community members to practice personal hygiene and treat water from rivers, streams and dams before drinking.

6.5.3 Healthcare Providers (Specifically Midwife Nurses):

- Should create awareness of toxoplasmosis transmission routes during community engagement and routine ANC services.

6.5.4 Municipal Veterinary Care officers

- Should collaborate with the health directorate to engage with the community and organize regular animal vaccination campaigns in households.

- ❖ Should advise pregnant women to avoid contact with livestock, particularly cats.

6.5.5 Future Research

- ❖ A study should be conducted purposely on congenital toxoplasmosis and co-morbidity with malaria by using multiple methods such as PCR, ELISA and microscopy, taking samples from the mother, newborn baby and umbilical cord.
- ❖ A study should be conducted to determine the prevalence of *T. gondii* occysts in soil, water, vegetables and fruits and the impacts of toxoplasmosis in the Mampong Municipality.

REFERENCES

Abdulai, M. A., Baiden, F., Adjei, G., & Owusu-Agyei, S. J. G. m. j. (2016). Low level of Hepatitis B knowledge and awareness among pregnant women in the Kintampo North Municipality: implications for effective disease control. *50*(3), 157-162.

Abesig, J., Chen, Y., Wang, H., Sompo, F. M., & Wu, I. X. J. P. o. (2020). Prevalence of viral hepatitis B in Ghana between 2015 and 2019: A systematic review and meta-analysis. *15*(6), e0234348.

Addo, S. O., Asare, T. O., Arthur, C., Amoateng, K., Addo, K., & Larbi, J. A. J. P. H. C. (2023). Toxoplasma gondii among pregnant women attending antenatal care in a district hospital in Ghana. *2*(2), e82.

Adem, D., Ame, M. J. J. o. B., & Sciences, B. (2023). Toxoplasmosis and its significance in public health: a review. *2*(1), 1-20.

Adjei, A. A., Brandful, J., Lurie, M., Lartey, M., Krampa, F., Kwara, A.,…Lawson, A. L. J. A. i. I. D. (2014). Human immunodeficiency virus, syphilis prevalence and risk factors among migrant workers in Konongo, Ghana. *2014*.

Adu, J., Mulay, S., & Owusu, M. F. J. P. A. M. J. (2021). Reducing maternal and child mortality in rural Ghana. *39*(1).

Adu, J., Owusu, M. F. J. T. I. J. o. H. P., & Management. (2023). How do we improve maternal and child health outcomes in Ghana? , *38*(4), 898-903.

Afzal, S., Abdullah, H. O., Saleem, H. A. R. J. P. J. A., & Wisdom. (2023). Sariah Rulings on Contagious Disease: An Analysis of HIV and AIDS Disease. *2*, 17.

Agordzo, S. K., Badu, K., Addo, M. G., Owusu, C. K., Mutala, A.-H., Tweneboah, A.,…Ayisi-Boateng, N. K. J. A. O. R. (2019). Seroprevalence, risk factors and impact of Toxoplasma gondii infection on haematological parameters in the Ashanti region of Ghana: a cross-sectional study. *2*.

Ahaduzzaman, M., Hasan, T. J. T., & Diseases, E. (2022). Seroprevalence of Toxoplasma gondii infection in sheep and goats from different geographical regions of the world: Systematic review and meta-analysis. *69*(6), 3790-3822.

Ahmad, I. J. H. m. (2016). Prevalence of hepatitis B and C viral infection among pregnant women in Peshawar, Pakistan. *16*(6).

Ajuwon, B. I., Yujuico, I., Roper, K., Richardson, A., Sheel, M., & Lidbury, B. A. J. B. i. d. (2021). Hepatitis B virus infection in Nigeria: a systematic review and meta-analysis of data published between 2010 and 2019. *21*, 1-15.

Algabbani, Q. (2023). Nanotechnology: A promising strategy for the control of parasitic infections. 108548.

Almashhadany, D. A., Alani, A. A. J., Dhiab, A. A., Zainel, M. A. M., & Abdulrahman, T. T. (2024). Public Health Significance of Human Toxoplasmosis.

Almeria, S., & Dubey, J. J. R. i. v. s. (2021). Foodborne transmission of Toxoplasma gondii infection in the last decade. An overview. *135*, 371-385.

Ameyaw, E. K. (2021). *Maternal referral systems in the northern region of Ghana*

Amissah-Reynolds, P. K. (2020a). Toxoplasmosis in Humans and Animals in Ghana (1962–2020): A Review.

Amissah-Reynolds, P. K. (2020b). Toxoplasmosis in Humans and Animals in Ghana (1962–2020): A Review. *International Journal of TROPICAL DISEASE & Health, 41(14)*. https://doi.org/10.9734/IJTDH/2020/v41i1430350

Anabire, N. G., Aryee, P. A., Abdul-Karim, A., Abdulai, I. B., Quaye, O., Awandare, G. A., & Helegbe, G. K. J. P. o. (2019). Prevalence of malaria and hepatitis B among pregnant women in Northern Ghana: comparing RDTs with PCR. *14*(2), e0210365.

Ani-Amponsah, M., Richter, S. J. O. J. o. R. N., & Care, H. (2021). Midwives' Experiences of Rural Maternal-Newborn Care in Ghana: A Phenomenological Inquiry. *21*(2), 84-116.

Antuamwine, B. B., Herchel, E. D., & Bawa, E. M. J. P. o. (2022). Comparative prevalence of hepatitis B virus infection among pregnant women accessing free maternal care in a tertiary hospital in Ghana. *17*(3), e0263651.

Arshad, H. M. (2022). Metabolomic profiling of the maternal foetal interface and developing foetus during Toxoplasma gondii infection.

Attias, M., Teixeira, D. E., Benchimol, M., Vommaro, R. C., Crepaldi, P. H., De Souza, W. J. P., & vectors. (2020). The life-cycle of Toxoplasma gondii reviewed using animations. *13*, 1-13.

Augusto, L., Martynowicz, J., Amin, P. H., Carlson, K. R., Wek, R. C., & Sullivan Jr, W. J. (2021). TgIF2K-B is an eIF2α kinase in Toxoplasma gondii that responds to oxidative stress and optimizes pathogenicity. *MBio*, *12*(1), e03160-03120.

