AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

VIRAL HEPATITIS B AND MALARIA CO-INFECTION AMONG PREGNANT WOMEN IN THE BONO EAST REGION OF GHANA

DENNIS BARDOE

MAY, 2025

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BY

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A thesis submitted to the Department of Public Health Education of the Faculty of Environment and Health Education, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development in partial fulfilment of the requirements for the award of a Master of Philosophy degree in Public Health.

MAY, 2025

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 at this university or elsewhere.

Candidate's Name: DENNIS BARDOE

Signature: …….. Date: 08/05/2025…….

Supervisors' Declaration

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

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ABSTRACT

Viral hepatitis B and malaria during pregnancy pose a significant risk. HBV and *Plasmodium* undergo certain developmental stages within the liver, and this has been linked with liver damage. Although some studies in the Bono East Region on HBV and malaria mono-infections provided valuable insights into these two infections, their co-infection during pregnancy has not been extensively explored. This study, therefore assessed the seroprevalence of HBV and malaria co-infection among pregnant women in the Bono East Region of Ghana. This multicentre health facility-based cross-sectional study employed the mixed method design to collect relevant data from 1430 pregnant women from seven health facilities. Serological screening, a closed-ended questionnaire, in-depth interviews (IDIs), and focus group discussions (FGDs) were used to collect relevant data. Quantitative data were analyzed using STATA 14. Descriptive statistics, Pearson's Chi-square tests, and logistic regression were performed as part of data analyses. The findings from the regression model were presented in crude and adjusted odds ratios at a 95% confidence interval. Qualitative data were analyzed using a four-step thematic analysis. The mean age of participants was 28.8 ± 3.73 years. The prevalence of HBV infection was 1.8%, while malaria infection stood at 10.8%. Co-infection with HBV and malaria was observed in 0.7% of the participants [95% CI: 0.37 – 1.29]. Among the co-infected, 6, 1, and 3 had high, moderate, and low malaria parasitemia, respectively. Blood transfusion, street nail trimming, residing closer to refuse dumping sites and closer to water bodies, being unmarried, having no formal education, primigravidae, and secundigravida were significantly associated with increased odds of co-infection. Barriers to adherence were linked to personal, psychological, and socio-cultural. Despite the relatively low prevalence, the identified determinants highlight the need for integrated antenatal screening protocols, targeted public health education, and policy-level interventions to reduce the dual burden of HBV and malaria among pregnant women and contribute to achieving maternal health targets under Sustainable Development Goal 3.

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DEDICATION

This thesis is dedicated to special people: my late father (Mr Mohammed Nuhu), my mother (Dorcas Adwoa Boatemaa), my wife (Mrs Ilham Abdul Ganiu), and finally, my children, whose understanding, sacrifices, encouragement, and prayers propelled me to this stage of the academic ladder.

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LIST OF ACRONYMS (ABBREVIATION) AND SYMBOLS

ANC	Antenatal Care
AOR	Adjusted Odds Ratio
CDC	Centres for Disease Control
CI	Confidence Interval
COR	Crude Odds Ratio
ccDNA	Covalently Closed Circular Deoxyribonucleic Acid
DNA	Deoxyribonucleic Acid
DOT	Directly Observed Therapy
EDTA	Di-Potassium Ethylenediaminetetraacetic Acid
Etc	Et Cetera
EPI	Expanded Immunisation Programme
FGDs	Focus Group Discussions
G6PD	Glucose-6-Phosphate Dehydrogenase
GDHS	Ghana Demographic and Health Survey
GDM	Gestational Diabetes Mellitus
GLSS6	Ghana Living Standards Survey Round 6
Hb	Haemoglobin
HBsAg	Hepatitis B Surface Antigen
HBV	Hepatitis B Virus
HIV	Human Immune Virus
IDIs	In-Depth Interviews
IPTp-SP	Intermittent Preventive Treatment in Pregnancy with Sulfadoxine-Pyrimethamine
IUFD	Intrauterine Foetal Death
LBW	Low-Birthweight
LLINs	Long-Lasting Insecticidal Nets
PHD	Pregnancy Hypertensive Disorders
PRTs	Pathogen Reduction Technologies
RTI	Reproductive Tract Infection
SB	Stillbirth
SDGs	Sustainable Development Goals
SOP	Standard Operating Procedure
SSA	Sub-Saharan Africa
UTIs	Urinary Tract Infections
WHO	World Health Organization
$\chi 2$	Chi-Square
%	Percentage
&	And
±	Plus, or minus sign
°C	Degree Celsius
/	Solidus
()	Parenthesis (bracket)

CHAPTER ONE

INTRODUCTION

This chapter presents the study's background and provides an overview of the research problem, objectives, questions, hypotheses, justification and significance, scope, limitations, and study organisation.

1.1. Background of the study

The United Nations pledged in the Sustainable Development Goal 3 (SDG 3.3) to end the epidemics of AIDS, tuberculosis, malaria, hepatitis, and other neglected tropical diseases by the year 2030 (United Nations, 2024). Some core strategies being implemented to help achieve SDG3.3 include awareness intensification, the right diagnoses and treatment, and effective immunisation programmes to reduce infections by 65%, especially in countries with moderate to high prevalence (Decouttere et al., 2021). Despite these interventions with some moderate gains, diseases such as viral hepatitis B (HBV) and malaria are still endemic in many countries, especially in sub-Saharan Africa, affecting children and pregnant women (Omatola & Okolo, 2021). The (re)emergence of these diseases, particularly in sub-Saharan Africa, could be attributed to a lack of awareness, mother-to-child transmission, horizontal transmission in early childhood, poor disease surveillance, and broken healthcare systems (Whiteside & Zebryk, 2017)

Hepatitis B Virus (HBV) infection is a viral disease that attacks the liver and can cause both acute and chronic conditions (Tripathi & Mousa, 2023). It is transmitted through contact with infected body fluids, including blood, semen, and vaginal fluids (di Filippo Villa & Navas, 2023; WHO, 2023b). Chronic HBV infection can lead to liver cirrhosis, liver cancer, and increased mortality (WHO, 2023b). Pregnant women with HBV

infection risk transmitting the virus to their newborns during childbirth, further perpetuating the cycle of infection (Tripathi & Mousa, 2023). Globally, over 2 billion people are infected with HBV, of which 296 million are chronic with 116 million and 81 million living in the Western Pacific and African regions, respectively (WHO, 2023b) resulting in the death of the most productive and youthful populations (WHO, 2023b). When acute HBV is untreated, it progresses to the chronic stage and serves as the primary reservoir for ongoing HBV transmission, especially in pregnancy (Zhao et al., 2021). In Ghana, the national prevalence of chronic HBV was estimated between 8.36% and 8.6% with a death toll of 3,118 (Coalition for Global Hepatitis Elimination, 2022; Sonderup & Spearman, 2022).

Malaria is a life-threatening disease caused by parasites of the genus *Plasmodium*, transmitted to humans through the bites of infected female *Anopheles* mosquitoes (Zekar & Sharman, 2024). Symptoms include fever, chills, headache, nausea, and in severe cases, organ failure or death (Ekpa et al., 2023). Pregnant women are particularly vulnerable to malaria due to immune system changes during pregnancy, increasing the risk of complications such as anaemia, low birth weight, and preterm delivery (Mirzohreh et al., 2022). As the world's most lethal vector-borne disease, is endemic in 104 tropical and subtropical countries in Africa, Central and South America, Asia, and Oceania (Mischlinger et al., 2020). In sub-Saharan Africa, an estimated 13.3 million pregnancies were exposed to malaria (WHO, 2022b), resulting in an estimated 961,000 low birth-weight children if no pregnancy-specific interventions were implemented (Mukala et al., 2024). Ghana is one of the 15 countries with the highest malaria burden in the world and is responsible for approximately 7% of malaria cases in West Africa (Orish et al., 2021).

HBV and malaria during pregnancy pose serious health risks, irrespective of transmission dynamics (Duri et al., 2023). In highly endemic areas, there are increasing trends of these infections, especially in the reproductive population cohort (Silk & Fefferman, 2021). Co-infection of HBV and malaria during pregnancy is likely to increase the incidence of adverse pregnancy and birth outcomes such as preterm birth, low birth weight, asphyxia, intrauterine foetal death and stillbirth (Liu et al., 2017). These consequences could be linked to the placental barrier breakdown and maternal blood leakage during delivery. Furthermore, mothers infected with HBV, even after delivery, could infect about 90% of their infants through breast milk (Perlman & Carusi, 2019), if no postexposure prophylaxis is administered (Hepatitis B Foundation, 2022).

The epidemiological trends of HBV and malaria mono-infections highlight the severity of these two diseases, and the burden could intensify in co-infection (Scotto & Fazio, 2018). This is due to the synergistic effect of the multiplication of the malaria parasite and the rapid progression of HBV infection (Omatola & Okolo, 2021) attributable to multifaceted dynamics within the liver (Anabire et al., et al., 2019). Earlier reports on the comorbidity of HBV with malaria were largely from the South American regions. For instance, a study conducted among 520 Brazilian miners who were exposed to malaria, showed that 431 (82.9%) were co-infected with HBV (Souto et al., 2001). Another study on 545 patients and 605 individuals with acute malaria found HBV prevalence of 4.2% and 3.3%, respectively (Braga et al., 2005, 2006). Likewise, a study among 636 individuals with acute and asymptomatic malaria revealed a 1.9% and 12.7% HBV co-infection, respectively (Andrade et al., 2011).

In sub-Saharan Africa, due to the high number of observed cases of mono-infections of HBV and malaria (Dortey et al., 2020; Kwadzokpui et al., 2020), some studies have

been conducted on the prevalence of co-infection of these diseases in the subregion too. In Nigeria, for instance, a study of 337 potential blood donors revealed an HBV and malaria co-infection rate of 40.67% (Aernan et al., 2011). In Ghana, a retrospective cohort study on 117 pre-transfusion samples revealed a comparatively higher prevalence of 59.2% HBV and malaria co-infection (Freimanis et al., 2012). Apart from these instances where HBV and malaria co-infection were reported among blood donors, some researchers have also explored the condition among pregnant women. To begin with, an earlier study reported a co-infection rate of 7.81% among 269 pregnant women (Omalu et al., 2012). Furthermore, another study on 200 patients in Nigeria revealed an HBV and malaria co-infection rate of 4.5% (Dabo et al., 2015a). In addition, a report on 200 blood samples from febrile patients showed a 5.5% HBV and malaria co-infection rate (Kolawole & Kana, 2018).

In Ghana too, before this research, only three studies focused on the comorbidity of HBV with malaria among pregnant women all of which were conducted in Northern Ghana. These studies revealed a prevalence of HBV and malaria co-infection of 0.7% (Helegbe et al., 2018), 1.7% (Anabire et al., 2019), and 16% (Asantewaa et al., 2023) among pregnant women. These remained the only available studies that have shared insight into HBV and malaria co-infection among pregnant women in Ghana.

1.2. Statement of the Problem

According to the 2017 Ghana Maternal Health Survey (GMHS), maternal deaths constitute 14% of all deaths in Ghana (Adu & Owusu, 2023). Of these, 10% result from direct maternal causes, while 4% are attributed to indirect maternal causes (Adu & Owusu, 2023). Direct maternal deaths make up 67.2% of all maternal fatalities, with indirect causes accounting for 27.3%, and 5.5% classified as unspecified maternal

causes (Ghana Statistical Service, 2018). The primary factors contributing to direct maternal deaths include obstetric haemorrhage (29.7%), hypertensive disorders such as pre-eclampsia and eclampsia (14.3%), infections (7.4%), pregnancy with abortive outcomes (7.1%), and other obstetric complications (8.7%) (Ghana Statistical Service, 2018). Specifically, the Bono East region mirrors these trends as the Ghana Demographic and Health Survey (GDHS) 2022 revealed an increasing trend of maternal (95 per 100,000 live births), neonatal (24 deaths per 1,000 live births), and infant (36 deaths per 1,000 live births) mortalities in the Bono East Region (GSS, 2024), higher than the national prevalences. Particularly for maternal mortality, the rate spiked to 107 for the entire year of 2023 (Ghana Health Service, 2023).

These trends could be attributed to the spread of a series of infectious diseases including viral hepatitis B (HBV) (Walana et al., 2014) and malaria (Bardoe et al., 2024). HBV and malaria mono-infections are particularly concerning, especially during pregnancy and the burden could worsen given co-infection. There are several interventions, such as HBV vaccination, uptake of IPTp-SP, and the use of LLINs to curb the HBV and malaria threat in Ghana. There are, however, still reported increasing trends of HBV and malaria co-infection among pregnant women in northern Ghana from a prevalence of 0.7% (Helegbe et al., 2018), to 1.7% (Anabire et al., 2019), and 16% (Asantewaa et al., 2023). Although some studies in the Bono East Region on HBV and malaria mono-infections in different settings provided valuable insights into the burden of these two infections (Dosoo et al., 2020; Abesig et al., 2020), the co-infection of these diseases during pregnancy has not been extensively explored. These epidemiological trends, burdens, and gaps in the literature necessitated a study to probe into the prevalence of HBV and malaria co-infection, related risk factors, socio-demographic predictors, and barriers to adherence to interventions among pregnant women in the Bono East Region.

This was not only a way of contributing literature but also to offer crucial insights into their vulnerability and associated risks.

1.3. Research objectives

The main aim of this study was to assess the prevalence and determinants of HBV and malaria co-infection among pregnant women in the Bono East Region of Ghana.

1.3.1. Specific Objectives

1. To determine the prevalence of HBV and malaria co-infection among pregnant women in the Bono East Region of Ghana.
2. To identify the risk factors for HBV and malaria co-infection among pregnant women in the Bono East Region of Ghana.
3. To examine the socio-demographic predictors of HBV and malaria co-infection among pregnant women in the Bono East Region of Ghana.
4. To explore the barriers to adherence to HBV and malaria interventions among pregnant women.

1.4. Research questions

1. What is the prevalence of HBV and malaria co-infection among pregnant women in the Bono East Region?
2. What risk factors are associated with HBV and malaria co-infection among pregnant women in the Bono East Region of Ghana?
3. What are the socio-demographic predictors of HBV and malaria co-infection among pregnant women in the Bono East Region of Ghana?
4. What are the barriers to adherence to HBV and malaria interventions among pregnant women in the Bono East Region of Ghana?

1.5. Hypothesis of the study

Null Hypothesis (H_0): There is no statistically significant difference between the proportion of pregnant women who are co-infected with HBV and malaria and those who are not co-infected.

Alternative Hypothesis (H_1): There is a statistically significant difference between the proportion of pregnant women who are co-infected with HBV and malaria and those who are not co-infected.

1.6. Justification of the study

In the Bono East Region, both HBV and malaria are major public health burdens (Bardoe et al., 2025), attributable to the spread of drug-resistant etiologic strains, poor sanitation systems, poor health behaviour, and the detrimental economic status of exposed populations (Denissen et al., 2022). The region also has unique socio-economic, environmental, and climatic factors that could influence the prevalence and severity of HBV and malaria and their comorbidity. The region is mostly made up of rural communities inhabited by various ethnic groups (Ghana Statistical Service, 2021b). Due to the region's notable agricultural and retail activities throughout the year, buyers and suppliers from other parts of the country consistently travel to and from the region to earn a living (Ghana Statistical Service, 2021b). These factors significantly contribute to an increased human population, especially during the year when there is a bumper harvest of produce such as yam, cassava, smoked fish, and vegetables. This socioeconomic situation could facilitate the transmission of communicable diseases.

In addition, the region is located within the forest-savannah transitional ecological zone in the middle belt of Ghana. It experiences a double rainfall pattern, averaging 1399.5 mm per year, with average monthly temperatures ranging between 22°C and 33°C (Yamba et al., 2023). The major rainfall season typically occurs from March to June, while the minor season spans from September to November (Awine et al., 2018). These

periods correspond to two peaks in malaria transmission (Awine et al., 2018). Likewise, the region has abundant land and vegetation cover (savannah, tropical forest, and mangrove and swampy areas) with several rivers and streams (Yamba et al., 2023). The abundant land and vegetation, combined with the rainfall pattern and warm temperatures, create convenient conditions for the breeding of female *Anopheles* mosquitoes, thereby increasing malaria transmission in the region (Mohammed et al., 2022). The predominant mosquito vectors distributed throughout the region are *Anopheles gambiae*, *An. arabiensis* and *An. funestus* (Akuamoah-Boateng et al., 2021).

As a region in the heart of the country, these dynamics have enormous public health implications, as emergencies that occur anywhere in the country or the sub-region could spread to the region and vice versa (Ghana Health Service, 2023). Although several initiatives have been taken to substantially reduce the burden of HBV and malaria in the Bono East Region. Despite these control efforts, several barriers are likely to exist which could facilitate the transmissions of HBV and malaria mono-or co-infection (Bardoe et al., 2025). Prior to this current study, there was a paucity of empirical data on HBV and malaria co-infection among pregnant women in the region. Meanwhile, ensuring the health and well-being of pregnant women and their infants is critical in promoting maternal and child health and reducing health disparities. Such a gap necessitates the development of effective interventions geared towards reducing these disparities. Without accurate local data, which the current study sought to generate, it would be challenging to design and implement targeted healthcare interventions that address such needs. By determining the prevalence, risk factors, and socio-demographic predictors of HBV and malaria co-infection, the study has contributed to policy formulation and healthcare planning, ultimately improving maternal and neonatal health outcomes in the Bono East Region. Furthermore, exploring barriers to intervention adherence will aid

stakeholders in designing culturally sensitive and socio-economically feasible health programs tailored to the region and beyond.

1.7. Significance of the study

HBV and malaria infections during pregnancy could lead to a range of negative outcomes for both mothers and newborns. This study has filled a crucial knowledge gap by investigating the prevalence of HBV and malaria co-infection, identifying risk factors, and socio-demographic predictors, and exploring the barriers to adherence to interventions. This study has also provided valuable insight for stakeholders to implement practical measures and other preventive measures, all geared to address the maternal and neonatal health challenges specific to the region.

1.8. Scope of the study

The study was limited to the Bono East Region with a focus on the examination of the prevalence, risk factors, predictors, and barriers to adherence to prevention of HBV and malaria among pregnant women, considering its unique environmental, climatic, and socio-economic factors. The study was conducted from September 2023 to June 2024. The Health Belief Model (HBM) was used to understand and predict the possible reasons for non-adherence to HBV and malaria interventions.

1.9. Limitation of the study

The study targeted pregnant women attending ANC in the municipal or district health facilities excluding the private health facilities. Furthermore, the cross-sectional design limits the ability to infer causality between identified barriers and adherence to HBV and malaria interventions. Finally, the qualitative data is inherently subjective and may be influenced by the participants' prior conception. Notwithstanding these limitations,

the findings of this study provided valuable insight for policy consideration and have contributed significantly to the literature.

1.10. Organization of the study.

This study is organised into six chapters. The first chapter (Chapter One) introduced the study. The second chapter (Chapter Two) reviewed relevant literature on HBV and malaria based on the study's objectives. The third chapter (Chapter Three) presents the research methodology used in this study. The fourth chapter (Chapter Four) presents and describes the study's key findings. The fifth chapter (Chapter Five) discusses the study's results based on the objectives and existing literature, and the theoretical framework underpinning the study. Finally, the sixth chapter (Chapter Six) summarises key findings, recommendations, and conclusions.

CHAPTER TWO

REVIEW OF RELEVANT LITERATURE

2.0. Introduction

This chapter reviews scholarly materials on key concepts relevant to this study. A series of databases, including Google Scholar, PubMed, Embase, Scopus, Web of Science, and others, were searched for relevant literature. Keywords used in the literature search included hepatitis B virus (HBV), malaria, pathophysiology, epidemiology, prevalence, and risk factors. Concepts and theories underpinning the topic, empirical evidence, transmission and risk factors, socio-demographic predictors, and barriers to adherence to intervention were also reviewed. This chapter concludes with the theoretical and conceptual framework on which the study was built.

2.1. Conceptual review

This section describes the concepts used in the study. These concepts include the pathophysiology of HBV and malaria, HBV and malaria co-infection, transmission, and risk factors.

2.1.1. Pathophysiology of hepatitis B virus and malaria

2.1.1.1. Hepatitis B virus (HBV)

The hepatitis B virus (HBV) belongs to the *Hepadnavirus* family and was first identified in the 1960s (Hepatitis B Foundation, 2022; Karayiannis, 2017). Viruses from this family preferentially infect liver cells (hepatocytes) (Hu, 2019). HBV's pathogenesis and clinical manifestations result from the virus and host immune system interaction. This interaction could eventually lead to liver injury and, if left unchecked, could advance to cirrhosis and hepatocellular carcinoma (Nevola et al., 2023). The onset of infection is characterised by clinical symptoms including, loss of appetite, fatigue, mild

fever, muscle and joint aches, nausea and vomiting, yellow skin and eyes, dark urine due to jaundice, swollen stomach or ankles, easy bruising, stomach ache, diarrhoea, and light-coloured stools (Pyrsopoulos, 2022).

After infection, HBV attaches itself to a receptor at the surface of liver cells. After a successful entry into the cell of the liver, a biosynthesis phase is initiated to ensure that the viral DNA takes control of the host cell nucleus (Clark et al., 2021). The viral DNA is then transcribed into a covalently closed circular DNA (cccDNA), which serves as a template for further viral replication. (Diogo Dias et al., 2021). This viral cccDNA is then translated into the viral core and surface proteins in the host cell cytoplasm, where reverse transcription is initiated to create several identical summits of the viral genome inside the core (Diogo Dias et al., 2021). This earmarks the maturational stage of the viral summits where they assume a destruction function, making them fully pathogenic to infect another hepatocyte (Jiang & Hildt, 2020). Neither the replication of HBV within the liver cells nor their release to other uninfected cells directly kills the infected liver cells. Instead, liver damage is because of the body's immune response to the infection (Jiang & Hildt, 2020).

2.1.1.2. Malaria

Malaria is a disease whose pathogen is a protozoan parasite of the genus *Plasmodium*. The five species of *Plasmodium* which are responsible for human malaria are *P. malariae, P. ovale, P. vivax, P. falciparum* and *P. knowlesi*, with *P. falciparum* being the deadliest (Zekar & Sharman, 2024). Although malaria is transmissible from person to person through blood transfusion (Niederhauser & Galel, 2022) and through congenital transmission from a mother to a baby (Nwaneli et al., 2022), the disease is predominantly transmitted through the bites of female *Anopheles* mosquitoes

(Pulvirenti et al., 2021). By biting the human host, the female *Anopheles* mosquito transmits sporozoites into the host's bloodstream (Arora et al., 2023). Within thirty minutes, the sporozoites exit the bloodstream and enter the liver's parenchyma cells, where they initiate a cycle of schizogony that results in the production of a massive, unpigmented schizont (Arora et al., 2023). Through a receptor-ligand-mediated process, thousands of infectious merozoites are released into the bloodstream and invade the erythrocytes (Arora et al., 2023). The merozoites intimately attach themselves to the erythrocyte, and by invagination of the erythrocyte membrane, they enter the cytoplasm and eventually live within the parasitophorous vacuole (Keller et al., 2022).

However, a tiny percentage of merozoites follow a different developmental pathway that results in a transmissible form called gametocyte (Arora et al., 2023; Wiser, 2023). Long-lived non-dividing gametocytes circulate in the bloodstream, awaiting uptake by female *Anopheles* in a blood meal. Within the female *Anopheles* mosquito midgut, the male gametocyte called microgametocyte undergoes rapid nuclear division, producing eight flagellated microgametes in 10-15 minutes (Talman et al., 2020). The microgamete fertilises the female macrogamete to produce an immobile zygote and then a motile ookinete, which invades the midgut epithelium, thereby infecting the mosquito (Ararat-Sarria et al., 2020). The active ookinetes then differentiate into oocysts under the basal lamina of the midgut epithelium during a period of plain latency lasting approximately 10 days, during which approximately 10,000 sporozoites are produced (Nakayama et al., 2021). The oocysts then rupture and discharge the sporozoites into the mosquito's body cavity, where they migrate to infect the salivary glands (Pathak et al., 2022).

2.1.2. Laboratory diagnosis of hepatitis B virus (HBV) and malaria

2.1.2.1. Hepatitis B virus (HBV)

The laboratory diagnosis of multiple viral antigens and corresponding antibodies is essential for the effective management and treatment of HBV (Pantaleo et al., 2022). Various diagnostic methods are used to detect HBV, each with advantages and limitations. Serologic testing with rapid diagnostic tests (RDTs) is a cornerstone of HBV diagnosis. The HBV Surface Antigen (HBsAg) test detects the presence of HBV antigens, indicating an active infection (Chevaliez et al., 2021). It is widely used as an initial screening tool. However, it cannot distinguish between acute and chronic infections and may miss low-level infections, leading to false negatives (Jeng et al., 2023). In addition, molecular techniques offer advanced diagnostic capabilities (Ortonne et al., 2021). Polymerase Chain Reaction (PCR) and Quantitative PCR (qPCR) detect and quantify HBV DNA with high sensitivity and specificity, crucial for monitoring viral load and treatment response (Ortonne et al., 2021). However, these methods are costly and require specialized equipment, limiting their accessibility in resource-limited settings (Abu et al., 2023).

2.1.2.2. Malaria

The microscopic detection and identification of *Plasmodium* species in Giemsa-stained thick blood films (for screening) and thin blood films (for species confirmation) remain the gold standard for malaria diagnosis (Gitta & Kilian, 2020). This method involves staining blood films on glass slides to visualize malaria parasites (Gitta & Kilian, 2020). Though the gold standard, microscopic detection of malaria is labour-intensive, time-consuming, and requires significant expertise (Slater et al., 2022). In addition, the quantitative buffy coat (QBC) technique enhances malaria diagnosis by staining parasite DNA with fluorescent dyes and detecting it via epi-fluorescent microscopy (Calderaro

et al., 2021). The QBC technique offers rapid and sensitive malaria diagnosis, especially for *P. falciparum*, but has reduced sensitivity for non-falciparum species and lower specificity due to leukocyte DNA staining (Calderaro et al., 2021). However, QBC requires specialized equipment, is costlier than light microscopy, and is less effective at determining parasite species and counts (Maturana et al., 2022).

Unlike conventional microscopic diagnosis and the QBC technique, rapid diagnostic tests (RDTs) detect malaria antigens in blood using a membrane with specific anti-malaria antibodies and do not require laboratory equipment (Kavanaugh et al., 2021). They extend parasite-based diagnosis beyond light microscopy, offering significant benefits in remote malaria-endemic areas (Slater et al., 2022). Despite generally excellent performance, some reports show varied sensitivity in these areas (Shankar et al., 2021). Finally, new laboratory techniques, such as PCR, loop-mediated isothermal amplification (LAMP), microarray, mass spectrometry (MS), and flow cytometric (FCM) assays, offer high sensitivity and specificity (Jang et al., 2024). However, their complexity, high cost, and need for specialized training limit their use in developing countries (Madadelahi et al., 2024).

2.2. Empirical review

2.2.1. Epidemiology of hepatitis B virus (HBV) infection

2.2.1.1. Global epidemiology

Hepatitis B virus (HBV) infection is a major public health concern, with a global seroprevalence of 5.8% (Olaru et al., 2023). According to the World Health Organisation (WHO), over two billion people are infected with HBV, of which 296 million are chronic (WHO, 2023b). The global distribution of this infection exhibited significant variations. In low-prevalence regions such as the United States, Canada, and Western Europe, the

prevalence rate is less than 2% (WHO, 2023b). Intermediate-prevalence regions, such as the Mediterranean countries, Japan, Central Asia, the Middle East, and parts of South America, exhibit a prevalence range of approximately 2–7% (WHO, 2023b). Conversely, high-prevalence regions, such as West Africa, have a prevalence rate exceeding about 8% (WHO, 2023b).

2.2.1.2. Epidemiological pattern in Africa

In Africa, over 91 million people are affected by HBV infections (WHO, 2022a). In 2020, the African region bore a significant burden, accounting for 26% of global cases of hepatitis B and C (WHO, 2022a). Within the region, it is estimated that over 60 million people suffer from chronic HBV infections, leading to at least 200,000 deaths annually. These deaths are most commonly recorded among the continent's young and productive population (WHO, 2023b). This not only has immediate health implications but also long-term consequences (Mpangah et al., 2023; WHO, 2022a). Compounding this issue is the lack of access to testing and treatment, with less than one in ten Africans having this critical access (WHO, 2023b).

2.2.1.3. Epidemiological pattern in Ghana

In Ghana, despite the availability of a safe and effective vaccine, there is a high prevalence of HBV (Abesig et al., 2020). Specifically, the prevalence is 8.36% among adults, 14.30% among adolescents, and 0.55% among children under the age of five years (Ofori-Asenso & Agyeman, 2016). In 2020, the national prevalence rate remained at 8.36% (Coalition for Global Hepatitis Elimination, 2022). Between 2015 and 2019, there was about a 7% increase in HBV-related deaths, which was lower than the WHO's 2020 goal of reducing HBV-related deaths by 10% (Coalition for Global Hepatitis Elimination, 2022).

2.2.2. Epidemiology of malaria

2.2.2.1. Global epidemiology

In 2021, there were 247 million reported cases of malaria across 84 endemic countries. Most of these cases were observed in African countries (WHO, 2022b). The incidence of malaria, measured as cases per 1,000 people at risk, has shown a positive trend over the years, decreasing from 82 in 2000 to 57 in 2019, before peaking at 59 cases in 2020 (Oladipo et al., 2022; WHO, 2022b). Regarding malaria-related deaths on a global scale, there has been a consistent decline (WHO, 2022b). In 2000, there were 897,000 malaria deaths, which decreased to 577,000 in 2015 and further dropped to 568,000 in 2019 (WHO, 2022b). Nevertheless, the number of malaria-related deaths increased by 10% in 2020, with an estimated 625,000 fatalities (WHO, 2022b).

2.2.2.2. Epidemiological pattern in Africa

Malaria cases in African regions account for a large proportion of the global malaria burden (Adum et al., 2023; WHO, 2019). With an estimated 234 million cases in 2021, four African countries accounted for slightly more than half of all malaria deaths worldwide: Nigeria (31%), the Democratic Republic of the Congo (13%), Niger (4%), and the United Republic of Tanzania (4%) (Lakew et al., 2023; WHO, 2023a). Case of malaria in Africa decreased from 373 to 225 per 1,000 population at risk between 2000 and 2019 but increased to 234 in 2020 (WHO, 2022b). These cases fell to 229 per 1000 population in 2021 (WHO, 2022b). Malaria deaths in Africa decreased from 841,000 in 2000 to 541,000 in 2018 before rising to 599,000 in 2020 (WHO, 2022b).

2.2.2.3. Epidemiological pattern in Ghana

Ghana is among the 15 countries noted for a high malaria burden. The country also accounts for approximately 4.3% of malaria cases in West Africa (Adum et al., 2023;

Afagbedzi et al., 2022). However, between 2020 and 2021, Ghana made significant progress in malaria control, with a steady output of 165 cases per 1000 of the population at risk, while mortality fell slightly by approximately 1.7% (WHO, 2021). To reduce the country's malaria burden, Ghana implemented the high-burden, high-impact approach in November 2019 (Afagbedzi et al., 2022).

2.2.3. Epidemiology of hepatitis B virus and malaria co-infection

Until recently, there was scanty data on the comorbidity between these two infections. Earlier reports on the comorbidity of HBV and malaria infection were mainly from the South American regions. An earlier report by Braga and co-authors on 545 patients and 605 individuals with acute malaria found HBV prevalence of approximately 4.2% and 3.3%, respectively (Braga et al., 2005, 2006). Narrowing the discussion to sub-Saharan Africa (SSA), several studies have been conducted. In Nigeria, for example, a study of 337 potential blood donors by Aernan and co-authors revealed an HBV and malaria co-infection rate of approximately 40.7% (Aernan et al., 2011). In addition, Omalu and co-authors reported a co-infection rate of 7.81% among 269 pregnant women (Omalu et al., 2012). Furthermore, Dabo and co-authors studied 200 patients in the same study area. Their study revealed a co-infection rate of about 4.5% (Dabo et al., 2015b). In addition, an earlier report on 200 blood samples from febrile patients by Kolawole and co-authors showed about 5.5% HBV and malaria co-infection rate (Kolawole & Kana, 2018). In Ghana, a retrospective cohort study on 117 pre-transfusion samples by Freimanis and co-authors revealed approximately 59.2% HBV and malaria co-infection in the studied samples. Studies in northern Ghana have shown an increasing trend of HBV and malaria co-infection among pregnant women. These include a prevalence of approximately 0.7% (Helegbe et al., 2018), 1.7% (Anabire et al., 2019), and 16% (Asantewaa et al., 2023).

2.2.4. Transmission and risk factors

2.2.4.1. Transmission and risk factors of Hepatitis B virus (HBV) mono-infection

The transmission of HBV involves several pathways. These include direct contact with infected body fluids such as semen, saliva, and vaginal fluids (Tripathi & Mousa, 2023). Categorically, transmission could occur during three distinct stages. These are perinatal (mother-to-child during birth), horizontal (during childhood), and parenteral (blood-borne and sexual transmission) (di Filippo Villa & Navas, 2023; WHO, 2023b). These modes of transmission vary across different regions. In countries with low endemicity of HBV infection, the main modes of transmission include sexual activity and blood-borne infections (including surgery, dental procedure transfusion, organ transplant, dialysis, unsafe injections, needle-stick injury, and other activities such as tattoos or acupuncture, intravenous drug abuse, and adult lifestyle choices) (WHO, 2023b).

2.2.4.2. Transmission and risk factors of malaria

Malaria parasite transmission in areas of high endemicity is attributed to several factors, including biological, environmental, and climatological factors (Savi et al., 2021). The biological factors represent the interrelationship between the host, parasite, and the mosquito vector (Merrill & Johnson, 2020). The biological factors include the preferred feeding and resting place of adult mosquito vectors and the susceptibility of these vectors to insecticides (Jobe et al., 2023). Similarly, the environmental or climatological factors contributing to malaria transmission include rainfall, temperature, relative humidity, and elevation (Ekpa et al., 2023). These factors may affect biological factors, such as the prolonged existence of the mosquito vector. For instance, variation in the parasite-vector-man transmission dynamics influences the risk of disease and death from malaria. In addition, the *Anopheles* vector species differ in their capacity to

transmit the malaria parasite and global distribution due to differences in climate (Al-Thukair et al., 2022).

2.2.5. Socio-demographic predictors of hepatitis B virus (HBV) and malaria co-infection

Socio-demographic predictors such as age, education, socio-economic status, marital status, quality of housing, access to health care, and control efforts also influence HBV and malaria mono-infection (Anabire et al., 2019). For education, earlier studies have reported lower levels of education to be consistently associated with higher odds of HBV (Anabire et al., 2019; Talla et al., 2021), malaria (Oladosu & Adeniyi, 2023; Touré et al., 2019; Yaro et al., 2021), and HBV and malaria co-infection (Anabire et al., 2019). Furthermore, unemployed or pregnant women with informal occupations are more likely to experience HBV infection (Kinfe et al., 2021; Kwadzokpui et al., 2020; Tanga et al., 2019), malaria (Oyerogba et al., 2023; Dosoo et al., 2020), and HBV and malaria co-infection (Anabire et al., 2019). Additionally, according to previous reports, pregnant women who are not married have increased odds of HBV infection (Kinfe et al., 2021; Kwadzokpui et al., 2020) and malaria (Oyerogba et al., 2023; Touré et al., 2019).

2.3. Interventions geared towards hepatitis B virus (HBV) and malaria prevention

Over the past decade, numerous large-scale initiatives have been undertaken to reduce or eradicate the burden of HBV and malaria infections, particularly during pregnancy in areas of high endemicity. These initiatives include vaccination, the use of intermittent preventive treatment using sulfadoxine-pyrimethamine for pregnant women (IPTp-SP), and long-lasting insecticidal nets (LLINs), (Kusi et al., 2023; Odwe et al., 2023; Tesfu et al., 2023).

2.3.1. Hepatitis B virus (HBV) vaccination

To significantly reduce the burden of HBV, the WHO has integrated HBV vaccination into routine immunisation programmes worldwide, particularly in highly endemic areas (Martyn et al., 2023). Since 1982, a safe and effective vaccine against HBV has been available to all (WHO, 2023b). According to WHO reports, by early 2011, the HBV vaccine had been routinely introduced in 179 countries, achieving global coverage of approximately 75%. Coverage rates were approximately 90% in the Americas, 78% in Europe, 76% in Africa, and 52% in Southeast Asia (Flores et al., 2022). The HBV vaccine is approximately 95% effective in controlling HBV and its associated complications. It is administered in a three-dose course, with the second dose given at least one month after the first and the third dose administered six months after the first (Hepatitis B Foundation, 2022).

2.3.2. Insecticide-treated nets (ITNs)

Insecticide-treated nets (ITNs), especially the long-lasting insecticidal nets (LLINs), serve a dual purpose: they either kill mosquitoes upon contact or repel them, offering protection to both mothers and newborns (Ng'ang'a et al., 2021). For pregnant women who are unable to take Sulphadoxine-Pyrimethamine (SP) due to allergies or hypersensitivity, resistance or efficacy Concerns, side effects, coexisting medical conditions, and G6PD defective, ITN use emerges as a superior and more appropriate intervention for preventing malaria infection (Onyinyechi et al., 2024). In regions with stable malaria transmission, the widespread use of ITNs has proven highly effective in preventing infection. This has led to a reduction in instances of anaemia, prematurity, low birth weight, and the risk of maternal and newborn mortality (Mangusho et al., 2023).

2.3.3. Intermittent preventive treatment using sulfadoxine-pyrimethamine

Intermittent Preventive Treatment (IPT) stands out as the most promising strategy for malaria control during pregnancy (CDC, 2019a; Figueroa-Romero et al., 2022). This approach involves administering antimalarial drugs to pregnant women at predetermined intervals after quickening (around 16 weeks of pregnancy), offering substantial benefits to maternal and infant health (Dosoo et al., 2021). IPT is preferred over weekly chemoprophylaxis due to its higher compliance rate. While weekly chemoprophylaxis necessitates women to take antimalarial drugs, typically chloroquine, several days each week at home, IPT allows for the administration of a total treatment dose during antenatal care visits under the supervision of healthcare providers (Rodrigo et al., 2020). This programme, aimed at malaria control in pregnancy, is well-documented and has demonstrated reductions in malaria episodes, maternal parasitaemia, anaemia, and the incidence of low birth weight (Ampofo et al., 2022).

2.4. Barriers to adherence to interventions

Although the integrated disease control initiatives explored above have reportedly led to a considerable reduction in the occurrence and severity of infectious diseases (Dosoo et al., 2021; Touré et al., 2019), several barriers to adherence still exist across different regions of recorded endemicity (Adjei et al., 2019). Barriers to health prevent an individual from acquiring access to health services and achieving the best health (Seidu et al., 2020). These barriers could be related to personal [knowledge about the infection, awareness, and misconceptions (Hossain et al., 2022)], psychological [fear, anxiety, pain, and stigma associated with infectious diseases (Adom et al., 2021)], and socio-cultural [punishment from the gods or ancestors (Koka et al., 2016), witchcraft (Msoka et al., 2021) or an outcome of spiritual poisoning (Adjei et al., 2019)].

2.5. Theoretical review

This section explains the theory on which the current study was grounded, as shown in **Figure 2.1**. The Health Belief Model (HBM) is considered appropriate for this study. It is one of the most commonly used frameworks in research on health behaviour (Ghorbani-Dehbalaei et al., 2021; Rosenstock et al., 1994). It was developed in the 1950s to explain why biomedical screening programmes which the U.S. Public Health Service offered were not very successful (Ghorbani-Dehbalaei et al., 2021; Rosenstock et al., 1994).

HBM is based on the principle that the two components of health-related behaviour are the desire to avoid illness or to recover if already sick and the belief that a specific health action will prevent or cure illness (Rosenstock et al., 1994). More importantly, an individual's course of action is frequently determined by their perceptions of the benefits and barriers associated with health behaviour (Ghorbani-Dehbalaei et al., 2021). The HBM has some primary indicators used to predict why people decide or do not decide to control, prevent, or screen for different illness conditions (Ghorbani-Dehbalaei et al., 2021). These primary indicators include;

1. Perceived susceptibility: Perceived susceptibility is the belief in the chance of suffering a risk or developing a disease or condition.
2. Perceived severity: Perceived severity is the ability to believe in the seriousness of a disease. It also includes associated consequences, such as mortality and burdens.
3. Perceived benefits: Believing in the effectiveness of various actions available to reduce the threat of illness or disease (or to cure illness or disease).
4. Perceived barriers: Perceived barriers are obstacles that hinder behaviour change and may facilitate the transmission of infections.

5. Cues for action. This refers to the stimulus required to initiate the decision-making process for accepting recommended health action. It involves the readiness to take healthcare-related actions based on the provided information about the consequences of infection.
6. Self-efficacy: This involves confidence in performing a behaviour successfully. Without the confidence to take action, pregnant women are at a higher risk of infection.