Ayi, I., Edu, S., Apea-Kubi, K., Boamah, D., Bosompem, K., & Edoh, D. J. G. m. j. (2009). Sero-epidemiology of toxoplasmosis amongst pregnant women in the greater Accra region of Ghana. *43*(3).

Ayi, I., Sowah, A. O.-K., Blay, E. A., Suzuki, T., Ohta, N., Ayeh-Kumi, P. F. J. T. m., & health. (2016). Toxoplasma gondii infections among pregnant women, children and HIV-seropositive persons in Accra, Ghana. *44*, 1-8.

Bayo, P., Ochola, E., Oleo, C., & Mwaka, A. D. J. B. o. (2014). High prevalence of hepatitis B virus infection among pregnant women attending antenatal care: a cross-sectional study in two hospitals in northern Uganda. *4*(11), e005889.

Bekele, D. (2020). A review on the relationship between nutrition and health condition in humans. *Archives of nutrition and public health*, *3*.

Belluco, S., Simonato, G., Mancin, M., Pietrobelli, M., Ricci, A. J. C. r. i. f. s., & nutrition. (2018). Toxoplasma gondii infection and food consumption: a systematic review and meta-analysis of case-controlled studies. *58*(18), 3085-3096.

Benedetti, K. C. S. V., da Costa Ribeiro, A. D., de Sá Queiroz, J. H. F., Melo, A. B. D., Batista, R. B., Delgado, F. M.,…hygiene. (2019). High prevalence of syphilis and inadequate prenatal care in Brazilian pregnant women: a cross-sectional study. *101*(4), 761.

Bigna, J. J., Tochie, J. N., Tounouga, D. N., Bekolo, A. O., Ymele, N. S., Youda, E. L.,…Nansseu, J. R. J. S. R. (2020). Global, regional, and country seroprevalence of Toxoplasma gondii in pregnant women: a systematic review, modelling and meta-analysis. *10*(1), 12102.

Blaga, R., Aubert, D., Thébault, A., Perret, C., Geers, R., Thomas, M.,…Halos, L. J. P. (2019). Toxoplasma gondii in beef consumed in France: regional variation in seroprevalence and parasite isolation. *26*.

Blay, E. A., Ghansah, A., Otchere, J., Koku, R., Kwofie, K. D., Bimi, L.,…Ayi, I. J. P. i. (2015). Congenital toxoplasmosis and pregnancy malaria detection post-partum: Effective diagnosis and its implication for efficient management of congenital infection. *64*(6), 603-608.

Bobie, S. A., Afakorzi, S. H., & Manortey, S. (2022). Prevalence of Hepatitis B infections and associated risk factors among pregnant women at Hawa Memorial Saviour Hospital in the Abuakwa North Municipality, Ghana.

Bollani, L., Auriti, C., Achille, C., Garofoli, F., De Rose, D. U., Meroni, V.,…Tzialla, C. J. F. i. P. (2022). Congenital toxoplasmosis: the state of the art. *10*, 894573.

Cabieses, B., Sepúlveda, C., & Obach, A. (2020). Prevention of vertical transmission of HIV in international migrant women: Current scenario and challenges.

Cabral Monica, T., Evers, F., de Souza Lima Nino, B., Pinto-Ferreira, F., Breganó, J. W., Ragassi Urbano, M.,…diseases, e. (2022). Socioeconomic factors associated with infection by Toxoplasma gondii and Toxocara canis in children. *69*(3), 1589-1595.

Campbell, C., Wang, T., McNaughton, A. L., Barnes, E., & Matthews, P. C. J. J. o. v. h. (2021). Risk factors for the development of hepatocellular carcinoma (HCC) in chronic hepatitis B virus (HBV) infection: a systematic review and meta-analysis. *28*(3), 493-507.

Cardenas, M. C., Farnan, S., Hamel, B. L., Mejia Plazas, M. C., Sintim-Aboagye, E., Littlefield, D. R.,…Johnson, E. J. V. (2023). Prevention of the Vertical Transmission of HIV; A Recap of the Journey so Far. *15*(4), 849.

Chaudhry, S., Akinlusi, I., Shi, T., & Cervantes, J. J. V. (2023). Secondary syphilis: pathophysiology, clinical manifestations, and diagnostic testing. *2*(2), 65-75.

Cho, Y., Bonsu, G., Akoto-Ampaw, A., Nkrumah-Mills, G., Nimo, J. J., Park, J. K.,…liver. (2012). The prevalence and risk factors for hepatitis B surface Ag positivity in pregnant women in eastern region of Ghana. *6*(2), 235.

Cornil, V. (2024). *Syphilis*. BoD–Books on Demand.

Curcio, A. M., Shekhawat, P., Reynolds, A. S., & Thakur, K. T. J. H. o. c. n. (2020). Neurologic infections during pregnancy. *172*, 79-104.

Dadah, A. a. A., A. (2021). Prevalence of syphilis among pregnant women attending antenatal clinics in some hospitals within kaduna metropolis. . *16*(3), 195-198.

Daher, D., Shaghlil, A., Sobh, E., Hamie, M., Hassan, M. E., Moumneh, M. B.,…El Sabban, M. J. P. (2021). Comprehensive overview of Toxoplasma gondii-induced and associated diseases. *10*(11), 1351.

Dambrun, M., Dechavanne, C., Guigue, N., Briand, V., Candau, T., Fievet, N.,…Viwami, F. J. P. o. (2022). Retrospective study of toxoplasmosis prevalence in pregnant women in Benin and its relation with malaria. *17*(1), e0262018.

Deganich, M., Boudreaux, C., Benmerzouga, I. J. T. M., & Disease, I. (2022). Toxoplasmosis infection during pregnancy. *8*(1), 3.

Deshmukh, A. S., Hebbar, B. K., Mitra, P., Shinde, S., Chaudhari, S., & Barbuddhe, S. B. J. P. I. (2021). Seroprevalence and risk factors of Toxoplasma gondii infection among veterinary personnel and abattoir workers in Central India. *84*, 102402.

Doline, F. R., Farinhas, J. H., Biondo, L. M., de Oliveira, P. R. F., Rodrigues, N. J. L., Patrício, K. P.,…Giuffrida, R. J. O. H. (2023). Toxoplasma gondii exposure in Brazilian indigenous populations, their dogs, environment, and healthcare professionals. *16*, 100567.