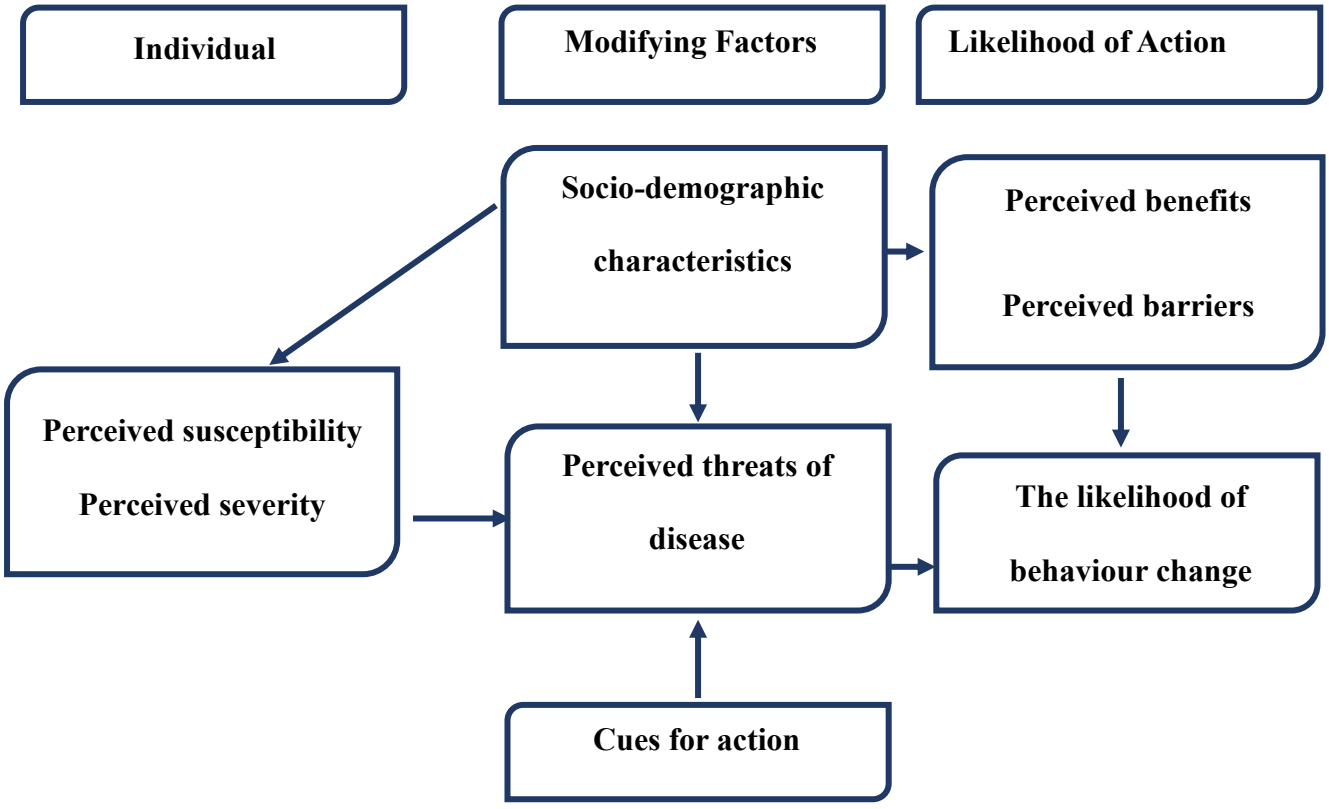

Figure 2.1: Theoretical Framework

[Adopted from Rosenstock and co-authors (Rosenstock et al., 1994)]

2.6. Conceptual framework

The study assessed the prevalence of HBV and malaria co-infection, risk factors, socio-demographic predictors and several barriers to intervention. Epidemiological studies, such as the current one, are guidable by the assumption that pregnant women who do

not adhere to HBV and malaria interventions are co-infected with HBV and malaria.. As presented in **Figure 2.2**, pregnant women's exposure to blood, body fluids, or objects infected with HBV, and mosquito bites, coupled with socio-demographic predictors such as (age, marital status, occupation, religious affiliation, level of education, income, household and maternal characteristics) and barriers such as personal (such as awareness, knowledge, age, occupational commitment, consultation, and discomfort), psychological (such fear of side effects, absence of signs and symptoms, forgetfulness, perceived efficacy of traditional herbal medicine, perception that formal care does not meet expectations, pain, uncertainty, misplaced trust in healthcare providers, distress about the death of a family member, and fatigue due to prolonged adherence), sociocultural barriers (such as neglect by family members, religious prohibition, taboo, punishment from the gods, and spiritual poison), and socio-economic (such as unemployment, concern about being a burden, costs of the intervention, and time burden) were the modifying factors that determine the prevalence and severity of HBV and malaria infections. Moreover, interventions to minimize the prevalence and severity of the impacts included; indoor residual spraying, vaccination, IPTp-SP uptake, LLINs usage, mosquito coil, spray and repellent). The cue to action needed to trigger the readiness of pregnant women to take healthcare-related actions include; accessibility to, cost, and availability of the interventions, regular health education, and institutional campaigns about the risks and consequences of infections.

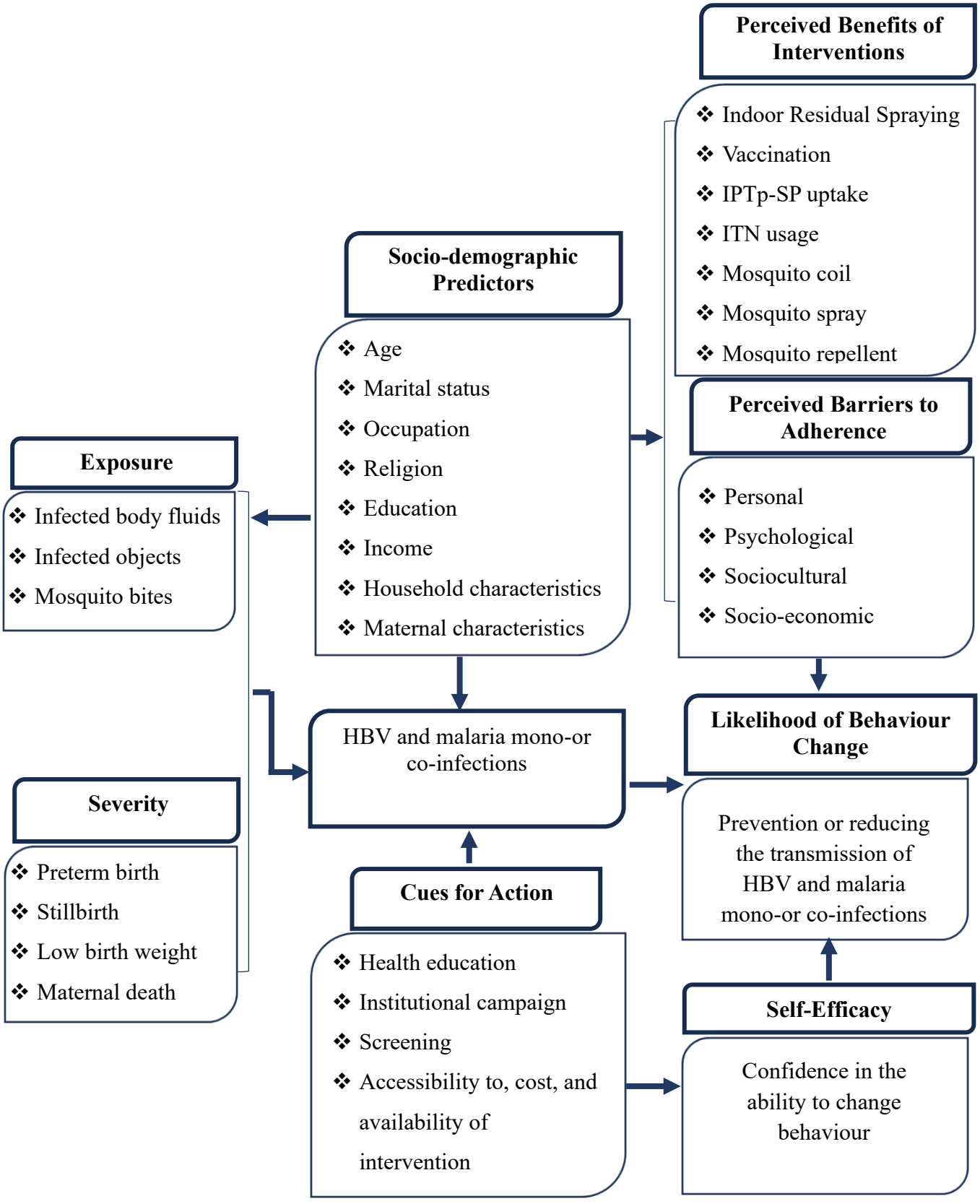

Figure 2.2: Author's construct, informed by the Health Belief Model.

CHAPTER THREE

METHODOLOGY

3.0. Introduction

This chapter outlines the research methodology of this study. It details the study area, study design, study population, and variables of interest. In addition, it describes the sampling procedure, data collection instruments and techniques, and quality control. This chapter also details data management and analyses, summary and data transformation, and finally, ethical approval.

3.1. Study area and context

The study was conducted across seven health facilities in various municipalities within the Bono East Region of Ghana, as shown in **Figure 3.1**: Atebubu-Amantin Municipal, Kintampo South District, Kintampo North Municipal, Nkoranza South Municipal, Techiman Municipal, Pru East District, and Pru West District. This region has a population of approximately 1,203,400 people spread over 22,952 square kilometres, yielding a density of around 48.8 individuals per square kilometre (Ghana Health Service, 2023).

Atebubu-Amantin District is positioned between latitudes 7°23’N and 8°22’N and longitudes 0°30’W and 1°26’W (Ghana Statistical Service, 2021a), while the Kintampo area, known as the geographical centre of Ghana, lies between latitudes 7°45’N and 8°45’N and longitudes 1°20’W and 2°1’W (Ghana Statistical Service, 2021c). Techiman Municipal extends between longitudes 10°49’E and 20°30’W and latitudes 8°00’N and 7°35’S (Ghana Statistical Service, 2021g), while Nkoranza South Municipality falls within longitudes 1°10’W and 1°55’W and latitudes 7°20’N and 7°55’N (Ghana Statistical Service, 2021d). The Pru East and West Districts lie between longitudes

0°30’W and 10°26’W and latitudes 7°50’N and 8°22’N (Ghana Statistical Service, 2021e, 2021f).

Previous to this current study, a study by Walana et al. (2014) at Kintampo Municipality reported an overall seroprevalence of the hepatitis B surface antigen of approximately 9.6%, with a higher prevalence among females and youth (Walana et al., 2014). Likewise, as one of the hotspot regions for malaria risk (Aheto et al., 2024), a previous study conducted in four settings (the Kintampo North Municipality, Kintampo South District, Nkoranza South Municipality, and Nkoranza North District) all within the Bono East Region reported a 20.4% prevalence of malaria among pregnant women (Dosoo et al., 2020). Regarding the adherence to the integrated HBV and malaria interventions among pregnant women, a previous study reported a low to moderate uptake of IPTp-SP among pregnant women in three different ecological zones of Ghana of which Kintampo, located in the Bono East Region was part (Dosoo et al., 2021). Moreover, a study conducted in four settings within the Bono East Region (Kintampo Municipality and South District and Nkoranza North and South Districts) reported that about 35% of the pregnant women studied do not utilize LLINs (Manu et al., 2017). Previous to the study by Manu et al. (2017), the Kintampo Birth Cohort conducted a LLINs ownership and utilisation study in 2010 among pregnant women and reported a low (47%) compliance with LLINs (Asante et al., 2013). A critical issue that remains unknown in the region is the prevalence of HBV and malaria co-infection among pregnant women and the association between non-adherence with interventions and the risk of co-infection.

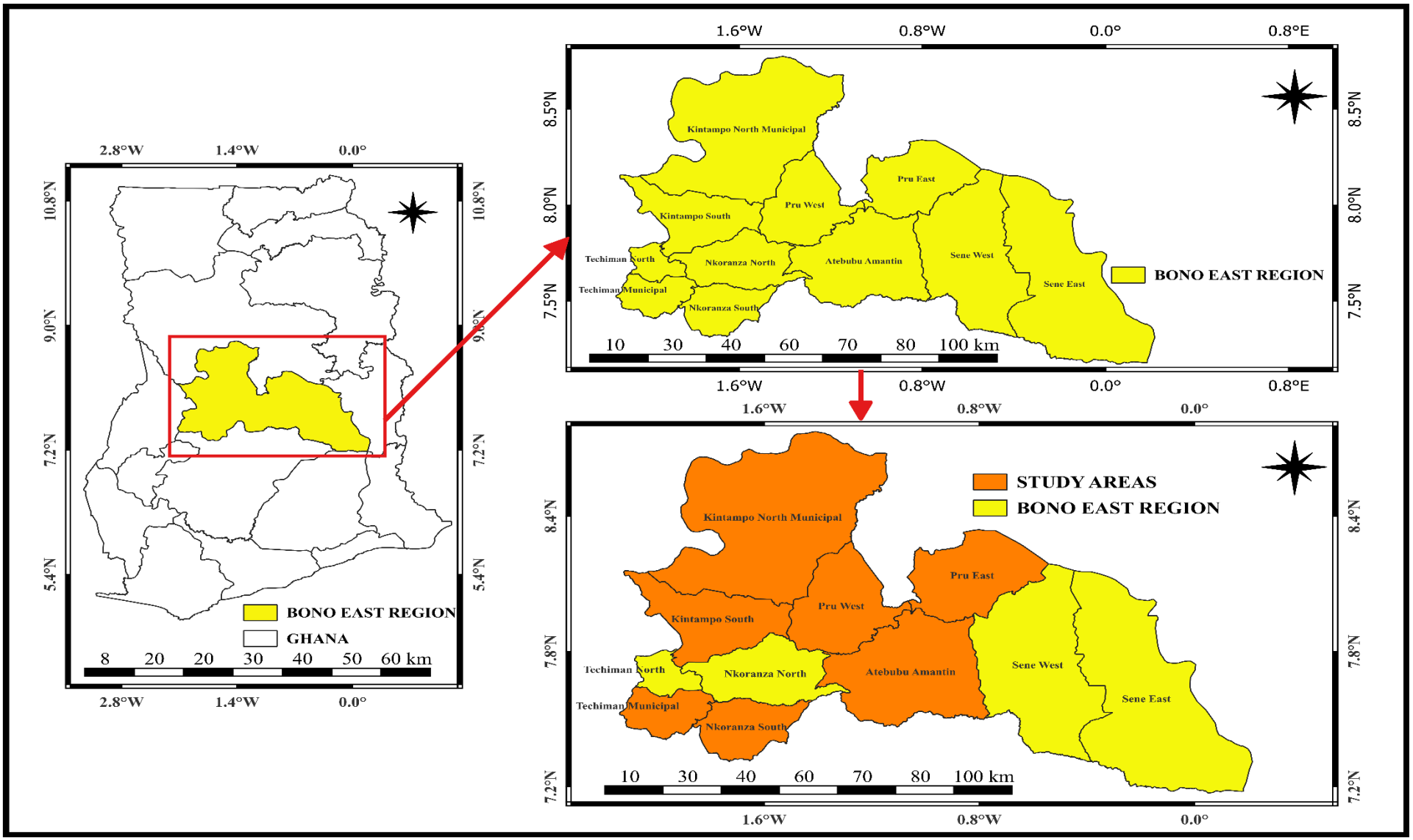

Figure 3.1: Bono East Regional Map showing the study sites

3.1.1. Health facilities and justification of their selection

In the Bono East Region, there are 366 health facilities, which include district hospitals, health centres, clinics, and community-based health planning services (CHPS) zones. These facilities are managed by the government, the Christian Health Association of Ghana (CHAG), and private entities, providing essential secondary-level health services (Ghana Health Service, 2023). Seven health facilities including district hospitals, municipal hospitals, and health centres were purposively selected to reflect geographic diversity and varying healthcare delivery capacities. The selected health facilities for the study included: Atebubu-Amantin Municipal Hospital, Kintampo South District Hospital, Kintampo North Municipal Hospital, St. Theresa's Hospital, Holy Family Hospital, Pru West District Health Centre, and St. Mathias Catholic Hospital. The selection of health facilities for this study was based on strategic considerations to ensure comprehensive and representative data collection. Thus, these facilities were selected because they serve as primary points of healthcare delivery for pregnant women and provide antenatal care (ANC) services. Their strategic locations allow access to a diverse population, encompassing both rural and urban settings, which is crucial for capturing varied socio-demographic and environmental factors that may influence the prevalence and determinants of HBV and malaria co-infection.

In addition, these health facilities are the channels through which the Ghana Health Service and National Malaria Eradication Programme support the region with HBV vaccines, LLINs, and IPTp-SP for distribution to ANC registrants and other beneficiaries. This is part of an effort to contribute to achieving the Sustainable Development Goal (SDG), which relates to health and well-being (Hales & Birdthistle, 2023). Nevertheless, the Bono East Region is still one of the hotspot regions for HBV and malaria (Aheto et al., 2024; Bardoe et al., 2025). By selecting facilities with active

participation in these programs, the study could effectively evaluate the uptake and adherence to interventions, as well as the barriers faced by pregnant women.

3.2. Study design

This multicenter hospital-based cross-sectional study employed the mixed method approach to collect data from 1452 pregnant women in seven selected municipalities/districts from September 2023 to June 2024. Including multiple health facilities was necessary to efficiently gather data across diverse populations within a reasonable timeframe (Kwok et al., 2022). Quantitative data collection allowed for the collection of measurable, numerical data on HBV and malaria infections (Apuke, 2017). This facilitated the identification of patterns, associations, and statistically significant findings. Besides, qualitative data collection provided rich, detailed insights into the experiences, perceptions, and contextual factors influencing non-adherence to health interventions (Horsfall et al., 2021).

3.3. Study population

The study population comprised pregnant women who attended ANC in selected healthcare facilities.

3.4. Variables of interest

3.4.1. Outcome variable

The outcome variable was HBV and malaria co-infection. This variable was categorical and measured on a dichotomous scale ("0 – Negative" and "1 – Positive").

3.4.2. Predictor variables

The predictor variables included risk factors, socio-demographic and maternal parameters, and barriers to adherence to interventions. A total of thirty-one categorical items (coded "0 – No" and "1 – Yes") assessed risk factors, while eighteen items

evaluated socio-demographic and maternal predictors. Personal-level barriers to compliance with the intervention were assessed using two categorical items related to awareness of HBV and malaria. Knowledge levels regarding these infections were measured with forty-four items on a 4-point Likert scale. The rationale was to obtain responses while minimizing the tendency for neutral answers (Kankaraš & Capecchi, 2024). Thus, the 4-point Likert scale eliminates the neutral midpoint, thereby providing pregnant women with options to make a definitive choice, which enhances the clarity and reliability of the data collected (Koo & Yang, 2025). Moreover, the 4-point Likert scale is straightforward and easy to comprehend, ensuring accessibility for participants with varying literacy levels (Joshi et al., 2015). This reduced the likelihood of respondent fatigue, contributing to higher data quality and response rates (Koo & Yang, 2025). In addition, five items examined lifestyle priorities affecting intervention adherence, all categorized into "0 – No" and "1 – Yes." Psychological barriers to compliance were evaluated using ten categorical items, and five items assessed socio-cultural barriers, also coded as "0 – No" and "1 – Yes."

3.5. Sampling

3.5.1. Eligibility criteria

3.5.1.1. Inclusion

Pregnant women who lived in the selected municipalities/districts, who also attended ANC at the selected health facilities, and who agreed to participate were included.

3.5.1.2. Exclusion

The study excluded pregnant women who did not attend ANC at the selected health facilities. Pregnant women who declined participation, withdrew after initial recruitment due to time constrains, discomfort, undisclosed personal reasons, or lacked reliable interpreters for language barriers were also excluded.

3.5.2. Sample size determination

A sample size of 1075 was estimated using the population of pregnant women registered in the selected municipals'/districts' ANC record book for 2022. The formula by (Khaleel et al., 2023) with a 3% margin of error was used.

$$n = \frac{N}{1 + \mathrm{N}(e)^2}$$

Where (N) is the specific population (33,395), (e) is the standard error (Chosen to be 3%), and (n) is the sample size.

$$= \frac{33395}{1 + 33395(0.03)^2}$$

$$1075.33$$

$$\approx 1075$$

After estimating the sample size, 35% of the total sample size (1075), which was approximately 377, was added to give a total sample size of 1452. The rationale was also to ensure sufficient statistical power and reliability from the sample for analysis and also to compensate for non-response (Bardoe et al., 2024, 2025). In addition, it was also to satisfy one of the assumptions of the logistic regression analysis, which emphasizes the presence of a larger sample size (Schreiber-Gregory & Bader, 2018). Each study site was allotted a quota based on the sample size proportional to the respective municipality/districts to maintain representativeness. A random selection of pregnant women was employed to ensure that their numbers reflected the sample size of the representative municipalities/districts. This was achieved by choosing a random starting point where every 3rd woman at the ANC for a particular time was selected until the required number of participants was obtained for that health facility as presented in **Table 3.1**.

Table 3.1. Sample Size Proportional to each Selected Municipal/District

Municipal/District	The population of pregnant women recorded in 2022	Sample proportion [%]	Estimated sample size	Approximated sample size
Atebubu-Amantin	5192	15.6	226.5	226
Kintampo North	6186	18.5	268.6	269
Kintampo South	2205	6.6	95.8	96
Nkoranza South	3932	11.8	171.3	171
Techiman Municipal	9334	27.9	405.1	405
Pru East	4140	12.4	180.1	180
Pru West	2406	7.2	104.5	105
Total	**33395**	**100**	**1451.9**	**1452**

3.5.3. Sampling procedure

This study employed a multistage sampling technique. The first stage of sampling involved selecting sampling points (clusters). The Bono East region was clustered into eleven (11) and stratified into seven (7) districts and four (4) municipalities. All four municipalities and three randomly selected districts from seven strata were used for the study. The municipal/district capital towns were then conveniently selected for the study. The second sampling stage involved the serial selection of participants. Every pregnant woman who attended ANC at the selected health facility was requested to participate. Consented pregnant women were randomly selected until their numbers became proportional to the sample size for the representative municipals/districts. Sampling bias could occur during the selection process and this was addressed by allotting a quota based on the sample size proportional to the respective municipality/districts to maintain representativeness. Selection bias was addressed through randomisation.

3.5.4. Enrolment of participants

The study was introduced to pregnant women during routine health education sessions. An initial examination was conducted to confirm eligibility. Those who met the inclusion criteria were approached to discuss the study objectives and provide consent for participation. Consent was also obtained from the parents or guardians of participants aged below 18 years. Of the 1452 expected participants, 1430 participated in the study. Twenty-two did not participate for various reasons, including feeling uncomfortable, a language barrier, a lack of time, and personal reasons, indicating a non-response rate of approximately 1.52% (as shown in **Figure 3.2**).

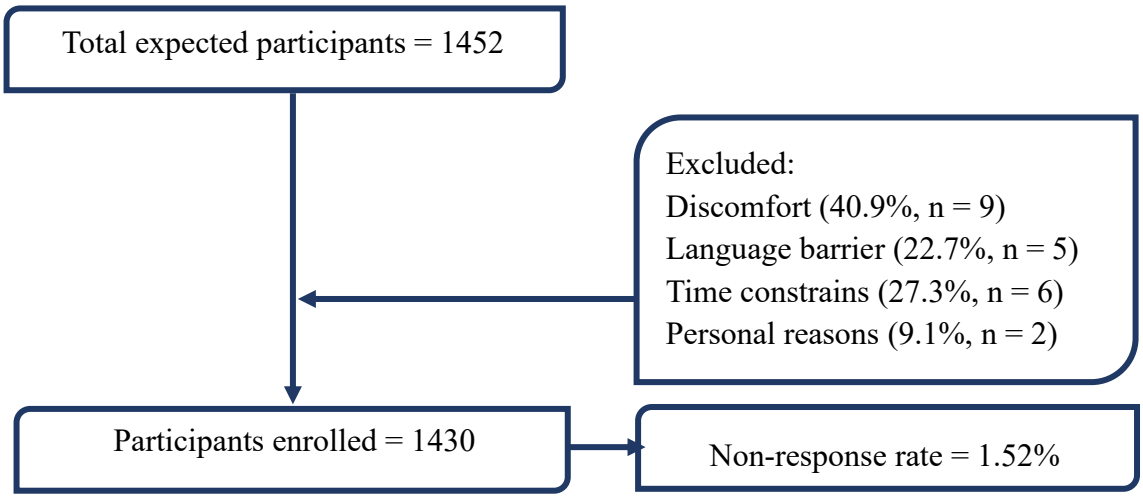

Figure 3.2. Flow Diagram showing recruitment process and non-response rate

3.6. Data collection instruments and techniques

Several instruments were used to collect relevant data for this study. These included a structured questionnaire, in-depth interviews (IDIs), focus group discussions (FGDs), and laboratory screening.

3.6.1. Quantitative data

Maternal (Obstetrics) parameters, including gravidity, parity, antenatal care (ANC) visit, gestation, Glucose-6-phosphate Dehydrogenase (G6PD), blood group, haemoglobin

(Hb) levels, sickling, and syphilis status were collected from the antenatal care (ANC) records book. Previous Hb levels of pregnant women during the study were averaged to determine the proportion of pregnant women who were anaemic during pregnancy. Information not documented in the ANC record book was verbally retrieved.

In addition, data on the socio-demographic characteristics of pregnant women and risk factors associated with HBV and malaria were collected using the questionnaire adapted from the Ghana Demographic and Health Survey (Ghana Statistical Service et al., 2015) and the Ghana Living Standards Survey Round 6 (Ghana Statistical Service, 2014) and was modified to suit the purpose of this study. The questionnaire was primarily structured into three sections:

1. Section A (focussed on the socio-demographic characteristics of the participants) consisted of 11 variables.
2. Section B (focussed on the risk factors associated with HBV and malaria mono-infection) consisted of 30 variables.
3. Section C (focussed on the barriers to adherence to preventive guidelines or interventions) comprised 75 variables.

3.6.2. Blood sample collection and serological examination

Then, a trained medical laboratory technician collected approximately five (5ml) millimetres of venous blood into purple-top EDTA tubes following the standard operating procedure (SOP).

3.6.2.1. HBV screening

The Micropoint HBsAg Gold Rapid Screen Test Kit (Trinity Biotech Plc, Japan) was used. The kit included one dip strip, a plastic pipette, and a desiccant. The blood samples were centrifuged at 1500 revolutions per minute (RPM) for 3 minutes to separate serum.

A test strip was vertically immersed in the serum for at least 10-15 seconds. The test strip was placed on the non-absorbent flat surface and the results were read after 5-10 minutes. Test strips were quality-controlled using known HBsAg-positive serum samples stored by the health facilities' laboratories for certainty of outcome. Besides, all HBV-positive samples were repeated for confirmation. A test was classified as positive for HBsAg if a pink band appeared on the test strips' control (C) and test (T) regions. In contrast, the test was negative if the pink band appeared only on the test strips' control (C) region. Likewise, a test was reported invalid if a pink band appeared on the test (T) region or if no pink band appeared on the test strips (Yambasu et al., 2018). Tests were repeated on samples reported invalid upon reading on the test strips.

3.6.2.2. Malaria screening

Thick blood films were prepared on a glass slide using 10 microlitres (µL) of blood, evenly spread to cover an area of 15×15 mm. The smear was stained with 10% Giemsa for 15 minutes and then examined under oil immersion (X100) using a binocular light microscope. The slides were double-read by trained Microscopists. Asexual parasite densities were estimated by counting the number of parasites per 200 white blood cells (WBCs) in the thick film. A sample was considered negative if no parasite was counted after 200 high-power fields had been read (CDC, 2019b). If there were inconsistencies in the slide reading (positive or negative or a 50% or more difference in parasite density), the senior microscopist's reading was accepted as the true report. Parasite counts were converted to parasites per microliter using a relative WBC of 8000 leukocytes per µL of blood (CDC, 2019b), using the notation:

$$\text{Parasites/µL blood} = \frac{Number\ of\ parasites\ counted \times 8000\ white\ cells/\mu L}{Number\ of\ white\ blood\ cells\ counted}$$

Parasitaemia was categorized as low (< 1000 parasites/μL blood), moderate (1000–4999 parasites/μL blood), high (5000–99,999 parasites/μL blood), and hyperparasitemia (≥100,000 μL).

3.6.3. Qualitative data

Seven focus group discussions (FGDs) were conducted, one for each health facility using a structured FGD guide. Also, seven in-depth interviews (IDIs) were conducted using an in-depth interview guide for the in-charges at the health facilities. With the consent of the participants, discussions during the session were recorded to facilitate data transcription and translation into English.

3.7. Quality control

3.7.1. Pre-test/ pilot study

A pilot study was conducted at the Agyenkwa Hospital in Jema. This allowed for the appraisal or evaluation of the feasibility of the study and data collection instruments and to determine whether the sample size and sampling technique were tolerable and adequate. Questions that seemed ambiguous were rephrased.

3.7.2. Validity and reliability

Each instrument was pre-tested before the data collection and revised to meet the study objectives. Reliability was achieved by subjecting the pretested response to a reliability test to determine Cronbach's alpha. The value of Cronbach's alpha ranges from 0 to 1. A value approaching 1 indicates high internal consistency. In contrast, a value closer to 0 means poor internal consistency. However, it has been suggested that an alpha of 0.8 or 0.9 would be more adequate (Bujang et al., 2018). Cronbach's alpha [α] for this study, as shown in **Table 3.2**, was 0.834. Since the α value is greater than 0.7, it indicates good reliability for all variables.

Table 3.2. Reliability Test for the Study's Data Collection Instrument

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
0.834	0.906	128

3.8. Data management and analysis

As part of data management, all data were examined for completeness, consistency, and clarity. The data were then coded, entered, and cleaned using Microsoft Excel version 2016 (Microsoft, USA) before being analysed using STATA 14 (StataCorp, College Station, USA).

3.8.1. Quantitative data statistical analysis

Descriptive statistical analyses were performed to summarise the frequency, percentage distribution, and mean with standard deviation for continuous variables. Pearson's chi-square tests were also performed to determine differences in proportions. Similarly, logistic regression analysis was performed to compute odd ratios and identify factors or predictors significantly associated with HBV and malaria co-infection at a test significance of 0.05 (95% CI).

3.8.1.1. Logistic regression model

Logistic regression models predict the probability of a change in a categorical dependent variable based on the values of independent variables. Besides providing an estimate of conditional probability, this model also allows for assessing the degree of influence that selected independent variables have on the occurrence of the dependent variable's categories. (Zhou et al., 2024). In this study, all measurements were observed, with no missing values. The general model of the logistic regression equation is expressed as;

$$\log(p) = \ln\left(\frac{P(Y=1)}{1-P(Y=1)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k \quad \text{.....(1)}$$

Where $P(Y = 1)$ is the probability of the dependent event (HBV and malaria co-infection) occurring, β_0 is the intercept, and $\beta_1, \beta_2, \ldots \beta_k$ are the coefficients for the independent variables $X_1,\ X_2, \ldots X_k$.

3.8.1.2. Assumptions for logistic regression

These analyses were grounded on certain assumptions, which included:

1. The outcome variable should be categorical and measured on a dichotomous scale (Schreiber-Gregory & Bader, 2018; Starbuck, 2023). That is, it should have mutually exclusive and exhaustive categories. For this study, the outcome variables are HBV, malaria, and HBV and malaria co-infection. The outcome variables were categorised into (Positive and Negative).
2. There should be one or more independent predictor variables, which are either continuous or categorical (Schreiber-Gregory & Bader, 2018). In this study, the continuous predictor variable was age, Hb levels, and ANC visits. The categorical variables, on the other hand, included the risk factors for HBV, malaria, barriers to intervention, and the rest of the socio-demographic and maternal characteristics (aside from age, Hb levels, and ANC visits).
3. There should be independence of observations (Schreiber-Gregory & Bader, 2018; Starbuck, 2023). The independence of observation has to do with autocorrelation (Starbuck, 2023). In this study, the Durbin-Watson test was used to check for autocorrelation. This test assumes a value between 0 and 4. A value substantially less than 2 indicates a positive serial correlation, a value close to 2 suggests little to no autocorrelation, and a value greater than 2 indicates a negative serial correlation (Turner, 2020). Durbin-Watson value ranging from 1.50 to 2.50 signifies independence of observation. Contrary, values less than 1.50 and greater than 2.50 imply dependence on observation. The Durbin-

Watson test value for this study was 1.970, which falls within the range, implying no autocorrelation.

4. There should be no multicollinearity among predictor variables (Schreiber-Gregory & Bader, 2018; Starbuck, 2023). That is predictor variables should not be highly correlated with each other. A correlation test was performed to obtain a correlation coefficient for socio-demographic and maternal predictors, risk factors for HBV and malaria, and the various barriers to intervention. In instances where the correlation coefficient of a predictor variable was ≥ 0.70, the variable was omitted from the regression model.
5. There should be a linear relationship between continuous predictor variables and the log odds of the outcome variable (Schreiber-Gregory & Bader, 2018; Starbuck, 2023). In this study, the continuous predictor variables were age, Hb levels, and ANC visits. The Box-Tidwell test was used to assess this assumption. For this test, the *p*-value less than 0.05 indicates that the relationship between the corresponding independent variable and the logit of the dependent variable is not linear. In contrast, a *p*-value greater than 0.05 indicates that the relationship between the corresponding independent variable and the logit of the dependent variable is linear. The *p*-values for age and log of age were (0.945), Hb and log of Hb were (0.006), and ANC visit and log of ANC visit was (0.310). This showed that there was a linear relationship between Age and ANC visit and the log odds of HBV and malaria co-infection. Eventually, the Hb level was eliminated from the logistic regression model.

3.8.2. Qualitative data analysis

Data-driven inductive thematic analysis (Braun & Clarke, 2006) was used to analyse qualitative data, with a focus on four steps: transcription, profiling, coding, and thematic

framework. All FGDs and IDIs were transcribed verbatim from the preferred local language into English. Transcripts were reviewed with the audio recordings to check for possible omissions of relevant responses.

Validated transcripts were assigned identification codes according to study location, as part of profiling. The FGDs were labelled FGD-ATBM (Focus Group Discussion for Atebubu-Amantin Municipal), FGD-KSD (Focus Group Discussion for Kintampo South District), FGD-KNM (Focus Group Discussion for Kintampo North Municipal), FGD-NSM (Focus Group Discussion for Nkoranza South Municipal), FGD-TM (Focus Group Discussion for Techiman Municipal), FGD-PWD (Focus Group Discussion for Pru West District), and FGD-PED (Focus Group Discussion for Pru East District). Equally, the IDIs were labelled IDI-ATBM (In-depth Interview for Atebubu-Amantin Municipal), IDI-KSD (In-depth Interview for Kintampo South District), IDI-KNM (In-depth Interview for Kintampo North Municipal), IDI-NSM (In-depth Interview for Nkoranza South Municipal), IDI-TM (In-depth Interview for Techiman South Municipal), IDI-PWD (In-depth Interview for Pru West District), and IDI-PED (In-depth Interview for Pru East District).

Once the transcripts were profiled, coding was performed manually by identifying keywords in the interview that were pertinent to the study. Sections of the transcripts that seemed significant based on the study's objectives were highlighted and assigned a shorthand label or "code" to describe their content. Microsoft Word was used to sift over the information and categorise it according to themes to match the objectives of the study. Patterns that emerged around barriers to HBV vaccination adherence, use of LLINs, and adherence to IPTp-SP were noted. Identified themes were cross-checked

against the original data to ensure they were coherent. Illustrative quotes from the participants were integrated into the results to support the quantitative findings.

3.10. Ethical clearance and approval

Ethical approval was sought from the Committee on Human Research, Publication, and Ethics (CHRPE), Kwame Nkrumah University of Science and Technology, School of Medical Sciences (CHRPE/AP/1081/23). Official permission was obtained from the Bono East Regional Health Directorate and the study sites. Informed consent was sought from each participant before being recruited into the study.

CHAPTER FOUR

RESULTS

4.0. Introduction

This chapter presents the results based on the study objectives, including the socio-demographic characteristics of pregnant women, the prevalence of hepatitis B virus (HBV) and malaria co-infections, the risk factors, and socio-demographic predictors of HBV and malaria co-infections. This also concludes barriers to adherence to HBV and malaria interventions.

4.1. Socio-demographic and maternal characteristics of the pregnant women

In **Table 4.1**, the mean age of participants was 28.8 ± 3.73 years (95% C.I: 28.63 – 29.02), ranging from 17 to 40 years and were mostly married (91.5%). Most had a primary education (42.8%) and identified as Christians (83.5%). Nearly all (97.6%) were employed in various occupations, including trading (42.9%), hairdressing (19.2%), and farming (14.3%). Most women (48.4%) earned a monthly income between Gh¢100 and 500.

Table 4.1. Sociodemographic Characteristics of Study Participants

Variable	Frequency [n]	Percentage [%]
Age ($\bar{x}$ ± SD)	28.8 ± 3.73 (95% C.I: 28.63 – 29.02)	
<18 years	7	0.5
18-25	167	11.7
26-30	1088	76.1
31-40	168	11.7
Marital status		
Not married	118	8.2
Married	1308	91.5
Cohabitation	4	0.3
Educational attainment		
No formal education	414	29
Primary education	612	42.8
Junior High School	251	17.6
Senior High School	127	8.9
Tertiary	26	1.8

Table 4.1. continued

Religious affiliation		
Islam	233	16.3
Christianity	1194	83.5
African tradition	3	0.2
Employment status		
Employed	1396	97.6
Unemployed	34	2.4
The type of occupation		
Hairdressing	275	19.2
Seamstress	234	16.4
Farming	204	14.3
Civil service	26	1.8
Trading/Marketing	613	42.9
Domestic activities	44	3.1
Housewife (unemployed)	14	1
Student (unemployed)	6	0.4
None (unemployed)	14	1
Monthly income		
Gh₵ 100-500	692	48.4
Gh₵ 600-1000	538	37.6
Gh₵ 1100-2000	141	9.9
Gh₵ 2100-3000	19	1.3
Gh₵ 3100-4000	6	0.4
None	34	2.4

(Source: Field Data, 2024)

4.2. Household characteristics of study participants

Table 4.2 shows the household characteristics of the study participants. Most of them (70.6%) lived in family households or compound houses, 89.1% lived in houses made of blocks and roofed with iron sheets, and 62.6% had between 1 and 5 household members.

Table 4.2. Household Characteristics of Study Participants

Variable	Frequency [n]	Percentage [%]
Household structure		
Extended	1086	75.9
Nuclear	344	24.1
Household type		
Compound House	1009	70.6
Self-Contain House	421	29.4
Household category		

Table 4.2. continued

Mud with thatch	27	1.9
Mud with iron sheets	129	9
Blocks with iron sheets	1274	89.1
Number of people in a household		
1-5	895	62.6
6-10	532	37.2
11-15	3	0.2

(Source: Field Data, 2024)

4.3. Obstetric characteristics of study participants

Table 4.3 shows the obstetric characteristics of study participants. Among them, 43.6% were secundigravida, with 20.7% of those with two previous pregnancies having one child, and 32.9% of women with three or more pregnancies having three children. ANC attendance ranged from 1 to 9 visits, with an average of 2.85 ± 1.9 (95% CI: 2.76 – 2.95). First-time ANC visitors comprised 31.2%, and 73.5% of the women were in their first trimester. Most participants (95.9%) had no G6PD deficiency, and 29.5% had blood type A. Most of the pregnant women (59%) had moderate anaemia, while 8.5% were not anaemic. In addition, 96.9% had no sickle cell trait, and 97.4% tested negative for syphilis.

Table 4.3. Obstetric Characteristics of Study Participants

Variable	Frequency [n]	Percentage [%]
Gravidity		
Primigravida	335	23.4
Secundigravida	624	43.6
Multigravida	471	32.9
Parity		
Nulliparous	296	20.7
Multiparous	1134	79.3
ANC Visits ($\bar{x}$ ± SD)	2.85 ± 1.9 (95% CI: 2.76 – 2.95)	
1-3	990	69.3
4-6	340	23.8
7-9	100	7
Gestation		
First trimester	1051	73.5
Second trimester	256	17.9

Table 4.3. continued

Third trimester	123	8.6
G6PD		
No defect	1371	95.9
Partial defect	49	3.4
Full defect	10	0.7
Blood Group		
A	422	29.5
B	420	29.4
AB	251	17.6
O	337	23.6
Anaemia		
Non-anaemic	122	8.5
Mild anaemia	449	31.4
Moderate anaemia	843	59
Severe anaemia	16	1.1
Sickling		
Positive	45	3.1
Negative	1385	96.9
Syphilis		
Positive	37	2.6
Negative	1393	97.4

(Source: Field Data, 2024).

4.4. Viral hepatitis B and malaria co-infection among the participants

This study determined the prevalence of HBV and malaria co-infections among pregnant women. As presented in **Table 4.4**, 0.7% (95% CI: 0.37 – 1.29) were co-infected with HBV and malaria. The Chi-square test for homogeneity of proportion showed that there was a significant difference between the proportion of pregnant women who were co-infected with HBV and malaria and those who were not co-infected ($\chi^2 = 1190.28$, DF = 1, $p < 0.05$). Specifically, the proportion of pregnant women who were co-infected with HBV and malaria was significantly lower than those who were not co-infected. Among the co-infected pregnant women (n = 10), 60% (n = 6) had high malaria parasitaemia, with levels ranging from 5,000 to 99,999 parasites/µL of blood. This was followed by 10% (n = 1) with moderate parasitaemia levels of 1,000–4,999 parasites/µL and 30% (n = 3) with low parasitaemia levels below 1,000 parasites/µL.

Table 4.4. Co-infection of HBV and Malaria among the study Participants

		Participants' Malaria status		Total
		Positive	Negative	
Participants' HBV status	Positive	**10 (0.7%)**	16 (1.1%)	26 (1.8%)
	Negative	145 (10.1%)	1259 (88%)	1404 (98.2%)
Total		**155 (10.8%)**	**1275 (89.2%)**	**1430 (100%)**

(Source: Field Data, 2024).

Table 4.5 shows that Nkoranza South and Techiman municipals had the highest prevalence of co-infection (0.2%), followed by Kintampo North (0.13%), while Kintampo South and Pru West Districts recorded no cases of co-infection.