Dortey, B. A., Anaba, E. A., Lassey, A., Damale, N., & Maya, E. T. J. P. o. (2020). Seroprevalence of Hepatitis B virus infection and associated factors among pregnant women at Korle-Bu Teaching Hospital, Ghana. *15*(4), e0232208.

Doudou, Y., Renaud, P., Jacqueline, F., Hypolite, S., Hypolite, M., Patrick, M.,…Van Geertruyden, J.-P. J. A. P. j. o. t. b. (2014). Toxoplasmosis among pregnant women: high seroprevalence and risk factors in Kinshasa, Democratic Republic of Congo. *4*(1), 69-74.

Dubey, J. P. J. P., & vectors. (2021). Outbreaks of clinical toxoplasmosis in humans: five decades of personal experience, perspectives and lessons learned. *14*(1), 263.

Dun-Dery, F., Adokiya, M. N., Walana, W., Yirkyio, E., & Ziem, J. B. J. B. I. D. (2017). Assessing the knowledge of expectant mothers on mother–to-child transmission of viral hepatitis B in Upper West region of Ghana. *17*, 1-10.

Dunay, I. R., Gajurel, K., Dhakal, R., Liesenfeld, O., & Montoya, J. G. J. C. m. r. (2018). Treatment of toxoplasmosis: historical perspective, animal models, and current clinical practice. *31*(4), 10.1128/cmr. 00057-00017.

El-Sayed, N. M., Ramadan, M. E. E., Masoud, N. G. J. F. S., & Perspectives, S. A. (2021). A step forward towards food safety from parasite infective agents. 807-832.

Elsheikha, H. M., Marra, C. M., & Zhu, X.-Q. J. C. m. r. (2020). Epidemiology, pathophysiology, diagnosis, and management of cerebral toxoplasmosis. *34*(1), 10.1128/cmr. 00115-00119.

Ephraim, R., Donko, I., Sakyi, S. A., Ampong, J., & Agbodjakey, H. J. A. h. s. (2015). Seroprevalence and risk factors of hepatitis B and hepatitis C infections among pregnant women in the Asante Akim North Municipality of the Ashanti region, Ghana; a cross sectional study. *15*(3), 709-713.

Ertug, S., Okyay, P., Turkmen, M., & Yuksel, H. J. B. p. h. (2005). Seroprevalence and risk factors for toxoplasmainfection among pregnant women in Aydin Province, Turkey. *5*(1), 1-6.

Esan, A., Omisakin, C., Ojo-Bola, T., Owoseni, M., Fasakin, K., & Ogunleye, A. J. A. J. B. R. (2014). Sero-prevalence of hepatitis B and hepatitis C virue co-infection among pregnant women in Nigeria. *2*(1), 11-15.

Evancare. (2024). *Evancar IVD Professor: TOXO Toxoplasma Ab IgM/IgG Rapid Test Cassette (WB/S/P):Specification:Test Procedure*. Evancare. Retrieved 24/07 from https://evancaremed.com/TOXO-Toxoplasma-Ab-IgM-IgG-Rapid-Test-Cassette-WB-S-P-PG7238081

Fikadu, B., Gebrish, S., Asfaw, T. J. J. o. M., & Sciences, M. (2019). Sero-prevalence of syphilis among pregnant women attending Antenatal Care Clinic at Jimma Univeristy specialized Hospital, Ethiopia. *10*(1), 1-5.

Frambo, A. A. B., Atashili, J., Fon, P. N., & Ndumbe, P. M. J. B. r. n. (2014). Prevalence of HBsAg and knowledge about hepatitis B in pregnancy in the Buea Health District, Cameroon: a cross-sectional study. *7*(1), 1-7.

Garweg, J. G., Kieffer, F., Mandelbrot, L., Peyron, F., & Wallon, M. J. P. (2022). Long-term outcomes in children with congenital toxoplasmosis—a systematic review. *11*(10), 1187.

Gebremedhin, E. Z., Tadesse, G. J. P., & Vectors. (2015). A meta-analysis of the prevalence of Toxoplasma gondii in animals and humans in Ethiopia. *8*, 1-9.

Ghenciu, L. A., Hațegan, O. A., Bolintineanu, S. L., Dănilă, A.-I., Iacob, R., Stoicescu, E. R.,…Olariu, T. R. J. M. (2024). Human Ocular Toxoplasmosis in Romania: History, Epidemiology, and Public Health: A Narrative Review. *12*(8), 1541.

Gómez-Chávez, F., Cañedo-Solares, I., Ortiz-Alegría, L. B., Flores-García, Y., Figueroa-Damián, R., Luna-Pastén, H.,…Bonilla-Ríos, C. A. J. F. i. i. (2020). A proinflammatory immune response might determine Toxoplasma gondii vertical transmission and severity of clinical features in congenitally infected newborns. *11*, 390.

Gomez-Marin, J. E., & de-la-Torre, A. (2020). Ocular disease due to Toxoplasma gondii. In *Toxoplasma gondii* (pp. 229-291). Elsevier.

GSS. (2020). population and housing census 2021: Ghana Statistical Service. https://doi.org/https://statsghana.gov.gh/gssmain/fileUpload/pressrelease/2021%20PHC%20General%20Report%20Vol%203A_Population%20of%20Regions%20and%20Districts_181121.pdf

GSS. (2021). 2021 Population and housing census, Ghana Statisrical Service.

Guegan, H., Robert-Gangneux, F. J. E. T. I. C. C., & Implications. (2020). Toxoplasma gondii in solid organ and stem cell transplant: prevention and treatment. 1-29.

Helegbe, G. K., Aryee, P. A., Mohammed, B. S., Wemakor, A., Kolbila, D., Abubakari, A.-W.,…Microbiology, M. (2018). Seroprevalence of malaria and hepatitis B coinfection among pregnant women in tamale metropolis of Ghana: a cross-sectional study. *2018*.

Hossain, M. S., Hatta, T., Labony, S. S., Kwofie, K. D., Kawada, H., Tsuji, N., & Alim, M. A. J. A. i. P. (2023). Food-and vector-borne parasitic zoonoses: Global burden and impacts. *120*, 87-136.

Hussen, S., & Tadesse, B. T. J. B. r. i. (2019). Prevalence of syphilis among pregnant women in sub-Saharan Africa: a systematic review and meta-analysis. *2019*.