Table 4.5. Co-infection of HBV and Malaria among Participants at the Study Sites

	HBV and malaria co-infection				
	Positive		**Negative**		
Data Collection Site	**[n]**	**[%]**	**[n]**	**[%]**	**Total**
Atebubu-Amantin Municipal	1	0.1	222	15.5	223
Kintampo North Municipal	2	0.1	263	18.4	265
Kintampo South District	0	0	94	6.6	94
Nkoranza South Municipal	3	0.2	166	11.6	169
Techiman Municipal	3	0.2	396	27.7	399
Pru East District	1	0.1	176	12.3	177
Pru West District	0	0	103	7.2	103
Total	**10**	**0.7**	**1420**	**99.3**	**1430**

(Source: Field Data, 2024)

The observed prevalence was reinforced by feedback during the series of in-depth interviews (IDIs) with the senior midwives (in-charges) of the health facilities. These key informants noted that:

"...We have noted cases of HBV, HIV, hypertension, diabetes, and UTIs. However, based on our records, malaria, UTIs, and HBV appear to be the most predominant..." – (In-charge, IDI-PWD, In-charge, IDI-KSD, and In-charge, IDI-PED)

"...The most commonly documented medical complications include UTIs, malaria, HBV, HIV, gestational diabetes, hypertension, depression, and anxiety. Among these, malaria, UTIs, and HBV emerge as the most prevalent..." – (In-charge, IDI-TM).

4.5. Risk factors for hepatitis B virus (HBV) and malaria co-infection

The study identified several risk factors associated with HBV and malaria co-infection among pregnant women as presented in **Table 4.6**. In bivariate analysis, sharing razor blades and shaving sticks, unprotected sex, abortion, blood transfusion, street nail trimming, netted windows, household windows fitting perfectly into walls, residing closer to refuse dumping sites, residing closer to water bodies, using mosquito repellents, and the use of insecticide mosquito sprays were risk factors significantly associated with HBV and malaria co-infection.

After adjusting the factors to eliminate confounders during the multivariate analysis, blood transfusion and street nail trimming were independent factors significantly associated with increased risk of HBV and malaria co-infection among pregnant women. Specifically, the risk of HBV and malaria co-infection was 21.56 times higher among pregnant women with a history of blood transfusion compared with those without a history of blood transfusion (AOR = 21.56; 95% CI: 2.01 – 31.62). Similarly, pregnant women who engaged in street nail trimming were 23.47 times more likely to be co-infected with HBV and malaria compared with those without a history of street nail trimming (AOR = 23.47; 95% CI: 1.70 – 34.04). In addition, there was a 2.34 times likelihood of co-infection among pregnant women whose households were closer to a refuse dumping site (AOR = 2.34; 95% CI: 1.08 – 4.03). Finally, pregnant women who resided closer to a water body had 8.84 times the odds of being co-infected with HBV and malaria (AOR = 8.84; 95% CI: 1.43 – 12.41).

Table 4.6 Association between risk factors and HBV and malaria co-infection among pregnant women

		Co-infection status					
Variable	**Frequency n [%]**	**Positive n [%]**	**Negative n [%]**	**COR [95%CI]**	**p-value**	**AOR [95%CI]**	**p-value**
Sharing a razor blade							
Yes	910 (63.6)	7 (0.5)	513 (35.9)	0.24 (0.06 - 0.94)	0.041*	0.45 0.03 - 5.44)	0.534
No	520 (36.4)	3 (0.2)	907 (63.4)	1		1	
Sharing a shaving stick							
Yes	205 (14.3)	6 (0.4)	1219 (85.2)	4.04 (1.13 - 14.45)	0.032*	2.38 (0.10 - 54.78)	0.586
No	1225 (85.7)	4 (0.3)	201 (14.1)	1		1	
Unprotected sex							
Yes	137 (9.6)	5 (0.3)	132 (9.2)	9.75 (2.78 - 34.14)	0.000*	7.67 (0.78 - 74.84)	0.080
No	1293 (90.4)	5 (0.3)	1288 (90.1)	1		1	
Abortion							
Yes	78 (5.5)	5 (0.3)	73 (5.1)	18.45 (5.22 - 65.16)	0.000*	12.42 (0.70 - 219.23)	0.085
No	1352 (94.5)	5 (0.3)	1347 (94.2)	1		1	
Blood transfusion							
Yes	232 (16.3)	7 (0.5)	225 (15.7)	12.36 (3.18 - 48.28)	0.000*	21.56 (2.01 - 31.62)	0.011*
No	1198 (83.8)	3 (0.2)	1195 (83.6)	1		1	
Piercing in a non-clinical setting							
Yes	192 (13.4)	3 (0.2)	189 (13.2)	2.79 (0.71 - 10.88)	0.139	1.81 (0.13 - 24.55)	0.654
No	1238 (86.6)	7 (0.5)	1231 (86.1)	1		1	
Street nail trimming							
Yes	180 (12.60	5 (0.3)	175 (12.2)	7.11 (2.03 - 24.82)	0.002*	23.47 (1.70 - 32.04)	0.018*
No	1250 (87.4)	5 (0.3)	1245 (87.1)	1		1	
Alcohol uptake							
Yes	114 (8.0)	2 (0.1)	112 (7.8)	2.91 (0.61 - 13.91)	0.179	0.34 (0.01 - 8.22)	0.513
No	1316 (92.0)	8 (0.60	1308 (91.5)	1		1	
HBV Vaccination							
Yes	1063 (74.3)	6 (0.4)	1057 (73.9)	0.51 (0.14 - 1.83)	0.306	0.84 (0.10 - 6.93)	0.879
No	367 (25.7)	4 (0.3)	363 (25.4)	1		1	
Ceramic, Tiles, and Terrazzo as the main materials for household floors							
Yes	523 (36.6)	4 (0.3)	519 (36.3)	1.15 (0.32 - 4.12)	0.822	0.18 (0.01 - 3.27)	0.250
No	907 (63.4)	6 (0.4)	901 (63.0)	1		1	

Netted windows in household							
Yes	1212 (84.8)	2 (0.1)	1210 (84.6)	0.04 (0.01 - 0.21)	0.000*	0.10 (0.01 - 1.27)	0.076
No	218 (15.2)	8 (0.6)	210 (14.7)	1		1	
Household windows perfectly fit into the wall							
Yes	1262 (88.3)	6 (0.4)	1256 (87.8)	0.19 (0.54 - 0.70)	0.012*	1.09 (0.08 - 14.67)	0.946
No	168 (11.7)	4 (0.3)	164 (11.5)	1		1	
Presence of farm or domestic animals in the household							
Yes	415 (29.0)	5 (0.3)	410 (28.7)	2.46 (0.70 - 8.55)	0.156	0.78 (0.08 - 7.66)	0.838
No	1015 (71.0)	5 (0.3)	1010 (70.6)	1		1	
Households' closeness to refuse dumping sites							
Yes	79 (5.5)	8 (0.6)	71 (4.9)	4.36 (1.91 - 6.88)	0.015*	2.34 (1.08 - 4.03)	0.013*
No	1351 (94.5)	2 (0.1)	1349 (94.4)	1		1	
Closeness of household to water body							
Yes	89 (6.2)	8 (0.6)	81 (5.6)	3.83 (1.80 - 6.31)	0.012*	8.84 (1.43 - 12.41)	0.016*
No	1341 (93.8)	2 (0.1)	1339 (93.7)	1		1	
Closeness of household to drainage tunnel							
Yes	301 (21.0)	3 (0.2)	298 (20.8)	1.60 (0.41 - 6.25)	0.494	2.13 (0.14 - 31.69)	0.582
No	1129 (79.0)	7 (0.5)	1122 (78.5)	1		1	
Closeness of household to overgrown vegetation							
Yes	112 (7.8)	1 (0.1)	111 (7.8)	1.31 (0.16 - 10.43)	0.799	0.24 (0.01 - 8.03)	0.431
No	1318 (92.2)	9 (0.6)	1309 (91.5)	1		1	
Availability of household toilet facility							
Yes	836 (58.5)	5 (0.3)	831 (58.1)	0.70 (0.20 - 2.45)	0.588	3.25 (0.19 - 55.02)	0.413
No	594 (41.5)	5 (0.3)	589 (41.2)	1		1	
Clothes hanging in a sleeping room							
Yes	493 (34.5)	4 (0.3)	489 (34.2)	1.26 (0.35 - 4.51)	0.713	0.79 (0.59 - 10.79)	0.865
No	937 (65.5)	6 (0.4)	931 (65.1)	1		1	
Using an insecticide mosquito coil							
Yes	835 (58.4)	3 (0.2)	832 (58.2)	0.30 (0.07 - 1.17)	0.084	0.13 (0.11 - 1.58)	0.110
No	595 (41.6)	7 (0.5)	588 (41.1)	1		1	
Use of mosquito repellent							
Yes	695 (48.6)	1 (0.1)	694 (48.5)	0.11 (0.01 - 0.91)	0.041*	0.04 (0.01 - 1.34)	0.073
No	735 (51.4)	9 (0.6)	726 (50.8)	1		1	
Using insecticide mosquito spray							

Yes	1008 (70.5)	3 (0.2)	1005 (70.3)	0.17 (0.04 - 0.68)	0.012*	0.44 (0.03 - 6.20)	0.551
No	422 (29.5)	7 (0.5)	415 (29.0)	1		1	
Uptake of IPTp-SP during ANC visits							
Always	842 (58.9)	3 (0.2)	839 (58.7)	0.29 (0.07 - 1.15)	0.079	NA	NA
Not always	588 (41.1)	7 (0.5)	581 (40.6)	1		1	
History of indoor residual spraying in household							
Yes	131 (9.2)	1 (0.1)	130 (9.1)	1.10 (0.13 - 8.77)	0.926	4.95 (0.14 - 167.33)	0.373
No	1299 (90.8)	9 (0.6)	1290 (90.2)	1		1	

HBV, hepatitis B virus; IPTp-SP, intermittent preventive treatment with sulfadoxine-pyrimethamine; ANC, antenatal care; COR, Crude odds ratio; AOR, Adjusted odds ratio; *, $p < 0.05$

(Source: Survey Data, 2024)

4.6. Socio-demographic and maternal predictors for co-infection of HBV with malaria

The study also examined the socio-demographic and maternal predictors of HBV and malaria co-infection among the pregnant women studied. In both bivariate and multivariate analyses, marital status, educational attainment, gravidity, and gestation were identified as predictors that were significantly associated with HBV and malaria co-infection, as shown in **Table 4.7**. As such, the likelihood of co-infection of HBV with malaria was 18.96 times higher among pregnant women who were not married (AOR = 18.96; 95% CI: 3.39 – 25.93) compared with those who were married. Furthermore, the risk of HBV and malaria co-infection was significantly higher among pregnant women with no formal education (AOR = 10.87; 95% CI: 8.72 – 14.87) compared with those with education. Likewise, the risk of HBV and malaria co-infection was 6.82 and 5.73 times higher among primigravidae and secundigravidae (AOR = 6.82; 95% CI: 2.74 – 8.48) and (AOR = 5.73; 95% CI: 2.54 – 7.80), respectively, compared with multigravida. Finally, pregnant women in their first trimester had significantly lower odds of being co-infected with HBV and malaria (AOR = 0.01; 95% CI: 0.00 – 0.09) than those in their second and third trimesters.

Table 4.7. Socio-demographic and Maternal Predictors of HBV and Malaria Co-infection among Pregnant Women

		Co-infection status					
	Frequency	Positive	Negative				
Variable	**n [%]**	**n [%]**	**n [%]**	**COR [95%CI]**	**p-value**	**AOR [95%CI]**	**p-value**
Age							
18-25	174 (12.2)	1 (0.1)	173 (12.0)	1.01 (0.06 - 2.21)	0.997	1.57 (0.01 - 4.49)	0.838
26-30	1088 (76.1)	8 (0.6)	1080 (75.5)	1.23 (0.15 - 2.95)	0.842	0.83 (0.04 - 1.35)	0.908
31-40	168 (11.7)	1 (0.1)	167 (11.7)	1		1	
Marital status							
Not married	118 (8.3)	7 (0.5)	111 (7.8)	27.43 (6.99 - 37.55)	0.000*	18.96 (9.39 - 25.93)	0.001*
Married	1312 (91.8)	3 (0.3)	1309 (91.5)	1		1	
Educational attainment							
No formal education	414 (28.9)	9 (0.6)	405 (28.3)	13.57 (1.71 - 17.57)	0.014*	10.87 (8.72 - 14.87)	0.048*
Formal education	1016 (71.1)	1 (0.1)	1015 (71.0)	1		1	
Household structure							
Extended	1086 (75.9)	8 (0.6)	1078 (75.4)	1.26 (0.26 - 6.00)	0.764	5.07 (0.57 - 44.91)	0.144
Nuclear	344 (24.1)	2 (0.1)	342 (23.9)	1		1	
Household type							
Compound house	1009 (70.6)	9 (0.6)	1000 (69.9)	3.78 (0.47 - 29.92)	0.208	0.49 (0.02 - 11.61)	0.660
Self-contain house	421 (29.4)	1 (0.1)	420 (29.4)	1		1	
Gravidity							
Primigravida	335 (23.4)	3 (0.2)	332 (23.2)	4.24 (2.43 - 7.01)	0.011*	6.82 (2.74 - 18.48)	0.012*

Secundigravida	624 (43.6)	6 (0.4)	618 (43.2)	4.56 (2.54 - 8.03)	0.006*	5.73 (2.54 - 11.80)	0.001*
Multigravida	471 (32.9)	1 (0.1)	470 (32.9)	1		1	
Parity							
Nulliparous	296 (20.7)	3 (0.2)	293 (20.5)	0.50 (0.30 - 0.83)	0.826	0.64 (0.01 - 0.84)	0.536
Multiparous	1134 (79.3)	7 (0.5)	1127 (78.9)	1		1	
Gestation							
First trimester	1051 (73.5)	2 (0.1)	1049 (73.4)	0.05 (0.01 - 0.31)	0.001*	0.01 (0.00 - 0.09)	0.000*
Second trimester	256 (17.9)	4 (0.3)	252 (17.6)	0.47 (0.11 - 1.92)	0.295	0.15 (0.01 - 1.55)	0.114
Third trimester	123 (8.6)	4 90.30	119 (8.3)	1		1	
Blood Group							
A	422 (29.5)	2 (0.1)	420 (29.4)	0.79 (0.11 - 5.69)	0.822	0.73 (0.10 - 5.27)	0.759
B	420 (29.4)	1 (0.1)	419 (29.3)	0.39 (0.03 - 4.42)	0.455	0.36 (0.03 - 4.04)	0.410
AB	251 (17.6)	5 (0.3)	246 (17.2)	3.40 (0.65 - 14.69)	0.145	3.08 (0.58 - 16.26)	0.185
O	337 (23.6)	2 (0.1)	335 (23.4)	1		1	

Key: HBV, hepatitis B virus; ANC, antenatal care; COR, Crude odds ratio; AOR, Adjusted odds ratio; *, $p < 0.05$

(Source: Survey Data, 2024)

4.7. Availability of interventions for collective control of HBV and malaria in pregnancy

Pregnant women require highly effective interventions to ensure collective control of HBV and malaria. Interventions for malaria and HBV include complete HBV vaccination, sulfadoxine-pyrimethamine (IPTp-SP), and usage of Long-lasting Insecticidal Nets (LLINs). Key informants highlighted the interventions as captured in this extract from IDIs:

"... In our unit, every eligible pregnant woman receives IPTp-SP, which is administered under observation. Also, we provide them with ITNs and encourage them to consider alternative mosquito prevention methods. As for HBV, they are strongly encouraged to undergo HBV vaccination…" – (In-charge, IDI-KSD)

"... For malaria, we provide pregnant women with ITNs and IPTp-SP. Regarding HBV, we educate them on how to protect themselves..." – (In-charge, IDI-PWD)

4.7.1. HBV vaccination, LLINs and IPTp-SP coverage among pregnant women

Table 4.8 presents the HBV vaccination coverage, utilisation of LLINs, and uptake of IPTp-SP among the pregnant women studied. 74.4% (95% CI: 72.1 – 76.6) have not been vaccinated against HBV and 60.3% (95% CI: 57.8 – 62.9) do not use the LLINs provided to them during their routine ANC visits. Of all the pregnant women studied, 73.5% were in their first trimester and hence were not due for IPTp-SP. Of the remaining (26.5%), 17.9% and 8.6% were in their second and third trimesters, respectively. Among the pregnant women due for IPTp-SP, 62.8%, 21.6%, 9.0%, and 6.6% had received ≤1, 2, 3 or ≥4 doses of IPTp-SP, respectively.

Table 4.8. HBV Vaccination, LLINs and IPTp-SP Uptake among Pregnant Women

	HBV vaccination coverage				
	Vaccinated		Not vaccinated		Total
Data Collection Site (Health Facility)	**[n]**	**[%]**	**[n]**	**[%]**	**[n]**
Atebubu-Amantin Municipal	79	5.5	144	10.1	223
Kintampo North Municipal	64	4.5	201	14.1	265
Kintampo South District	12	0.8	82	5.7	94
Nkoranza South Municipal	23	1.6	146	10.2	169
Techiman Municipal	145	10.1	254	17.8	399
Pru East District	30	2.1	147	10.3	177
Pru West District	14	1	89	6.2	103
Total	**367**	**25.6**	**1063**	**74.4**	**1430**
	LLINs utilisation				
	Yes		No		Total
Data Collection Site (Health Facility)	**[n]**	**[%]**	**[n]**	**[%]**	**[n]**
Atebubu-Amantin Municipal	55	3.8	168	11.7	238.5
Kintampo North Municipal	119	8.3	146	10.2	283.5
Kintampo South District	29	2	65	4.5	100.5
Nkoranza South Municipal	31	2.2	138	9.7	180.9
Techiman Municipal	166	11.6	233	16.3	426.9
Pru East District	88	6.2	89	6.2	189.4
Pru West District	79	5.5	24	1.7	110.2
Total	**567**	**39.7**	**863**	**60.3**	**1530**
	Uptake of IPTp-SP				
	Doses				
Data Collection Site (Health Facility)	**≤1**	**2**	**3**	**≥4**	**Total**
Atebubu-Amantin Municipal	27	13	4	2	46
Kintampo North Municipal	33	10	6	9	58
Kintampo South District	16	9	2	5	32
Nkoranza South Municipal	37	16	7	2	62
Techiman Municipal	72	20	9	4	105
Pru East District	31	9	4	2	46
Pru West District	22	5	2	1	30
Total	238	82	34	25	379
Percentage	**62.8**	**21.6**	**9.0**	**6.6**	**100**

(Source: Survey Data, 2024)

4.8. Barriers to adherence to hepatitis B virus (HBV) and malaria interventions

Despite the presence of interventions, several barriers hindered their adherence. These barriers were categorised into personal, psychological, and socio-cultural.

4.8.1. Personal barriers to adherence to interventions

In **Tables 4.9-14**, as explored by this study, the personal barriers to adherence included awareness of the disease, knowledge about the disease, age, occupational commitment, consultation, and discomfort. For knowledge as part of personal barriers to adherence to preventive guidelines or interventions, individual scores were categorised to determine the proportion of participants with extremely low, low, moderate, or high knowledge of HBV, malaria, and associated interventions.

4.8.1.1. Awareness of hepatitis B virus (HBV) and malaria

From **Table 4.9**, 95.3% and 96.6% had heard of and were aware of HBV and malaria, respectively, with only 9.2% exhibiting awareness of HBV and malaria co-infection. A significant difference was noted between pregnant women who were aware of HBV and malaria and their co-infections and those who were not ($p < 0.05$).