Iddawela, D., Vithana, S. M. P., & Ratnayake, C. J. B. P. H. (2017). Seroprevalence of toxoplasmosis and risk factors of Toxoplasma gondii infection among pregnant women in Sri Lanka: a cross sectional study. *17*(1), 1-6.

Jash, S., & Sharma, S. J. P. (2022). Pathogenic infections during pregnancy and the consequences for fetal brain development. *11*(2), 193.

Jones, J. L., Parise, M. E., & Fiore, A. E. (2014). Neglected parasitic infections in the United States: toxoplasmosis. *The American journal of tropical medicine and hygiene*, *90*(5), 794.

Kalantari, N., Gorgani-Firouzjaee, T., Moulana, Z., Chehrazi, M., & Ghaffari, S. J. M. P. (2021). Toxoplasma gondii infection and spontaneous abortion: A systematic review and meta-analysis. *158*, 105070.

Kalogeropoulos, D., Sakkas, H., Mohammed, B., Vartholomatos, G., Malamos, K., Sreekantam, S.,…Kalogeropoulos, C. J. I. o. (2022). Ocular toxoplasmosis: a review of the current diagnostic and therapeutic approaches. *42*(1), 295-321.

Karakavuk, M., Can, H., Selim, N., Yeşilsiraz, B., Atlı, E., Şahar, E. A.,…Alan, N. J. T. J. o. I. i. D. C. (2021). Investigation of the role of stray cats for transmission of toxoplasmosis to humans and animals living in İzmir, Turkey. *15*(01), 155-162.

Karl, W., Lucille, P., Martin, L., Jeanne, S., Laurent, M., Isabelle, a. V., & Picone. (2022). Hygiene measures as primary prevention of toxoplasmosis during pregnancy: A systematic review. *51*(3), 102300.

Kordy, K., Tobin, N. H., & Aldrovandi, G. M. J. C. i. r. (2019). HIV and SIV in body fluids: From breast milk to the genitourinary tract. *15*(1), 139-152.

Kuruca, L., Belluco, S., Vieira-Pinto, M., Antic, D., & Blagojevic, B. J. F. C. (2023). Current control options and a way towards risk-based control of Toxoplasma gondii in the meat chain. *146*, 109556.

Kuugbee, E. D., Maaldu, G., Adamu, A., Salia, N., Walana, W., Kampo, S.,…Microbiology, M. (2023). Seroprevalence and Risk Factors of Sexually Transmitted Blood-Borne Infections among Pregnant Women Attending Antenatal Care in Jirapa, Upper West Region of Ghana. *2023*.

Kwadzokpui, P. K., Akorsu, E. E., Abaka-Yawson, A., Quarshie, S. S., Amankwah, S. A., & Tawiah, P. A. J. I. j. o. h. (2020). Prevalence and knowledge of hepatitis B virus infection among pregnant women in the Ningo-Prampram District, Ghana. *2020*.

Kwamena, A., Arthur, S., Bram, P., Baffe, C., Aglagoh, G., Rhodalyn, G., & Agyarko, E. J. J. o. D. (2019). A retrospective assessment of syphilis seroprevalence among pregnant women, cape coast, Ghana. *6*(2), 54-60.

Kwofie, K. D. (2012). *Risk of Mother-To-Child Transmission of Toxoplasma Gondii Infection among Pregnant Women in the Greater Accra Region*

Kwofie, K. D., Ghansah, A., Osei, J. H. N., Frempong, K. K., Obed, S., Frimpong, E. H.,…journal, c. h. (2016). Indication of risk of mother-to-child Toxoplasma gondii transmission in the Greater Accra Region of Ghana. *20*, 2581-2588.

Leeson, P. (2024). Ecosystem restoration and zoonotic disease risk in humans: an integrative literature review.

Liu, Y., & Liu, L. J. C. (2022). Changes in the epidemiology of hepatocellular carcinoma in Asia. *14*(18), 4473.

Luuse, A., Dassah, S., Lokpo, S., Ameke, L., Noagbe, M., Adatara, P.,…Binka, F. J. J. o. p. h. i. A. (2016). Sero-prevalence of Hepatitis B surface antigen amongst pregnant women attending an antenatal clinic, Volta region, Ghana. *7*(2).

Lyons, M. R., Arantes, T., Vieira, B. R., Furtado, J. M., & Smith, J. R. J. B. J. o. O. (2024). Impact of gender on clinical features and outcomes of ocular toxoplasmosis. *108*(5), 710-714.

Mampong-Municipal-Assembly, M. (2021). *Mampong Municipal assembly* https://www.ghanadistricts.com/Home/District/22

Mampong-Municipal-Health-Directorate. (2024). 2014 to 2023 ANC Records for MMHD, GHS, retreived on April 2024.

Manyahi, J., Jullu, B. S., Abuya, M. I., Juma, J., Ndayongeje, J., Kilama, B.,…Somi, G. J. B. p. h. (2015). Prevalence of HIV and syphilis infections among pregnant women attending antenatal clinics in Tanzania, 2011. *15*(1), 1-9.

Marín-García, P.-J., Planas, N., & Llobat, L. J. F. (2022). Toxoplasma gondii in foods: prevalence, control, and safety. *11*(16), 2542.

Mboera, L. E., Kishamawe, C., Kimario, E., & Rumisha, S. F. J. F. i. P. H. (2019). Mortality patterns of toxoplasmosis and its comorbidities in Tanzania: a 10-year retrospective hospital-based survey. *7*, 25.

Mehmood, S., Raza, H., Abid, F., Saeed, N., Rehman, H. M., Javed, S., & Khan, M. S. J. J. o. P. H. (2020). National prevalence rate of hepatitis B and C in Pakistan and its risk factors. *28*, 751-764.

Mensah, D. A., Debrah, L. B., Aryee, C. E., & DEBRAH, A. Y. Y. (2019). Seroprevalence and the associated risk factors of Toxoplasma gondii infection among pregnant women in the middle belt of Ghana.

Milne, G. C., Webster, J. P., & Walker, M. J. T. i. p. (2023). Is the incidence of congenital toxoplasmosis declining? , *39*(1), 26-37.

Montazeri, M., Mikaeili Galeh, T., Moosazadeh, M., Sarvi, S., Dodangeh, S., Javidnia, J.,…vectors. (2020). The global serological prevalence of Toxoplasma gondii in felids during the last five decades (1967–2017): a systematic review and meta-analysis. *13*, 1-10.

Nartey, Y. A., Okine, R., Seake-Kwawu, A., Ghartey, G., Asamoah, Y. K., Senya, K.,…Suglo, D. J. B. P. H. (2022). A nationwide cross-sectional review of in-hospital hepatitis B virus testing and disease burden estimation in Ghana, 2016-2021. *22*(1), 2149.

Nasiru Wana, M., Mohd Moklas, M. A., Watanabe, M., Nordin, N., Zasmy Unyah, N., Alhassan Abdullahi, S.,…health, p. (2020). A review on the prevalence of Toxoplasma gondii in humans and animals reported in Malaysia from 2008–2018. *17*(13), 4809.

Nyande, F. K., Ricks, E., Williams, M., & Jardien-Baboo, S. J. B. h. s. r. (2022). Socio-cultural barriers to the delivery and utilisation of child healthcare services in rural Ghana: a qualitative study. *22*(1), 289.

Obeagu, E., & Obeagu, G. J. E. J. o. M. S. (2024). Supporting Lymphatic Function: Blood Transfusions in HIV and the Immune System. *2*(9), 12-20.

Oladeinde, B. H., Omoregie, R., Olley, M., & Anunibe, J. A. J. N. A. j. o. m. s. (2011). Prevalence of HIV and anemia among pregnant women. *3*(12), 548.

Olariu, T. R., Ursoniu, S., Hotea, I., Dumitrascu, V., Anastasiu, D., Lupu, M. A. J. V.-B., & Diseases, Z. (2020). Seroprevalence and risk factors of Toxoplasma gondii infection in pregnant women from Western Romania. *20*(10), 763-767.

Opsteegh M., H. R., Swart A., Mensink-Beerepoot M., Hofhuis A., Langelaar M., & Van der Giessen. (2012). Seroprevalence and risk factors for Toxoplasma gondii infection in domestic cats in The Netherlands. .

Owusu-Dommey, A., Pogreba-Brown, K., & Villa-Zapata, L. J. P. i. (2020). Seroprevalence of Toxoplasma gondii in the US: evidence from a representative cross-sectional survey. *79*, 102175.

Pal, P., & Chetty, R. (2020). Infections. In *Muir's Textbook of Pathology* (pp. 527-564). CRC Press.

Picone, O., Fuchs, F., Benoist, G., Binquet, C., Kieffer, F., Wallon, M.,…reproduction, h. (2020). Toxoplasmosis screening during pregnancy in France: Opinion of an expert panel for the CNGOF. *49*(7), 101814.

Polanunu, N. F. A., Wahyuni, S., & Hamid, F. J. P. o. (2021). Seroprevalence and associated risk factors of Toxoplasma gondii infection among pregnant mother in Makassar, Indonesia. *16*(6), e0245572.

Purwoko, M. I. H., Devi, M., Nugroho, S. A., Fitriani, F., Pamudji, R., Candra, N. C. J. B. M. J. o. B., & Research, T. (2021). Laboratory examination of syphilis. *5*(8), 726-745.

Raheem, D., Dayoub, M., Birech, R., & Nakiyemba, A. (2021). The contribution of cereal grains to food security and sustainability in Africa: Potential application of UAV in Ghana, Nigeria, Uganda, and Namibia. *Urban Science, 5*(1), 8.

Rasheed, M., Riaz, A., Naz, G., Majeed, A., Akhter, N., Ashraf, K.,…Uroos, A. J. Z., Unique Scientific Publishers, Faisalabad, Pakistan. (2023). Role of cats in ecology and modeling of zoonotic diseases. *1*, 513-529.

Rocha, É. M. d., Lopes, C. W. G., Ramos, R. A. N., & Alves, L. C. J. R. d. S. B. d. M. T. (2015). Risk factors for Toxoplasma gondii infection among pregnant women from the State of Tocantins, Northern Brazil. *48*, 773-775.

Rostami, A., Riahi, S., Gamble, H., Fakhri, Y., Shiadeh, M. N., Danesh, M.,…Infection. (2020). Global prevalence of latent toxoplasmosis in pregnant women: a systematic review and meta-analysis. *26*(6), 673-683.

Safarpour, H., Cevik, M., Zarean, M., Barac, A., Hatam-Nahavandi, K., Rahimi, M. T.,…Shahrivar, F. J. A. (2020). Global status of Toxoplasma gondii infection and associated risk factors in people living with HIV. *34*(3), 469-474.

Sakr, M. (2023). Solid Swellings of the Anterior Triangle: Cervical Lymphadenopathy. In *Lateral Neck Swellings: Diagnostic and Therapeutic Challenges* (pp. 59-163). Springer.

Sapmaz, Ş. Y., Şen, S., Özkan, Y., & Kandemir, H. J. P. R. (2019). Relationship between Toxoplasma gondii seropositivity and depression in children and adolescents. *278*, 263-267.

Sarmah, H. K., Hazarika, B. B., & Choudhury, G. (2013). An investigation on effect of bias on determination of sample size on the basis of data related to the students of schools of Guwahati. *International Journal of Applied Mathematics & Statistical Sciences (IJAMSS)*, *2*(1), 33-48.

Satyaputra, F., Hendry, S., Braddick, M., Sivabalan, P., & Norton, R. J. J. o. c. m. (2021). The laboratory diagnosis of syphilis. *59*(10), 10.1128/jcm. 00100-00121.

Sefah-Boakye, J., Frimpong, E., Dompreh, A., & Turpin, A. J. I. J. M. A. I. (2016). Seroprevalence of Toxoplasma gondii Infection among Pregnant Women in the Ashanti Region of Ghana. *4*(1), 70-74.

Shapiro, K., Bahia-Oliveira, L., Dixon, B., Dumètre, A., de Wit, L. A., VanWormer, E.,…parasitology, w. (2019). Environmental transmission of Toxoplasma gondii: Oocysts in water, soil and food. *15*, e00049.

Sharma, R., Parker, S., Elkin, B., Mulders, R., Branigan, M., Pongracz, J.,…Jenkins, E. (2019). Risk factors and prevalence of antibodies for Toxoplasma gondii in diaphragmatic fluid in wolverines (Gulo gulo) from the Northwest Territories, Canada. *Food and Waterborne Parasitology*, *15*, e00056.