Table 4.9. Awareness of HBV and Malaria Infections

Infection	Observed	[%]	Expected	[χ2]	*[df]*	*[p]*
Hepatitis B viral infection						
Yes	1363	95.3	715	1174.56	1	0.0001
No	67	4.7				
Malaria						
Yes	1381	96.6	715	1240.72	1	0.0001
No	49	3.4				
HBV and malaria co-infection						
Yes	132	9.2	715	950.73	1	0.0001
No	1298	90.8				

(Source: Survey Data, 2024)

4.8.1.2. Knowledge of the HBV

The study found that pregnant women had limited knowledge about HBV transmission and symptoms, as presented in **Table 4.10**. Only small percentages believed in the likelihood of person-to-person transmission (3.8%), transmission by a healthy-looking person (6.6%), or through shared items like toothbrushes (7.4%). Vertical transmission

from mother to child during pregnancy (5.9%), delivery (8.4%), and breastfeeding (8.6%) were also noted. Awareness of HBV symptoms and prevention through vaccination was low, with only 1% recognizing vaccination as a preventive measure. Overall, 83.6% of the women demonstrated moderate knowledge about HBV, as shown in **Table 4.12.**

4.8.1.3. Knowledge of malaria

The study found that pregnant women had varying levels of knowledge about malaria, also presented in **Table 4.11**. Only a small percentage believed healthy individuals could carry malaria parasites (6.4%) and that transmission from female Anopheles mosquitoes could occur during the day (5.7%), at night (8.5%), or anytime (8.2%). Some women recognized fever with sweating (7.8%), headaches (9.8%), and loss of appetite (9.4%) as symptoms. They also identified mosquito habitats like ponds (16.4%) and overgrown vegetation (14.2%). Preventive measures such as using insecticide spray (17.6%) and sleeping under ITNs (18.5%) were acknowledged. Overall, 67.0% demonstrated a high level of malaria knowledge, as shown in **Table 4.12.**

Table 4.10. Pregnant Women's Knowledge of HBV

Responses	Extremely Likely		Very Likely		Somewhat Likely		Not Very Likely	
Variables	**[n]**	**[%]**	**[n]**	**[%]**	**[n]**	**[%]**	**[n]**	**[%]**
Compared with the AIDS virus, HBV can spread from person to person more easily.	55	3.8	1177	82.3	159	11.1	39	2.7
Can healthy individuals have HBV?	95	6.6	1200	83.9	102	7.1	33	2.3
Infected but healthy individuals can spread HBV	80	5.6	1177	82.3	143	10	30	2.1
HBV can be transmitted by consuming foods prepared by an infected person	74	5.2	1172	82	148	10.3	36	2.5
HBV can be transmitted by eating foods rechewed by an infected person.	84	5.9	1216	85	101	7.1	29	2
HBV can be transmitted by sharing a toothbrush with an infected person.	106	7.4	1190	83.2	109	7.6	25	1.7
HBV can be transmitted by sharing sharp objects with an infected person	101	7.1	1214	84.9	92	6.4	23	1.6
HBV can be transmitted by sharing earrings with an infected person.	94	6.6	1186	82.9	119	8.3	31	2.2
HBV can be transmitted through coughing by an infected person.	103	7.2	1177	82.3	121	8.5	29	2
HBV can be transmitted through unprotected sexual intercourse with an infected person.	99	6.9	1177	82.3	121	8.5	33	2.3
HBV can be transmitted by holding the hands of an infected person	79	5.5	1171	81.9	144	10.1	36	2.5
HBV can be transmitted from mother to child during pregnancy.	84	5.9	1171	81.9	144	10.1	31	2.2
HBV can be transmitted from mother to child during pregnancy.	120	8.4	1181	82.6	104	7.3	25	1.7
HBV can be transmitted from mother to child during breastfeeding	123	8.6	1162	81.3	116	8.1	29	2
HBV symptoms include fever	88	6.2	1135	79.4	174	12.2	33	2.3
HBV symptoms include fatigue	105	7.3	1174	82.1	125	8.7	26	1.8
The symptoms of HBV include appetite	117	8.2	1181	82.6	101	7.1	31	2.2
The symptoms of HBV include nausea,	103	7.2	1192	83.4	100	7	35	2.4
The symptoms of HBV include abdominal pain	103	7.2	1191	83.3	110	7.7	26	1.8
HBV symptoms include dark urine	111	7.8	1189	83.1	109	7.6	21	1.5
The symptoms of HBV include joint pain	116	8.1	1168	81.7	115	8	31	2.2
The symptoms of HBV include jaundice,	72	5	869	60.8	139	9.7	350	24.5
Do you know HBV can be prevented through vaccination?	14	1	276	19.3	102	7.1	1038	72.6

(Source: Survey Data, 2024)

Table 4.11. Pregnant Women's Knowledge of Malaria

Responses	Extremely Likely		Very Likely		Somewhat Likely		Not Very Likely	
Variables	**[n]**	**[%]**	**[n]**	**[%]**	**[n]**	**[%]**	**[n]**	**[%]**
Malaria is a serious disease, particularly in pregnant women and their babies.	92	6.4	1180	82.5	129	9	29	2
Possibility of a healthy and active person with no symptoms of malaria to acquire malaria	90	6.3	1152	80.6	152	10.6	36	2.5
Malaria is spread through bites from infected female *Anopheles* mosquitoes during the day	82	5.7	1158	81	155	10.8	35	2.4
Malaria is spread through bites from infected female *Anopheles* mosquitoes at night	121	8.5	1165	81.5	115	8	29	2
Malaria is spread via bites from an infected female *Anopheles* mosquito.	117	8.2	1126	78.7	152	10.6	35	2.4
Malaria can be transmitted from mother to child during pregnancy.	101	7.1	1061	74.2	238	16.6	30	2.1
Malaria can be transmitted from mother to child during pregnancy.	139	9.7	1080	75.5	181	12.7	30	2.1
The symptoms of malaria include fever and sweats.	112	7.8	1132	79.2	150	10.5	36	2.5
The symptoms of malaria include headache	140	9.8	1128	78.9	134	9.4	28	2
The symptoms of malaria include muscle joint pain	124	8.7	1137	79.5	146	10.2	23	1.6
The symptoms of malaria include loss of appetite	135	9.4	1111	77.7	155	10.8	29	2
The resting place of the mosquito includes dark spaces inside rooms.	142	9.9	1115	78	140	9.8	33	2.3
The resting places of mosquitoes include dirty areas	195	13.6	1116	78	91	6.4	28	2
The resting place of mosquitoes includes the edges of ponds or stagnant water.	234	16.4	1072	75	100	7	24	1.7
The resting places of mosquitoes include sheds of domestic animals.	217	15.2	1106	77.3	79	5.5	28	2
The resting places of mosquitoes include overgrown vegetation	203	14.2	1090	76.2	106	7.4	31	2.2
Malaria can be prevented by draining and cleaning choked gutters.	201	14.1	1078	75.4	129	9	22	1.5
Malaria can be prevented by regularly weeding the surroundings	237	16.6	1076	75.2	94	6.6	23	1.6
Malaria can be prevented using insecticide sprays.	252	17.6	1074	75.1	85	5.9	19	1.3
Malaria can be prevented by sleeping in insecticide-treated nets.	264	18.5	1057	73.9	84	5.9	25	1.7
Malaria can be prevented by prophylaxis	192	13.4	1097	76.7	109	7.6	32	2.2

(Source: Survey Data, 2024)

Table 4.12. Rating of Pregnant Women's Knowledge of HBV and Malaria

Variable	Scale	[n]	[%]
HBV			
Low	0 - 1.9	53	3.7
Moderate	2 - 2.9	1196	83.6
High	3 - 3.9	181	12.7
Malaria			
Low	0 - 1.9	47	3.7
Moderate	2 - 2.9	425	29.7
High	3 - 3.9	958	67.0

(Source: Survey Data, 2024)

4.8.1.4. Health implications of HBV and malaria co-infection (perceived severity)

From **Tables 4.13 and 14**, some pregnant women recognized the extreme likelihood of complications like preterm birth, stillbirth, low birth weight, and maternal death, with most showing high knowledge about the severity of HBV and malaria co-infection.

Table 4.13. Health Implications of HBV and Malaria Co-infection

	Extremely Likely	Very Likely	Somewhat Likely	Not Likely
Variable	**n [%]**	**n [%]**	**n [%]**	**n [%]**
Preterm birth	106 (7.4)	1124 (78.6)	164 (11.5)	36 (2.5)
Stillbirth	137 (9.6)	1105 (77.3)	169 (11.8)	19 (1.3)
Low birth weight	142 (9.9)	1088 (76.1)	170 (11.9)	30 (2.1)
Maternal deaths	140 (9.8)	804 (56.2)	378 (26.4)	108 (7.6)

(Source: Survey Data, 2024)

Table 4.14. Rating of Pregnant Women's Knowledge of the Health Implications of HBV and Malaria Co-Infection

Health implication	Scale	[n]	[%]
Low	0 - 1.9	169	11.3
Moderate	2 - 2.9	440	30.8
High	3 - 3.9	821	57.4

(Source: Survey Data, 2024)

4.8.1.5. Age, occupational commitment, consultation, and discomfort

As part of personal barriers to adherence to HBV and malaria interventions, lifestyle priorities despite the interventions were also assessed, as shown in **Table 4.15**. These included uncertainty about the intervention's worth to age (14.5%) and occupational commitment (19.4%). In addition, 79.4% of pregnant women did not consult healthcare providers about their planned intervention, and 19.0% identified discomfort as a barrier.

Table 4.15. Age, Occupational Commitment, Consultation, and Discomfort

Responses	Yes		No	
Barrier	**[n]**	**[%]**	**[n]**	**[%]**
Unsure of the worth of interventions due to age	208	14.5	1222	85.5
Occupational commitment	278	19.4	1152	80.6
Consultation	295	20.6	1135	79.4
Discomfort	271	19.0	1159	81.0

(Source: Survey Data, 2024)

During the FGDs, evidence was provided to substantiate the personal barriers mentioned. Some remarks included:

Firstly, regarding age as a barrier, some pregnant women mentioned: *"...In my opinion, younger women should be the ones taking IPTp-SP because they might be too lazy to sleep under a mosquito net..." – (4th Pregnant woman, FGD-TM).*

For occupational commitment, a pregnant woman highlighted: *"...I am a fishmonger. Because of this busy schedule, I have not had time to attend ANC or even consider taking the medication they provide for pregnant women..." – (7th Pregnant woman, FGD-PED).*

For consultation, a pregnant woman remarked*: "... Some nurses here do not take the time to explain the importance of the injection. They don't spend time discussing it with us so we can understand..." – (3rd Pregnant woman, FGD-PED).*

For discomfort, some of the consented pregnant women associated heat, body itching, fatigue, respiratory disorders, nausea, dizziness, headache, abdominal pains, depression, tiredness, and joint aches. These were highlighted:

"... I experience itching whenever I sleep in the mosquito nets..." – (6th Pregnant woman, FGD-NSM)

"... The injection is painful, and I feel stressed whenever I take the IPTp-SP medication..." – (2nd Pregnant woman, FGD-PWD)

4.8.2. Psychological barriers

Various psychological barriers to adherence to HBV and malaria interventions were assessed. As shown in **Table 4.16**, a quarter (25%) cited concerns about side effects, while 41.9% noted the absence of symptoms as a reason. Forgetfulness was identified by 16.6%, and 23.2% preferred herbal medicine for its perceived efficacy. In addition, 7.4% felt formal care did not meet their expectations, and 13.2% cited pain as a barrier. Uncertainty (27%), lack of trust in healthcare providers (18%), and distress over a family member's death (11.8%) were psychological barriers. Finally, 32.2% found prolonged adherence difficult.

Table 4.16. Psychological Barriers to Adherence to Intervention

Responses	Yes		No	
Barrier	**[n]**	**[%]**	**[n]**	**[%]**
Concern about the side effects of the intervention	358	25.0	1072	75.0
The absence of signs or symptoms of HBV and malaria	599	41.9	831	58.1

Table 4.16 Continued

Often forget due to daily routine	237	16.6	1193	83.4
Perceived efficacy of traditional herbal medicine	332	23.2	1098	76.8
Formal care does not meet expectations	106	7.4	1324	92.6
Feel pain to intervention	189	13.2	1241	86.8
Unsure whether the interventions are necessary	386	27.0	1044	73.0
Lack of trust in health service providers	258	18.0	1172	82.0
Distress about the death of a family member	169	11.8	1261	88.2
Getting tired of the prolonged period of adherence	460	32.2	970	67.8

(Source: Survey Data, 2024)

The FGDs with selected pregnant women yielded valuable insights, as participants provided remarks that supported the identified psychological barriers.

Regarding the fear of side effects, the participants made the following remarks:

"... After the first injection, I could not raise my arm for nearly 3 days..." – (5th Pregnant Woman, FGD-TM)

Regarding the absence of signs or symptoms, another pregnant woman emphasised:

"... I do not notice the presence of mosquitoes. I rarely experience headaches, high body temperature, or joint pains..." – (3rd Pregnant Woman, FGD-NSM)

Regarding forgetfulness, a pregnant woman commented:

"... I was informed that I needed three injections for complete vaccination. I took two but forgot the exact date for the third..." – (4th Pregnant Woman, FGD-PED)

In line with the perceived efficacy of herbal medicine, a pregnant woman commented:

"... Every time I take the IPTp-SP, I feel weak. Instead, I go to Kwapongs pharmacy to get Taabea Herbal..." – (6th Pregnant Woman, FGD-ATM)

Regarding the lack of trust in health service providers, a pregnant woman highlighted:

"... Some nurses here do not take the time to explain the importance of the injection. If you ask them questions, they will respond rudely..." – (3rd Pregnant Woman, FGD-PED)

4.8.3. Socio-cultural barrier

Table 4.17 highlights the socio-cultural barriers to HBV and malaria intervention adherence among pregnant women. Key factors include family neglect (24.9%), religious prohibitions (4.9%), taboos (5.5%), fear of divine punishment (12.5%), and beliefs in spiritual poisoning (15.8%).

Table 4.17. Socio-Cultural Barriers to Adherence to Interventions

Responses	Yes		No	
Barrier	**[n]**	**[%]**	**[n]**	**[%]**
Neglect by family members	356	24.9	1074	75.1
Religious prohibition	70	4.9	1360	95.1
Taboo	78	5.5	1352	94.5
Devine punishment	179	12.5	1251	87.5
Spiritual poison	226	15.8	1204	84.2

(Source: Survey Data, 2024)

During the FGDs, some pregnant women provided remarks that substantiated the sociocultural barriers identified.

In line with religious prohibitions, a pregnant woman remarked:

"... When COVID-19 emerged, our pastor advised us to resist any form of vaccination..." – (1st Pregnant Woman, FGD-NSM)

For taboo, divine punishment, and spiritual poisoning, a pregnant woman said:

"... In Volta, there is a common belief that our gods can inflict diseases like 'Aklame-dor' (meaning liver inflammation), and 'Efutome-dor' (meaning jaundice) on anyone who disrespects them..." – (4th Pregnant Woman, FGD-PED)

CHAPTER FIVE

DISCUSSION

5.0. Introduction

This chapter discusses the study's results based on the objectives of the study. The scope includes the socio-demographic and maternal characteristics of the pregnant women studied and the prevalence, risk factors, and predictors of HBV and malaria co-infections. It also discusses the various barriers to adherence to HBV and malaria interventions and concludes with a discussion of the findings in relation to the theoretical and conceptual frameworks.

5.1. Prevalence of hepatitis B virus (HBV) and malaria co-infection

This study reported 0.70% co-infection of Hepatitis B virus and malaria among pregnant women with varied frequencies across the study site. The study was grounded on the null assumption that "*there is no statistically significant difference in the prevalence of hepatitis B virus (HBV) and malaria co-infection among pregnant women in the Bono East Region of Ghana compared to those without co-infection of HBV with malaria*", as against the alternative hypothesis that "*there is a statistically significant difference in the prevalence of hepatitis B virus (HBV) and malaria co-infection among pregnant women in the Bono East Region of Ghana compared to those without co-infection with HBV and malaria*". The result showed that there was a significant difference between the proportion of pregnant women who were co-infected with HBV and malaria and those who were not co-infected (χ^2 = 1190.28, DF = 1, $p < 0.05$). Specifically, the proportion of pregnant women who were co-infected with HBV and malaria was lower than those who were not co-infected. This provided enough evidence to warrant the rejection of the null hypothesis.

This study's result is consistent with previous studies in Ghana and Nigeria, which reported co-infection rates ranging between 0.7 and 16% (Abah et al., 2019; Asantewaa et al., 2023; Helegbe et al., 2018; Omatola & Okolo, 2021).

5.2. Risk factors for hepatitis B virus (HBV) and malaria co-infection

The study further revealed that the risk of HBV and malaria co-infection was significantly higher among pregnant women with a history of blood transfusion. This association could be attributed to several factors, including the prevalence of these diseases in the donor population, poor screening, and transfusion protocols. As a standard practice, the World Health Organisation (WHO) recommends that all donor blood should screened for HIV, syphilis, HBV, and malaria, particularly in malaria-endemic countries in sub-Saharan Africa (Tetteh et al., 2023; WHO, 2023b). However, in Ghana, malaria is not screened during blood donation despite its potential transmission through blood products (Tetteh et al., 2023).

For the presence of HBV in the donor population, at the exposure and early infection stage, usually between 0 – 4 weeks, HBV may be present but undetectable in routine tests (Nguyen et al., 2020). Similarly, studies have also shown that HBV infection has a "*window period*", which usually occurs between 4 – 12 weeks following infection (Fasola et al., 2021). During this period, an infected person may test negative for HBsAg and could transmit the virus to others, including through blood transfusions. This has been supported by some studies conducted among blood donors in Ghana and Nigeria which reported HBV and malaria co-infection of 59.2% (Freimanis et al., 2012) and 40.7 (Aernan et al., 2011), respectively.

Regarding the presence of *Plasmodium falciparum* in the donor population, Tetteh et al. (2023) reported a 2.5% prevalence of *Plasmodium falciparum* trophozoites among

blood donors in the coastal belt of Ghana (Tetteh et al., 2023). Likewise, the prevalence of 3% and 8% *Plasmodium* parasitaemia were reported among blood donors using microscopy and RDT, respectively, in the Kumasi Metropolis, Ghana (Adusei & Owusu-Ofori, 2018).

The study further revealed that the likelihood of co-infection was highly high among pregnant women with a history of street nail trimming. Street nail trimming is very common in Ghana because of the diversity of cultural practices and preferences (Adjei-Gyamfi et al., 2025). Pregnant women who subscribe to these practices do it for various purposes, including beautification, a sign of identity, and low cost. In the focus group discussions, some pregnant women expressed the following:

"… For me, I mostly rely on the services of street nail trimmers (Abookyi) for my nail care, even before I became pregnant. Now that I am pregnant, I still call on them because I cannot bend comfortably to trim my nails. Plus, they do a great job, and my nails look clean and well-groomed afterwards…" (7th Pregnant woman, FGD-ATM)

Unlike clinical settings, street-based cosmetic procedures may lack adequate sterilization of instruments such as nail clippers, razors, and needles (Rutala & Weber, 2016). In addition, these services may also lack access to proper hand hygiene, antiseptics, or disposable tools, which further increase the risk of HBV transmission (Adjei-Gyamfi et al., 2025). This association could be attributed to cross-infection resulting from the reuse of contaminated trimming instruments.

The study also revealed an increased likelihood of HBV and malaria co-infection among pregnant women living closer to refuse dumping sites and water bodies. This may be attributed to several environmental, behavioural, and biological factors. Refuse dumping sites and water bodies often create suitable breeding grounds for *Anopheles*

mosquitoes (Bardoe et al., 2024). This site may also experience inadequate waste management, leading to improper disposal of shared needles, or unsterile medical equipment (Raphela et al., 2024). Pregnant women living near such sites are more likely to experience frequent mosquito bites, increasing the risk of malaria (Bardoe et al., 2024). Moreover, proximity to sites with inadequate sanitation could also increase the risk of exposure to HBV through open wounds or mucous membranes (Raphela et al., 2024). The combined effects of these factors are likely to facilitate the likelihood of HBV and malaria co-infection, as observed in this study.

5.3. Socio-demographic and maternal predictors of co-infection

The study further revealed that marital status, educational attainment, gravidity, and gestation were independent predictors significantly associated with increased risk of HBV and malaria co-infection among the pregnant women studied ($p < 0.05$). The increased risk of co-infection among unmarried pregnant women could be attributed to possible multiple sexual partners and their inability to afford healthcare services, lack of support, and behavioural practices that could expose them to these infections (Tripathi & Mousa, 2023). Because HBV is transmitted through bodily fluids, including semen (Tripathi & Mousa, 2023), unprotected sexual activity could facilitate the exchange of the virus. Moreover, the practice of multiple sex partners increases the risk of contracting several sexually transmitted infections (STIs). STI comorbidities increase the likelihood of HBV infection due to genital inflammation or compromised immune systems (Marseille et al., 2021). Furthermore, unmarried women often lack income and social support systems networks (Deschênes et al., 2020), making them vulnerable to these diseases (Grand-Guillaume-Perrenoud et al., 2022).

In this current study, education was significantly associated with HBV and malaria co-infection. This is affirmed by a study conducted in Northern Ghana (Anabire et al., 2019), even though the reported odd ratio differs from that found in this study. In this present study, pregnant women with no formal education had 10.87 times the odds of being co-infected, a possible indication of a lack of knowledge of the various preventive guidelines (Boachie et al., 2024) and limited responsiveness to seeking early medical care (Khoza et al., 2023).

This study also demonstrated a significant association between gravidity and HBV and malaria co-infection, which is contrary to previous studies in Northern Ghana (Anabire et al., 2019; Helegbe et al., 2018). Co-infection was higher among primigravidae and secundigravida and could be linked to substantial changes in immunity among pregnant women due to hormonal alterations (Abu-Raya et al., 2020). These changes in immunity could increase the likelihood of infections (Zhang et al., 2023), while multiple pregnancies enhance the immunity against malaria (Cutts et al., 2020; Tran et al., 2020). Attitudinal changes regarding the adherence to interventions among pregnant women of lower gravidity could increase the risk of infections (Moshi et al., 2020). Also, for secundigravida, due to several routine activities associated with ANC visits, labour, delivery and postnatal care, there could be nosocomial transmission due to increased exposure to risk factors, such as blood transfusion, intravenous drugs and/or surgical procedures (Anaedobe et al., 2015).