Shojaee, S., Teimouri, A., Keshavarz, H., Azami, S. J., & Nouri, S. J. B. i. d. (2018). The relation of secondary sex ratio and miscarriage history with Toxoplasma gondii infection. *18*, 1-6.

Simon, L., Fillaux, J., Guigon, A., Lavergne, R.-A., Villard, O., Villena, I.,…Pomares, C. J. P. (2020). Serological diagnosis of Toxoplasma gondii: analysis of false-positive IgG results and implications. *27*.

Singh, B., Debrah, L. B., Acheampong, G., Debrah, A. Y. J. I. D. i. O., & Gynecology. (2021). Seroprevalence and risk factors of toxoplasma gondii infection among pregnant women in Kumasi: a cross-sectional study at a district-level hospital, Ghana. *2021*.

Stull, J. W. (2021). Companion Animal Zoonoses in Immunocompromised and Other High-Risk Human Populations. In *Greene's Infectious Diseases of the Dog and Cat* (pp. 218-237). Elsevier.

Tarekegn, Z. S., Dejene, H., Addisu, A., & Dagnachew, S. J. P. N. T. D. (2020). Potential risk factors associated with seropositivity for Toxoplasma gondii among pregnant women and HIV infected individuals in Ethiopia: A systematic review and meta-analysis. *14*(12), e0008944.

Tavares, H. D. S., & Silva, G. R. d. (2020). Therapeutic alternatives for the treatment of ocular toxoplasmosis.

Teimouri, A., Mohtasebi, S., Kazemirad, E., & Keshavarz, H. J. J. o. c. m. (2020). Role of Toxoplasma gondii IgG avidity testing in discriminating between acute and chronic toxoplasmosis in pregnancy. *58*(9), 10.1128/jcm. 00505-00520.

Teweldemedhin, M., Gebremichael, A., Geberkirstos, G., Hadush, H., Gebrewahid, T., Asgedom, S. W.,…Gebreyesus, H. J. B. i. d. (2019). Seroprevalence and risk factors of Toxoplasma gondii among pregnant women in Adwa district, northern Ethiopia. *19*(1), 1-9.

Thebault, A., Kooh, P., Cadavez, V., Gonzales-Barron, U., & Villena, I. J. M. R. A. (2021). Risk factors for sporadic toxoplasmosis: a systematic review and meta-analysis. *17*, 100133.

Torgerson, P. R., & Mastroiacovo, P. (2013). The global burden of congenital toxoplasmosis: a systematic review. *Bulletin of the World Health Organization*, *91*, 501-508.

Trovato, E., Tognetti, L., Campoli, M., Cinotti, E., & Rubegni, P. J. D. (2021). Syphilis diagnosis and treatment: state of the art. 1-11.

Udainiya, S., Tiwari, A., Mishra, A., & Dubey, A. (2024). Zoonotic diseases of dogs and cats. In *Introduction to Diseases, Diagnosis, and Management of Dogs and Cats* (pp. 559-572). Elsevier.

Uku, A., Albujasim, Z., Dwivedi, T., Ladipo, Z., Konje, J. C. J. E. J. o. O., Gynecology, & Biology, R. (2021). Syphilis in pregnancy: The impact of “the Great Imitator”. *259*, 207-210.

Van der Colf, B. E. (2020). *Seroprevalence and incidence of Toxoplasma gondii, rubella and cytomegalovirus among Namibian women of childbearing potential* Stellenbosch: Stellenbosch University].

Vargas-Villavicencio, J. A., Cañedo-Solares, I., & Correa, D. J. M. (2022). Anti-Toxoplasma gondii IgM long persistence: what are the underlying mechanisms? , *10*(8), 1659.

Varsa, R. G., Gica, N., Demetrian, M., Ciobanu, A. M., Botezatu, R., Gica, C.,…Panaitescu, A. M. J. R. J. I. D. (2021). Toxoplasma gondii infection in pregnancy. *24*, 24-28.

Vueba, A. N., Faria, C. P., Almendra, R., Santana, P., & Sousa, M. d. C. J. P. o. (2020). Serological prevalence of toxoplasmosis in pregnant women in Luanda (Angola): Geospatial distribution and its association with socio-demographic and clinical-obstetric determinants. *15*(11), e0241908.

Wakjira, M., Darega, J., Oljira, H., Tura, M. R. J. C. E., & Health, G. (2022). Prevalence of hepatitis B virus and its associated factors among pregnant women attending antenatal care in Ambo town, Central Ethiopia: A cross-sectional study. *15*, 101054.

Wehbe, K., Pencole, L., Lhuaire, M., Sibiude, J., Mandelbrot, L., Villena, I., & Picone, O. (2022). Hygiene measures as primary prevention of toxoplasmosis during pregnancy: a systematic review. *Journal of Gynecology Obstetrics and Human Reproduction*, 102300.

Xu, F., Ma, X., Zhu, Y., Sutterland, A., Cheng, R., Miao, S.,…Zhou, Y. (2020). Effects of Toxoplasma gondii infection and schizophrenia comorbidity on serum lipid profile: A population retrospective study from Eastern China. *Microbial Pathogenesis, 149*, 104587.

Yan, C., Liang, L.-J., Zheng, K.-Y., Zhu, X.-Q. J. P., & vectors. (2016). Impact of environmental factors on the emergence, transmission and distribution of Toxoplasma gondii. *9*, 1-7.

Yideg Yitbarek, G., & Ayele, B. A. J. J. o. p. (2019). Prevalence of syphilis among pregnant women attending antenatal care clinic, Sede Muja District, South Gondar, Northwest Ethiopia. *2019*.

Zeinali, S., Khademvatan, S., Jafari, R., Vazifekhah, S., Yousefi, E., & Behroozi-Lak, T. J. P. o. (2023). Prevalence and risk factors of Toxoplasma gondii infection among women with miscarriage and their aborted fetuses in the northwest of Iran. *18*(10), e0283493.

Zhu, K., Liu, K., Huang, J., Weng, X., Chen, Q., Gao, T.,…Yang, G. (2022). Toxoplasma gondii infection as a risk factor for osteoporosis: a case–control study. *Parasites & Vectors*, *15*(1), 1-9.