Gestation had a significant association with HBV and malaria co-infection. This is in agreement with a previous study in Northern Ghana (Helegbe et al., 2018). In the current study, the likelihood of co-infection was lower among pregnant women in their first trimester of pregnancy, contradicting a previous study by Anabire et al. (2019).

5.4. Barriers to adherence to hepatitis B virus (HBV) and malaria interventions

The study revealed a very low viral hepatitis B (HBV) vaccination coverage among pregnant women. This finding is consistent with a previous study that has also reported low vaccination coverage among pregnant women (Boachie et al., 2024). Low vaccination rates might be attributed to inadequate access to healthcare services, lack of awareness of HBV, and cultural barriers, as highlighted by previous studies conducted in Ghana and other low- and middle-income countries (LMICs) (Faniyi et al., 2024; Nartey et al., 2022).

Likewise, the majority of the pregnant women did not use the LLINs provided during ANC visits. This mirrors the series of trends reported in other sub-Saharan African countries, despite significant investments in malaria control interventions (Leal Filho et al., 2023; Negasa et al., 2024). Their low utilization is worrying due to their high susceptibility to malaria, which increases their risk of miscarriage, stillbirth, low birth weight, and maternal death (Tamir et al., 2023). The low utilisation rate observed in this study could be attributed to multiple factors including discomfort, lack of proper knowledge regarding the importance of LLINs, and socio-economic, and socio-cultural beliefs (Negasa et al., 2024).

Furthermore, among those eligible, 62.8% had received ≤1 dose of IPTp-SP, 21.6% had received 2 doses, 9.0% had received 3 doses, and only 6.6% had received ≥4 doses. This finding aligns with evidence from other sub-Saharan African countries where IPTp-SP coverage remains suboptimal (Adeojo & Fayehun, 2024; Xu et al., 2024), despite recommendations from the World Health Organization (WHO) to administer at least three doses of IPTp-SP to all pregnant women in malaria-endemic areas (Figueroa-Romero et al., 2022). The low uptake could be attributed to stockouts of SP drugs

(Aberese-Ako et al., 2021), delays in initiating ANC visits, and poor quality of healthcare services (Boachie et al., 2024). Also, misinformation about the side effects and safety concerns may reduce IPTp-SP adherence (Aberese-Ako et al., 2021)

5.4.1. Personal barriers to adherence to interventions

The personal barriers that compromised the adherence to interventions were awareness of the disease, knowledge about the disease, and lifestyle priorities despite the interventions. Regarding awareness and knowledge of HBV and malaria mono-infections, the study revealed that most of the pregnant women studied were fully aware of these infections and had moderate to high knowledge regarding them. This is in line with a series of earlier studies from different ecological zones (Adum et al., 2023; Venkatesh et al., 2023). Good awareness and knowledge of infections could be linked with superior responsiveness to HBV and malaria transmission. This could promote the likelihood of adopting preventive measures, including the use of ITNs, adhering to the uptake of IPTp-SP, vaccination, practising safe sex, and avoiding risky behaviours such as sharing items and staying close to mosquito breeding sites. However, lower levels of awareness and knowledge, as reported in this study, could mean that pregnant women stand a higher chance of not adhering to preventive guidelines or interventions, and with this, there is a heightened risk of infections.

The study further revealed some lifestyle priorities, including non-adherence due to age, as evident from the focused group discussions (FDGs). Age as a barrier to adherence to intervention has also been reported in a previous study (Mekuria et al., 2016). Similar to the current study, these previous studies have associated high levels of non-adherence among young individuals. Pregnant women who emphasised non-adherence due to age had increased odds of being infected with HBV. In the series of FDGs with some of the

consented pregnant women, there was a certain perception that some interventions were age-specific and that a certain cohort of pregnant women needed these interventions. Some pregnant women incorrectly presumed that HBV primarily affects older individuals and that malaria is more severe in younger people. These misconceptions about disease susceptibility and the effectiveness of interventions for certain age groups might have led to the false belief that only certain age groups need protection against certain infections.

Another factor contributing to the assumption that certain age cohorts should be the ones adhering to the interventions could be health education given during ANC visits (Urmale Mare et al., 2022). If the health education provided during ANC sessions is not age-inclusive and thus disproportionately focuses on a certain age cohort or risk group without completely emphasising that the interventions are for all pregnant women, some pregnant women may think the interventions are targeted to the focused group (Lori et al., 2024). This may, in turn, shape their perception and hence, be a barrier to adherence to intervention. This observation highlights the need for inclusive health education during ANC sessions to inform all pregnant women regardless of their age that interventions are not targeted at certain age groups, and hence adhering to these interventions regardless of age is crucial.

The results of the current which showed that occupational commitment is a significant personal barrier to adherence to interventions are of interest. A considerable proportion of the pregnant women emphasised that their private or professional duties were hardly compatible with adherence to the interventions. The pregnant women who highlighted this as a barrier had a high level of dedication to their jobs or professions, and this resulted in the attachment of strong priority to their work responsibilities over their

health. For instance, some pregnant women found it difficult to attend ANC due to the limited time and work schedules. According to them, the time they attend the ANC conflicts with the operational hours of their work. This observation is consistent with previous studies that also reported occupational commitment as a barrier to adherence to health interventions (Okafor & Goon, 2022; Penman et al., 2023).

Additionally, lack of consultation was revealed as a barrier to adherence to intervention. Consultation with healthcare providers regarding the planned course of interventions could significantly influence the management of pregnancy-related complications by fostering effective communication to better understand the need for adherence to interventions. In such a circumstance, health education on risk factors, and the consequences of these infections on pregnancy are provided to further reinforce their cue to behaviour modification. This could aid in curtailing the risk of adverse outcomes that could result from pregnancy-related diseases. This is affirmed by a previous study that highlighted that consultation provides counselling avenues, where pregnant women receive education regarding transmission, prevention, and several treatment options (Lu et al., 2023). These are crucial for reducing the burden of HBV and malaria among pregnant women. In contrast, pregnant women who do not consult their healthcare providers regarding a planned course of intervention might be at a higher risk of infections because of limitations in information concerning the importance of the intervention in promoting maternal safety, which is affirmed by previous studies (Djaogol et al., 2019; Penman et al., 2023).

Finally, discomfort during adherence was also revealed as a barrier to compliance. Some consented pregnant women associated heat, body itching, fatigue, respiratory disorders, nausea, dizziness, headache, abdominal pains, depression, tiredness, and joint aches as

discomforts that contributed to them compromising their adherence to interventions. Several earlier studies have associated discomfort as a significant barrier to non-adherence to intervention (Abebe et al., 2022; Okafor & Goon, 2022). Most of the pregnant women aligned with this barrier ascribe it to the HBV injection, IPTp-SP, and ITNs. Previous literature has found that IPTp-SP could cause side effects like nausea, fatigue, dizziness, or skin itching (Figueroa-Romero et al., 2022). Similarly, the use of ITNs has been associated with heat, itching, or a feeling of suffocation (Akello et al., 2022). These adverse effects could lead to non-adherence, thereby increasing the risk of transmission of these infections. To reduce non-adherence due to discomfort, health campaigns regarding the importance of adherence and managing expectations of side effects could be strengthened during ANC visits (Baryakova et al., 2023).

5.4.2. Psychological barriers to adherence to interventions

This study revealed fear of side effects, absence of signs and symptoms, forgetfulness, perceived efficacy of traditional herbal medicine, a perception that formal care does not meet expectations, pain, uncertainty, misplaced trust in healthcare providers, distress about the death of a family member, and fatigue as psychological barriers to adherence to interventions. Fear of side effects and prolonged periods of adherence to the intervention were also affirmed by several earlier studies (Adeniyi et al., 2018; Auriti et al., 2021; Dun-Dery et al., 2021; Penman et al., 2023). Some interventions for HBV and malaria have several side effects (CDC, 2024; Figueroa-Romero et al., 2022). With prolonged periods of adherence, pregnant women may overestimate the effectiveness of the interventions and associate their usage with negative outcomes (Joseph Davey et al., 2022), leading to lower rates of adherence and an increased likelihood of transmission.

The study also revealed the absence of signs and symptoms and forgetfulness as barriers to adherence, which are also affirmed by a series of earlier reports (Adeniyi et al., 2018; Adjei et al., 2019). This could largely be attributed to lower awareness and knowledge of the infections, their transmission, and risk factors. Both HBV and malaria can be asymptomatic, and most people infected may not show symptoms (Tripathi & Mousa, 2023). Most pregnant women may not perceive the urgency to follow through with medical interventions and recommended preventive guidelines when they do not feel sick, thereby compromising their adherence to interventions (Alhassan et al., 2022).

Similarly, the perceived efficacy of alternative medicine, the opinion that conventional care did not meet their expectations, and the lack of trust in healthcare providers were also revealed as barriers to adherence to interventions. These conform to earlier reports (Adjei et al., 2019; Agyei-Baffour et al., 2017; Penman et al., 2023). Pregnant women may rely on alternative medicines because of the perception that formal care does not meet expectations, herbal formulations have few or no side effects, provision of quick relief, cultural beliefs, family traditions, or personal experiences (Makombe et al., 2023). This could breed distrust in conventional medicine and healthcare providers, leading to lower adherence to recommended interventions. Improving accessibility to interventions and integrating culturally sensitive or responsive approaches into health educational routines during ANC visits could mitigate these barriers.

The results of the current study also showed that pain is a barrier that compromises adherence to intervention among pregnant women. This observation is consistent with the results of previous studies conducted elsewhere (Okafor & Goon, 2022; Shanmugalingam et al., 2020). Pain associated with non-adherence could be attributed to the side effects of interventions. To bridge this barrier and improve adherence, safe

analgesics and anti-inflammatory drugs could be given alongside interventions such as IPTp-SP and HBV injections to relieve pregnant women's pain.

Another important barrier to adherence which was revealed in the current study was uncertainty about the necessity of the interventions. This barrier has also been reported in previous studies (Okafor & Goon, 2022; Penman et al., 2023). This barrier stems from the lack of clarity regarding the necessity, benefits, and potential side effects of the interventions (Klaic et al., 2022). Inadequate education or information during ANC visitation and the cultural orientation of pregnant women may have necessitated this barrier. Providing pregnant women with comprehensive, clear, consistent, and culturally oriented information regarding the interventions, including their effectiveness in reducing the burden of these diseases could help mitigate this barrier.

Lastly, the current study showed distress over the death of a family member due to interventions as another barrier to adherence to interventions. A previous study also made such an observation (Mostafavi et al., 2021). Usually, the death of a family member could impose significant psychological distress on individuals. The distress may come along with grief, fear, depression, and anxiety (Joaquim et al., 2021). This emotional instability may interrupt regular adherence associated with positive health-related behaviours, increasing susceptibility to infections. The provision of psychosocial support by integrating mental health education into routine ANC sessions could aid in sensitising pregnant women who might have experienced a family loss due to the perceived effects of interventions.

5.4.3. Socio-cultural barriers to adherence to interventions

Some socio-cultural barriers that compromised adherence included neglect by family members, religious prohibitions, taboos, divine punishment, and spiritual poisoning.

Most cultures view the family as the most critical unit (Bau & Fernández, 2023). The roles of families vary from being the primary unit of social organisation to financial support, social structures, care, and, most importantly, preserving the cultural values of society (Elsayed, 2024). Neglect by family members could lead to many psychological and emotional imbalances ranging from resentment, stigma, isolation, shame, depression, and anxiety (Brandt et al., 2022). Consequently, individuals faced with these emotional disparities would be unlikely to adhere to interventions (Ghazzawi et al., 2023; Penman et al., 2023). Increasing support systems that facilitate the family's responsiveness and orientation regarding adherence and creating a supportive environment for the pregnant woman could help improve adherence to interventions.

The highlighting of religious prohibitions, taboos, divine punishment, and spiritual poisoning as barriers to adherence also aligns with the results of previous studies (Azia et al., 2023; Onyeneho et al., 2023). These could be attributed to fear of judgement or punishment from supreme beings. In some Muslim-dominated societies, for example, the use of vaccines containing gelatine derived from pigs is forbidden unless halal-certified alternatives are provided (Alsuwaidi et al., 2023). In addition, some customs see adherence to intervention as challenging the decree of supreme beings. These customs presume illnesses as a way of drawing people closer to divinity and appreciating the existence of supreme beings (Kahissay et al., 2017). These religious and ancestral beliefs have given credence or supremacy to certain individuals regarded as living representatives of supreme beings or ancestors (gods). As authoritative individuals, they tend to enforce specific prohibitions regarding interventions to diseases on their followers, as highlighted in the FDGs with some of the consented pregnant women. For some pregnant women, prohibitions arising from their faith-based perspectives may influence their decisions about adherence to interventions, especially

screening, vaccination, and treatment for HBV. From another perspective, some pregnant women perceived diseases, especially HBV, as an after-effect of moral shortcomings or divine retribution. This perception is common among most people, especially in peri-urban settings (Adjei et al., 2018, 2019). Pregnant women with such an orientation may feel shame or guilt, which could breed delay in seeking care and possibly adhering to intervention (Adjei et al., 2019). Similarly, the revelation of spiritual poisoning as a barrier to compliance with disease control interventions is worthy of note. This is because, in such circumstances or societies where such a barrier is prevalent, most people reportedly associate the aetiology of diseases with vindictive spiritual forces or witchcraft (Burabari & Grace, 2023). Instead of adhering to formal interventions, such a belief could cause pregnant women to resort to traditional healers or prayer centres (Aberese-Ako et al., 2022).

5.5. Discussion of findings in relation to the Health Belief Model (HBM)

The study examines the application of the Health Belief Model (HBM) in understanding pregnant women's adherence to preventive interventions for Hepatitis B Virus (HBV) and malaria. Drawing on existing research, the study focuses on how HBM factors including perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (Ghorbani-Dehbalaei et al., 2021; Rosenstock et al., 1994) influence behaviour related to the use of preventive measures, particularly in the context of maternal and neonatal health.

This study employed perceived susceptibility and severity as the individual predictors influencing adherence to interventions (Baek et al., 2022). It highlights that most pregnant women involved in the study had a high level of awareness of HBV and malaria, indicating a strong perceived susceptibility to these infections. They recognized

that HBV could be transmitted through actions such as sharing personal items or from seemingly healthy individuals. Similarly, awareness of malaria and its transmission was widespread. Importantly, many women understood the severe consequences of contracting these diseases during pregnancy, such as preterm birth, stillbirth, and maternal death. This awareness of the potential complications reflects a high perceived severity of the diseases.

Despite this, the study found a gap between awareness and action. Although women recognized their susceptibility to HBV and malaria and acknowledged the severity of these diseases, adherence to preventive interventions was low. This trend aligns with earlier studies, which also found that a high perception of disease risk does not always translate into preventive behaviours (Atibila et al., 2022).

Pregnant women were encouraged to use various interventions, including long-lasting insecticidal nets (LLINs), intermittent preventive treatment in pregnancy with sulfadoxine-pyrimethamine (IPTp-SP), and HBV vaccination, all of which were presented as highly beneficial in preventing malaria and HBV infection, highlighting strong perceived benefits (Alyafei & Easton-Carr, 2024). Most women acknowledged these perceived benefits. For example, the free distribution of LLINs and IPTp-SP indicated a basic understanding of the protective benefits these measures offered. However, adherence to the recommended doses of IPTp-SP and consistent use of LLINs was still low. Similarly, uptake of the HBV vaccine remained low, despite awareness of its importance. The findings suggest that perceived benefits alone may not be enough to drive compliance. This observation is supported by previous research, such as Muiruri et al. (2023), which also found that a strong perceived benefit does not necessarily lead to adherence to preventive interventions (Muiruri et al., 2023).

The study identified several perceived barriers that hindered adherence to both HBV and malaria prevention measures (Alyafei & Easton-Carr, 2024),. These included occupational commitments, financial constraints, cultural and spiritual beliefs, and fears about pain or side effects. For instance, despite being educated about the importance of the HBV vaccine, financial barriers and cultural misconceptions limited uptake. Similarly, reluctance to use LLINs or take IPTp-SP often stemmed from perceived discomfort or distrust in the efficacy of these measures. This finding resonates with Ihm et al. (2021), who highlighted that perceived barriers are strong determinants of non-compliance (Ihm et al., 2021).

The study also examined the role of cues to action, such as health education sessions, antenatal care (ANC) visits, and community campaigns. These cues were designed to encourage adherence to preventive measures. Midwives played a significant role in providing education about the risks of HBV and malaria, yet these cues often proved insufficient to overcome the barriers mentioned earlier. While cues to action did motivate some women to adopt preventive behaviours, the overall impact was limited by the strong influence of perceived barriers. This finding aligns with Nelson et al. (2021), who emphasized the need for more tailored and context-specific cues that account for the unique barriers women face (Nelson et al., 2021).

Finally, a key challenge identified in the study was the low level of self-efficacy among pregnant women. For example, many women found the use of LLINs uncomfortable, while others believed that taking IPTp-SP was not a wise decision, which affirmed an earlier finding (Aberese-Ako et al., 2021). Similarly, financial difficulties, coupled with cultural or religious beliefs, undermined confidence in the ability to follow through with HBV vaccination. This lack of self-efficacy is consistent with previous findings which

also reported low confidence among pregnant women in carrying out recommended health behaviours (Bayrami et al., 2024). Improving self-efficacy may be crucial in enhancing adherence to health interventions. Strengthening support systems, addressing financial barriers, and offering more personalized health education could significantly the risk of maternal HBV and malaria mono-or co-infection (Tavakoly-Sany et al., 2024).

CHAPTER SIX

SUMMARY OF THE FINDINGS, CONCLUSION, RECOMMENDATION, AND POLICY IMPLICATION

6.0. Introduction

This chapter summarizes the findings, recommendations, and conclusions. It reviews the research objectives and summarizes the findings. The chapter further explores various recommendations for implementation and highlights some areas for future research directions. Finally, it concludes with a conclusion statement.

6.1. Summary of the findings

This study revealed a 0.7% (95% CI: 0.37 – 1.29) prevalence of HBV and malaria co-infection among the studied pregnant women. This highlights the importance of integrated disease management strategies to mitigate health risks in this vulnerable population. Moreover, the multivariate analysis revealed that blood transfusion and street nail trimming were significant independent risk factors ($p < 0.05$). These findings highlight the importance of rigorous blood screening protocols, sterilization practices, and hygienic nail care education to minimise the co-infection risk. Furthermore, this study revealed that being unmarried, lack of formal education, lower gravidity, and advanced gestation were associated with a higher risk of co-infection ($p < 0.05$), which also highlights the importance of comprehensive education, support systems and healthcare access. Finally, the current study revealed personal, psychological, and socio-cultural barriers that significantly impacted adherence.

6.2. Conclusion

The study revealed a low prevalence of HBV and malaria co-infection among pregnant women in the Bono East Region of Ghana, highlighting the public health importance

of this dual burden. Key risk factors, including blood transfusion and street nail trimming, suggest the need for specific interventions targeting these behaviours. Strengthening maternal health interventions that address both blood safety and personal hygiene practices could help mitigate the risk. Socio-demographic factors such as marital status, educational attainment, gravidity, and gestation were significantly associated with co-infection susceptibility, warranting targeted interventions for high-risk groups. Moreover, low adherence to HBV vaccination, long-lasting insecticidal nets (LLINs), and intermittent preventive treatment for malaria in pregnancy with sulfadoxine-pyrimethamine (IPTp-SP) were observed. This was influenced by barriers such as occupational commitments, age, discomfort, perceived lack of side effects, prolonged adherence periods, and socio-economic and cultural beliefs. To address these gaps, tailored interventions should focus on increasing awareness about the importance of adherence, enhancing healthcare accessibility, and engaging communities in educational campaigns that tackle socio-economic and cultural barriers.

6.3. Recommendations

This study recommends a multi-sectoral approach that combines the action of the Government, Ministry of Health (MoH), Ghana Health Service (GHS), and the various health facilities to reduce mono-or co-infection rates and improve maternal health outcomes in Ghana:

6.3.1. Government of Ghana (GoG)

1. The government should legislate mandatory malaria screening for blood donations, especially in malaria-endemic areas, to reduce the risk of HBV and malaria co-infection transmitted through blood transfusion.

2. The government should enact policies to regulate street nail trimming and strengthen health education targeting people involved in these practices.
3. The government should increase funding for integrated disease control programs targeting HBV and malaria, especially in high-risk regions.

6.3.2. Ministry of Health (MoH)

1. The Ministry of Health (MoH) should enhance the hepatitis B vaccination program, particularly for pregnant women, through increased coverage and community outreach. In regions where vaccination rates are low, special attention should be given to increasing access.
2. The Ministry of Health should enhance health data and services interoperability to improve the management and outcomes of HBV and malaria during pregnancy. This could be achieved by ensuring that all healthcare facilities use compatible electronic health record systems that share patient information seamlessly across different levels of care.