APPENDICES

APPENDIX I: OTHER RESULTS

Table 3: prevalence of toxoplasmosis

Variables	frequency	Percentages %	X^2 (P-value)
T. *gondii* test			
Overall Positive	100	49.75	
IGG positive (Past Infection)	81	40.30	136.97 (< 0.001)
IGM positive (current Infection)	5	2.49	
Both Positive (current infection)	14	6.97	
Negative	101	50.25	

Table 4: Seroprevalence of toxoplasmosis against Démographiques /ANC diseases/risks factors

Religion	Toxoplasma gondii Test					X^2 (P-value)
	IGG positive (%)	IGM positive (%)	Both Positive (%)	Total positive (%)	Negative (%)	
Christian	75 (43.6)	4 (2.3)	10 (5.8)	89 (51.7)	83 (48.3)	6.570
Muslim	6 (20.7)	1 (3.4)	4 (13.8)	11 (37.9)	18 (62.1)	(0.087)

Chi-Square Test

Frequencies

Malaria Test

	Observed N	Expected N	Residual
Positive	16	67.0	-51.0
Negative	151	67.0	84.0
Not tested	34	67.0	-33.0
Total	201		

Hepatitis B virus Test

	Observed N	Expected N	Residual
Positive	26	67.0	-41.0
Negative	152	67.0	85.0
Not tested	23	67.0	-44.0
Total	201		

Hepatitis C virus Test

	Observed N	Expected N	Residual
Negative	41	100.5	-59.5
Not tested	160	100.5	59.5
Total	201		

HIV Test

	Observed N	Expected N	Residual
Positive	1	67.0	-66.0
Negative	164	67.0	97.0
Not tested	36	67.0	-31.0
Total	201		

Syphilis Test

	Observed N	Expected N	Residual
Positive	5	67.0	-62.0
Negative	158	67.0	91.0
Not Tested	38	67.0	-29.0
Total	201		

Sickling Test

	Observed N	Expected N	Residual
Positive	9	67.0	-58.0
Negative	142	67.0	75.0
Not Tested	50	67.0	-17.0
Total	201		

Test Statistics

	Malaria Test	Hepatitis B virus Test	Hepatitis C virus Test	HIV Test	Syphilis Test	Sickling Test
Chi-Square	160.388[a]	161.821[a]	70.453[b]	219.791[a]	193.522[a]	138.478[a]
df	2	2	1	2	2	2
Asymp. Sig.	.000	.000	.000	.000	.000	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 67.0.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 100.5.

APPENDIX II: QUESTIONNAIRES

PROJECT TITLE: THE CURRENT STATUS OF *TOXOPLASMA GONDII* INFECTION AND CO-MORBIDITY WITH INFECTIOUS DISEASES AMONG PREGNANT WOMEN IN THE MAMPONG MUNICIPALITY OF GHANA.

BY: ASSOAH EBENEZER

PROJECT WORK QUESTIONNAIRE (2023)

INTERVIEWER: INTRODUCTION AND CONSENT. May I begin the interview now?

Date of interview: …….

Location: ……

ID of interviewer: ……..

ID of respondent: ……..

NO	QUESTION AND FILTERS	CODING CATEGORY	SKIP
SECTION A: SOCIO-DEMOGRAPHIC CHARACTERISTICS **I want to start by asking you a few questions about yourself.**			
Q1	Please, how old are you?	15-19…….1 20-30…….……2 31-49…….……3	
Q2	What is your current marital status?	Single……...…….1 Married……...…...…….....2 Divorced……...……...……..…...3	

		Co-habitation…….…..…4	
Q3	What is your religious affiliation?	Christian……1 Muslim……..2 Traditional…….3 Atheist…….……..……4 Others……..…….…….5	
Q4	What is your highest level of education?	No formal education……..……..….1 Basic (primary & JHS).....2 SHS…….……..…..…..…….…....3 Tertiary……..……....4	
Q5	Indicate your employment status.	Employed……..1 Unemployed……..2	Q7
Q6	What is your main occupation?	Farmer……..1 Public servant……...…2 Food vendors…….……3 Traders ……...…….4 Others(specify)……..……..…….……5	
Q7	Location of Health facility.	Mampong Gov Hospt……..……..1 Calvary Hospt……...…2 Sist Philippa Health Centre……...…3 Kofiase Health Centre……..…..…..4 Asaam Health enter……..……5 Krobo Health Centre……..…….…….6	
Q8	Residential area status	Rural……..……..……1	

		Urban……..……..…2 Peri-Urban…….……..…….3	
Q9	Housing Typology	Compound House…….……...1 Apartments and Flats…….……...2 Semi-detached Houses……...……..3 Detached Houses…….……..4	

SECTION B: OTHER INFORMATION ON PARTICIPANTS'(MEDICAL HISTORY OR BACKGROUND)			
Q10	Gestation period	First trimester (0-12 weeks)……1 Second trimester (12-24 weeks)……..2 Third trimester (24-40 weeks)……....3	
Q11	Gravida/Number of previous pregnancies	Gravida I……..…..1 Gravida II..…….……...….2 ≥Gravida III……..……..……3	**Q17**
Q12	Parity/How many children do you have?	Parity 0……..…..1 Parity 1…..……..…...….2 Parity 2 to 5…….……3 Parity 6 to 0……...……..4	**Q16**
Q13	Do you have a child auditory infection?	Yes……...……..…..1 No……...….2	
Q15	Do you have a child/ren that is/are academically challenged?	Yes……..……..…..1 No.……...……...….2	

Q16	Do you ever have a miscarriage before?	Yes……...……..…..1 No.……...……...….2	
Q17	Do you experience/suffer from eye (chorioretinitis) defection currently or in the past?	Yes……..1 No.……..……...….2	

SECTION C: PARTICIPANTS' KNOWLEDGE OF TOXOPLASMOSIS (TRANSMISSION, EFFECTS, ETC)			
Q18	Do you hear of the disease toxoplasmosis before?	Yes……..1 No.……..……...….2	**Q21**
Q19	Do you know some of the risks of acquiring toxoplasmosis? (Multiple options: you can choose more than one option)	Contaminated water……1 Eat uncooked meat…….....2 Living with and getting close contact with pets/droppings……....3 Not yet……4	
Q20	Do you know of the preventive measures to reduce the risk of toxoplasmosis during pregnancy?	Yes……..…..…..1 No.……..…...….2	
Q21	Have you received any guidance or information from healthcare providers about toxoplasmosis during your pregnancy?	Yes……..…..…..1 No.……....….2	

Q22	Have you ever been tested for toxoplasmosis during your current pregnancy?	Yes……..……..…..1 No.……..……...….2	
Q23	Have you ever been diagnosed with toxoplasmosis in the past?	Yes……..……..…..1 No.……..……...….2	
Q24	How familiar are you with the transmission routes of toxoplasmosis?	Very familiar……...……1 Somewhat familiar……...……..2 Not familiar at all……..…….3	

SECTION D: POSSIBLE RISK FACTORS OF TOXOPLASMOSIS TRANSMISSION-<u>HUMAN ANIMAL CONTACT</u>			
Q25	Do you have any animals in or around the house?	Yes…….……..…..1 No.…….……...….2	**Q32**
Q26	What type of animals?	Pets (cats, dogs, etc.)..……..……...1 Poultry/birds…….……..……2 Ruminant…….……..…….…3	
Q27	Indicate the levels of confinements used for keeping these animals.	Intensive system…….....……1 Semi-intensive system…….....2 Extensive system……..…..3	
Q28	Where do these animals/pets often defecate?	Around the compound……..……..1 In their pen or shelter house…..……..2 Don't know…..……...3	

Q29	Do you ever have contact with these animals/faeces?	Yes…….……...…..1 No.…….……..…...….2 Rarely/Never…….…….…….3	
Q30	How do you often handle these animals' faeces/droppings?	Keep it in bins……...…….1 Burry it in the backyard immediately.…2 Sweep it every morning with the other waste……...3	
Q31	Do these animals need veterinary care (vaccination, drugs, etc.)?	Yes……..……1 No.…….....….2	**Q32**
Q32	How often do these animals receive veterinary care to your animals?	Every six months……..…..…1 Yearly ….…….……...…2 Rarely/Never……..…….3	
Q33	Are there cats in or around your house?	Yes……..…..…..1 No.……..……...….2	**Q37**
Q34	Do you put on disposable gloves when handling cat faeces?	Yes……..……..…..1 No.……...……...….2	
Q35	How do you temporarily manage the cat faeces?	Keep in a dedicated litter box before disposing of…….1 Keep it in bins…….……2 Burry it in the backyard immediately.…3	
Q36	Do you regularly clean the litter box/bins	Yes……..1 No……. .2	

Q37	How often do you clean the litter box?	Daily……1 Every other day…….……..2 Once a week……..……..3 Rarely/Never……..…….4	
Q38	How do you handle sick animals?	Take them to the vet…….…..1 Treat them myself……..2 I do nothing……3	
Q39	Do you wash your hands with detergents after handling sick animals or handling cats' faeces?	Yes……..……..…..1 No.……..……...….2 I do not handle sick animals……...3	
Q40	Do you wear gloves or take any precautions while handling soil or gardening?	Yes……..……..…..1 No.……..……...….2	

SECTION E: POSSIBLE RISK FACTORS OF TOXOPLASMOSIS TRANSMISSION-<u>CONSUMPTION OF ANIMAL PRODUCT</u>			
Q41	Which of the following meat do you eat? (Multiple Options: you can choose more than one option)	Beef…….……..…..1 Pork…….……...….2 Mutton(sheep/goat)…….3 Cat……...……4 None of the above……...……5	
Q42	Have you ever eaten any meat that you felt that wasn't well-	Yes, frequently……...……..1 Occasionally……..……..2	

	cooked? OR Do you consume raw or undercooked meat?	No, never……..……...3	
Q43	When was the last time you ate any of the meat above?	Days ago……...……...1 Weeks ago……..…….2 Months ago……..……3 Not at all……...……...4	
Q44	Do you drink or use fresh/unpasteurised milk from sheep/cattle for food?	Yes, always……..……..…..1 Yes, sometimes..……..…...….2 Not at all……..……3	

SECTION F: POSSIBLE RISK FACTORS OF TOXOPLASMOSIS TRANSMISSION- <u>WATER SOURCE & HYGIENE</u>			
Q45	Your source of drinking water?	Pipe……..…..1 Borehole…….…...….2 Well/dam…….……...3 River/stream…….……..4 Others (Bottle water, sachet water)……5	
Q46	Do you filter or treat the water before drinking?	Yes……..……..…..1 No.……..……...….2	
Q47	Do you use water from rivers/streams/well/dams/boreholes for bathing or cooking?	Yes……..……..…..1 No.……..……...….2	

Q48	Do animals also drink from the same source of water you use?	Yes……..……..…..1 No.……..……...….2	
Q49	Do you wash fruits and vegetables before you consume them?	Yes, always……1 Sometimes…..……..……..2 Rarely/Never..……..……..3	
Q50	Where do your kids play?	Cemented floor…….….1 Sandbox…….……2 Compound…….……3	

SECTION G: LABORATORY TESTS AND OTHER PARTICIPANTS' RECORDS (FROM PATIENT FOLDERS OR RECORD BOOKS)			
Q51	*Toxoplasma gondii* Test	IGG positive…...…….……...……1 IGM positive……..……..……..2 Both positive….……..…....…..3 Negative..……...4	
Q52	Malaria Test	Positive……,..…….……..….1 Negative……...……..…2 Not tested……...……3	
Q53	Hepatitis B Virus Test	Positive……...…….……..….1 Negative……...……..…2 Not tested……...……3	
Q54	Hepatitis C Virus Test	Positive……...…….……..….1 Negative……...……..…2	

		Not tested……..……3	
Q55	HIV Test	Positive……..…….……..….1 Negative……...……...…2 Not tested……...……3	
Q56	Syphilis Test	Positive……..…….……..….1 Negative……...……...…2 Not tested……...……3	
Q57	Hb range	Below11.5 g/dL (anemia)….……1 11.5 to 13.5 g/dL (normal)……..….……..2 Above 13.5 g/dL (hypoxia)……..….……..3	
Q58	RBC range	Below 2.72 X 10^{12}/L……..1 2.72 to 4.55 X 10^{12}/L…….2 Above 4.55 X10^{12}/L……..…….3	
Q59	WBC range	Below 4,500/ nm^3……..…1 4,500 to 11,000/nm^3 …….2 Above 11,000/nm^3……..……3	
Q60	Blood Group	A……1 B……2 AB…….3 O……4	