6.3.3. Ghana Health Service (GHS)

1. The Ghana Health Service (GHS) should improve the quality of ANC services by addressing stockouts of IPTp-SP, ensuring adequate supplies of insecticide-treated nets (ITNs), expanding vaccination coverage, and improving staff training on the administration of these interventions. Consistent monitoring and feedback mechanisms should be instituted to assess the effectiveness of these programs.
2. The Ghana Health Service (GHS) should strengthen maternal health services, enhance surveillance systems, and improve data collection for better health planning

6.3.4. Health facilities

1. The health facilities should develop standard operations for home healthcare by assigning healthcare personnel to groups of pregnant women to provide healthcare services, including screening for HBV and malaria, administering treatments, monitoring maternal and foetal health, and providing education and counselling. This could be achieved by determining an optimal number of pregnant women per group that a healthcare team (consisting of midwives, obstetricians, health educators, and community health nurses) can manage effectively.
2. The health facilities should foster strong collaboration between health stakeholders and religious, community, or traditional leaders to endorse and promote adherence to help moderate religious and cultural barriers.
3. The health facilities should encourage continuous professional development for healthcare providers on the management of co-infections and reinforce adherence to prevention guidelines.

6.3.5. Pregnant women

1. Pregnant women should attend all scheduled antenatal care (ANC) visits to receive timely vaccinations, health education, and regular screenings for HBV and malaria.
2. Pregnant women should seek early testing and treatment for HBV and malaria to improve outcomes through timely intervention and management.
3. Pregnant women should maintain proper hygiene and sanitation, avoiding exposure to unsanitary conditions to reduce the risk of infections.

4. Pregnant women and the general public should be educated on the risks associated with non-clinical body modifications and street-based cosmetic procedures.

6.4. Policy implication

The findings of this study highlight several critical policy implications that could drive meaningful change in public health focus aimed at improving maternal healthcare outcomes. Addressing the dual burden of HBV and malaria among pregnant women requires a multifaceted approach that prioritizes resource allocation, education, and targeted interventions. The following policies, when considered could offer a roadmap for more effective mechanisms to reduce transmission and burden of maternal HBV and malaria. These include:

1. Prioritization of maternal health services: The government should prioritize funding and resource allocation to enhance maternal healthcare facilities, with a specific focus on preventing co-infections among pregnant women.
2. Strengthening health education programs: Policymakers must invest in comprehensive health education campaigns to improve awareness about HBV and malaria prevention. These programs should emphasize vaccination, personal hygiene, and the use of LLINs.
3. Targeted interventions for high-risk groups: Policies should be tailored to target high-risk populations identified in the study, such as primigravidae and women living near refuse dumping sites.
4. Integration of services: Health policies should promote the integration of HBV and malaria screening into routine antenatal care services, allowing early detection and timely management of co-infections.

5. Addressing Socio-cultural barriers: Policymakers should work with community leaders to address socio-cultural norms that hinder healthcare access, promoting a supportive environment for women seeking medical care.

6.5. Future research directions

Further studies could consider;

1. Studies to track changes in HBV and malaria prevalence over time, considering current interventions' effectiveness and new risk factors' emergence.
2. Studies to evaluate the impact of national and regional health policies and programmes on the prevalence of HBV and malaria and identify gaps in policy implementation and areas for improvement.
3. Research to explore the use of new technologies, such as mobile health applications and telemedicine, to improve education, screening, and treatment adherence among pregnant women.

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APPENDIX I: Participant Information Leaflet and Consent Form

Statement of the person obtaining informed consent
I have fully explained this research to the participant with code number_____ and have given sufficient information, including that about risks and benefits, to enable her to make an informed decision to or not to participate.

DATE:……. NAME:……

Statement of the person giving consent
I have read the information on this study/research or have had it read to me in a language I understand. I have also talked it over with the interviewer to my satisfaction.
I understand that my participation is voluntary (not compulsory).
I know enough about the purpose, methods, risks, and benefits of the research study to decide that I want to take part in it.
It has been explained to me that I may freely stop being part of this study at any time without having to explain myself.
I have received a copy of this information leaflet and consent form to keep for myself.

DATE:…… SIGNATURE/THUMPRINT:……

APPENDIX II: Obstetric and Haematological Template

Clinical Record	Operational definition	Result					
Gravidity	Number of pregnancies a participant has had including the current						
Parity	The number of children ever born to a woman						
ANC Visits	Number of times a participant had visited the antenatal care clinic during the current pregnancy						
Trimester	The trimester in which a participant attended the first ANC clinic						
Blood Group	Participant's blood group						
Haemoglobin (Hb) level	Participant's Hb level	1ST	2ND	3RD	4TH	5TH	6TH
		AVERAGE Hb					
Anaemia	Participant's anaemia status						
Sickling	Sickling status of a participant						
Glucose-6-phosphate Dehydrogenase (G6PD)	G6PD status						
Syphilis	Participant's Syphilis status						
HBsAg	Participant's HBV status						
Malaria	Participant's Malaria status						

ANC, Antenatal Care; Hb, Haemoglobin; HBV, Hepatitis B Virus; G6PD, Glucose-6-phosphate dehydrogenase;

APPENDIX III: Structured Questionnaire

SECTION A: SOCIO-DEMOGRAPHIC CHARACTERISTICS		
Question	Response options	Skip
Age	1. <18 years 2. Between 18 and 25 3. Between 26 and 30 4. Between 31 and 40	
Marital Status:	1. Never married 2. Married 3. Cohabitation	
How long have you been married/living together?	1. Between 1 and 11 months 2. Between 1 and 10 years 3. Between 11 and 20 years 4. Between 21 and 30 years	
Education	1. No formal education 2. Primary 3. JHS/Middle School 4. SHS 5. Tertiary 6. TVET	
Religious Affiliation	1. Islam 2. Christianity 3. African Tradition	
Occupational status	1. Employed 2. Unemployed	
On the average, how much do you earn from your work monthly?	1. Between Gh¢ 100 - 500 2. Between Gh¢ 600 - 1000 3. Between Gh¢ 1100 - 2000 4. Between Gh¢ 2100 - 3000 5. Between Gh¢ 3100 - 4000	
Which of the following best describes the household structure?	1. Female Centered 2. Male-Centred 3. Nuclear 4. Extended 5. Polygamous	
Which one of the following housing types best describes the type of dwelling of your household?	1. Self-contain house 2. Compound house	
Which one of the following housing categories best describes the type of dwelling of your household?	1. Mud with thatch 2. Mud with iron sheets 3. Bricks with thatch 4. Bricks with iron sheets 5. Blocks with thatch 6. Blocks with iron sheets	
What is the main occupation of your household?	1. Farming 2. Fishing	

	3. Trading/business 4. Civil service	
How many people in total live in your household?	1. Between 1 and 5 2. Between 6 and 10 3. Between 11 and 15	

SECTION B: RISK FACTORS ASSOCIATED WITH HBV AND MALARIA		
HEPATITIS B INFECTION		
Question	Response options	Skip
Any history of Female circumcision	1. Yes 2. No	
Any history of Sexually Transmitted Infection(s)	1. Yes 2. No	
Which of the following do you share?	1. Toothbrush 2. Razor Blade 3. Shaving stick 4. Nail cutter 5. Earrings	
Do you have multiple sex partners?	1. Yes 2. No	
Any history of Abortion or Miscarriage?	1. Yes 2. No	
Have you ever had a blood transfusion?	1. Yes 2. No	
Do you do or have you ever done piercing in non-clinical settings?	1. Yes 2. No	
Do you do or have you ever had tattoos	1. Yes 2. No	
Have you ever had a needle prick as a result of a medical procedure?	1. Yes 2. No	
Have you ever had a cut as a result of nail clipping?	1. Yes 2. No	
Do you smoke cigarettes or tobacco?	1. Yes 2. No	
Do you take alcohol?	1. Yes 2. No	
Have you taken the Hepatitis B vaccine?	1. Yes 2. No	
MALARIA		
Question	Response options	Skip
What is the main material of the floor in your household?	1. Natural floor 2. Rudimentary floor	

	3. Finished floor 4. Parquet/polished wood 5. Ceramic/marble/tiles/terrazzo 6. Cement 7. Woollen/synthetic carpet 8. Linoleum/rubber carpet	
What is the main material of the interior and exterior walls in your household?	1. Bamboo with mud 2. Stone with mud 3. Plywood 4. Cement 5. Stone with lime/cement 6. Bricks	
Are windows in your household netted?	1. Yes 2. No	
Are windows in your household fitting perfectly into the wall	1. Yes 2. No	
Does your household own any livestock?	1. Yes 2. No	
Is your house close to a refuse dumping site?	1. Yes 2. No	
Is your house close to a water body?	1. Yes 2. No	
Is your house close to the drainage tunnel (Gutter)?	1. Yes 2. No	
Is your house close to overgrown vegetation?	1. Yes 2. No	
Do you have a household toilet facility?	1. Yes 2. No	
Do you have clothes hanging in your sleeping room?	1. Yes 2. No	
Do you sleep in an insecticide-treated mosquito net?	1. Yes 2. No	
Do you use the Insecticide Mosquito Coil?	1. Yes 2. No	
Do you use Mosquito Repellent?	1. Yes 2. No	
Do you use the Insecticide Mosquito spray?	3. Yes 4. No	
Do you take IPTp-SP during ANC visits?	1. Always 2. Not always	
Has Indoor Residual Spraying been done in your household?	1. Yes 2. No	

SECTION C: BARRIERS TO HBV AND MALARIA INTERVENTIONS

Here are some questions about why people fail to adhere to interventions. I will read you a statement. Please answer which of the options is most closely suited to you.		
PERSONAL BARRIERS		
AWARENESS OF HEPATITIS B VIRUS AND MALARIA INFECTION		
Question	Response options	Skip
In the past 6 months, have you seen or heard any messages about Hepatitis B and Malaria?	1. Yes 2. No	
KNOWLEDGE OF HEPATITIS B INFECTION		
Question	Response options	Skip
Compared with the AIDS virus, the hepatitis B virus can spread from person to person more easily.	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
A healthy-looking person can have Hepatitis B	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
If someone is infected with the hepatitis B virus but looks and feels healthy, do you think that person can spread Hepatitis B?	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Do you think you can be infected with Hepatitis B virus:		
By eating food prepared by an infected person?	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
By eating food that has been prechewed by an infected person?	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
By sharing a toothbrush with an infected person	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
By sharing sharp objects with an infected person	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
By sharing earrings with an infected person	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
By being coughed on by an infected person	1. Not very likely	

	2. Somewhat likely 3. Very likely 4. Extremely likely	
By having unprotected sexual intercourse with an infected person	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
By holding hands with an infected person	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Can the virus that causes Hepatitis B be transmitted from a mother to her baby:		
During pregnancy?	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
During delivery?	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
By breastfeeding?	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Which of the following are the symptoms?		
Fever	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Fatigue	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Loss of appetite	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Nausea	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Vomiting	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	

Abdominal pains	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Dark urine	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Joint pains	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Jaundice (yellow colour in the skin or eyes)	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Do you know Hepatitis B can be prevented through vaccination?	1. Yes 2. No	
KNOWLEDGE OF MALARIA		
Malaria is a serious disease, especially for pregnant women and their babies.	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
It is possible for a healthy and active person with NO symptoms of malaria to have malaria parasite in their body.	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
How is malaria spread?		
By a mosquito	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
During the day	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
At night	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Any time	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Which of the following are the symptoms?		

Fever with sweats	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Headache	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Muscle/joint pain	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Loss of appetite	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
The resting place of mosquitoes includes		
Dark places inside rooms	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Dirty areas	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
On edges of ponds or stagnant water	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Sheds of domestic animals	5. Strongly disagree Not very likely 6. Somewhat likely 7. Very likely 1. Extremely likely	
Overgrown vegetation	2. Not very likely 3. Somewhat likely 4. Very likely 5. Extremely likely	
Malaria can be prevented through		
Draining and cleaning of choked gutters	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Weeding surroundings regularly	1. Not very likely 2. Somewhat likely 3. Very likely	

	4. Extremely likely	
Using insecticide sprays	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Sleeping in insecticide-treated nets	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Adhering to prophylaxis	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
WHAT ARE THE HEALTH RISKS OF HBV AND MALARIA?		
Preterm babies	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Stillbirth	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Low birth weight	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	
Maternal deaths	1. Not very likely 2. Somewhat likely 3. Very likely 4. Extremely likely	

PSYCHOLOGICAL BARRIERS

Here are some questions about why people fail to adhere to interventions. I will read you a statement. Please answer which of the options is most closely suited to you.

No.	Question	Response options	Skip
	Concern about the effect of the intervention	1. Yes 2. No	
	I am afraid of the interventions and/or the side effects (Fear of side effects) (Fear)	1. Yes 2. No	
	Generally, I often feel downcast and sometimes discouraged and depressed	1. Yes 2. No	
	I often forget things during my daily routine (Forgetfulness)	1. Yes 2. No	
	Feel sad to adhere to intervention.	1. Yes 2. No	

Feel nervous about adhering to an intervention.	1. Yes 2. No	
Feel pain to intervention?	1. Yes 2. No	
Sometimes I am unsure whether the interventions are indeed necessary (uncertainty)	1. Yes 2. No	
Concern due to the lack of trust in health service providers	1. Yes 2. No	
Distress about the death of a family member (sister, brother)	1. Yes 2. No	
Getting tired of the prolonged period of treatment	1. Yes 2. No	

SOCIOCULTURAL BARRIERS

Here are some questions about why people fail to adhere to interventions. I will read you a statement. Please answer which of the options is most closely suited to you.

Question	Response options	Skip
Concern about being neglected by the family members	1. Yes 2. No	
My religious affiliation prevents taking interventions.	1. Yes 2. No	
It is taboo in my ethnic group to adhere to the interventions (Indoor Residual Spraying, Vaccination, IPTp-SP uptake, and ITN usage)	1. Yes 2. No	
Fearing the community's bad reactions to the disease	1. Yes 2. No	
Fearing the stigma caused by having HBV or Malaria	1. Yes 2. No	

APPENDIX IV: Interview Guide

BACKGROUND INFORMATION
Name Respondent_____
Gender_____
Designation_____
Number of years working with the facility_____
Municipality/District_____
Name of Health Facility_____

GENERAL KNOWLEDGE, RISK FACTORS, AND INTERVENTION OF HEPATITIS B AND MALARIA INFECTIONS		
	Question	Response
1.	What would you say your health facility is?	1. CHPS 2. Sub-District 3. Clinic 4. Hospital
2.	Besides this community, do you serve other communities?	1. Yes 2. No
3.	What do you think are the most common diseases in pregnant women in this municipality/district you serve and why?	
4.	What about HBV and Malaria (If not mentioned)	
5.	Has there been any birth complications suffered by a pregnant woman as a result of these infections?	
6.	In your opinion, what are some of the risk factors associated with the transmission of these infections?	
7.	Are you involved in delivering an intervention, activity, or strategy that aims to improve the uptake of HBV and Malaria intervention?	
8.	Does your facility provide education/sensitization on HBV and Malaria?	
9.	Does your service promote and/or offer testing for HBV and Malaria?	
10.	If yes, where do you get your test kits from?	
11.	Are the test kits always available?	
12.	If No, why are your clients not tested?	
13.	Do you have records on HBV and Malaria testing?	
14.	What are the challenges with the HBV and Malaria testing?	
15.	Do you vaccinate your clients (pregnant women)?	
16.	In your opinion, what are some of the barriers that influence pregnant women not to adhere to the interventions you provide	Personal: Psychological: Socio-cultural

APPENDIX V: Focus Group Discussion Guide

GENERAL KNOWLEDGE, RISK FACTORS, AND INTERVENTION OF HEPATITIS B AND MALARIA INFECTIONS		
	Question	Response
1.	What do you think are the most common diseases in pregnant women in this municipality/district you serve and why?	
2.	What about HBV and Malaria (If not mentioned)	
3.	Do you know anything about HBV and Malaria in pregnancy?	
4.	Where did you first hear about HBV and Malaria in pregnancy?	
5.	What are some of the effects of HBV and Malaria on a pregnant woman and her baby if she does not seek early intervention?	
6.	How do you think you can be infected with HBV and Malaria? (TRANSMISSION)	HBV: Malaria:
7.	In your opinion, what are the symptoms of HBV and Malaria? (SYMPTOMS)	HBV: Malaria:
8.	In your opinion, what are some of the risk factors associated with the transmission of these infections? (RISK FACTORS)	
9.	How can HBV and Malaria be prevented?	HBV: Malaria:
10.	If a pregnant woman is infected with chronic HBV what do you think can be done to protect the mother and the child?	
11.	How often do you (or your spouse/partner) use a condom during sexual intercourse?	
12.	Do you sleep in an Insecticide Treated Mosquito Net?	
13.	If “Yes”, Why	
14.	If “No”, Why?	
15.	Do you know the various interventions to help prevent HBV and Malaria during pregnancy?	
16.	In your opinion, what are some of the barriers that influence pregnant women not to adhere to the interventions provided to prevent the transmission of HBV and Malaria?	Personal: Psychological: Socio-cultural

APPENDIX VI: Introductory Letter

AKENTEN APPIAH-MENKA UNIVERSITY
of Skills Training and Entrepreneurial Development

FACULTY OF ENVIRONMENT & HEALTH EDU.
DEPARTMENT OF PUBLIC HEALTH EDUCATION
P.O. Box 40, Asante Mampong 0209777318

M/DPHE/ADM/G/03/23/6 August 3, 2023

The Regional Director
Ghana Health Service
Bono East Region
Kintampo

Dear Sir/Madam,

PERMISSION TO CONDUCT RESEARCH

Mr. Dennis Bardoe (Index Number 8222030012) is our M.Phil. Public Health student at the Department of Public Health Education, Faculty of Environmental and Health Education, AAMUSTED-Mampong Campus of the erstwhile University of Education Winneba.

Mr. Bardoe, as part of his academic requirements for the award of Master of Philosophy Degree in Public Health, is to conduct research titled "**Prevalence of Hepatitis B and Malaria Co-infection Among Pregnant Women in Bono East Region.**" This will be cross-sectional study aimed at determining the prevalence of HBV and Malaria co-infection among pregnant women in seven (7) selected Municipal/Districts in the region. Seven health facilities which conduct deliveries and antenatal care are chosen to recruit participants for the study. These are, Atebubu-Amantin District Hospital, Kintampo South District Hospital, Kintampo North Municipal Hospital, Nkoranza South Municipal Hospital, Holy Family Hospital, Pru West District Health Centre, and St. Matthias Catholic Hospital.

We seek your official consent to permit him to collect data from the proposed study sites and participants under your jurisdiction. The outcome of this study would provide empirical data on HBV and Malaria co-infection among pregnant women. Your approval letter will pave the way for him to apply for ethical clearance before the commencement of the research. The data collected will be used solely for academic purposes.

We would be grateful if your outfit would accord him the needed assistance for the successful execution of this proposed study. Therefore, your kind approval is required to conduct this study to fulfil this academic obligation.

Yours faithfully

REV. DR. DENIS DEKUGMEN YAR
HEAD OF DEPARTMENT

www.aamusted.edu.gh
Mampong Campus: 0506476198 / 0501613082 Email: dphe@aamusted.edu.gh
GhanaPost Code: AM0030-1697

APPENDIX VII: Approval Letter from Study Area

OUR CORE VALUES
- **People-Centered**
- **Team work**
- **Innovation**
- **Discipline**
- **Integrity**

My Ref: GHS/BE-RHD/RU/RD.08.23/023
Your Ref:

Your Health Our Concern

Regional Health Directorate
Ghana Health Service
P. O. BOX KH 155
Kintampo, BE
Ghana

Tel: 0506202600
Fax:
E-mail: rdhs.ber@ghs.gov.gh

29th August, 2023.

The Chairman
Ethics and Review Committee
Ghana Health Service
Accra

SUPPORT LETTER FOR ETHICAL CLEARANCE FOR MR. DENNIS BARDOE TO CONDUCT A STUDY

I write to support the request for Ethical Clearance for Mr. Dennis Bardoe, an MPhil student at the department of Public health Education, Faculty of Environmental and Health Education, Akenten Appiah-Menka, AAMUSTED-Mampong Campus of the erstwhile University of Education, Winneba. He is undertaking research entitled: **"Prevalence of Hepatitis B and Malaria Co-infection among Pregnant Women in Bono East Region".** This study will be cross-sectional study aimed at determining the prevalence of HBV and Malaria co-infection among pregnant women in selected district that conduct deliveries and antenatal care in the region.

The findings of the study will provide empirical data on the said health issue among pregnant women.

I would be much grateful if he is given Ethical Clearance to facilitate the data collection process.

Thank you.

DR. FRED ADOMAKO-BOATENG
REGIONAL DIRECTOR OF HEALTH SERVICE
BONO EAST REGION

APPENDIX VIII: Ethical Approval

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/1081/23

11th December 2023

Mr. Dennis Bardoe
Department of Public Health Education
Akenten Appiah-Menka University of Skills
Training and Entrepreneurial Development.

Dear Sir,

LETTER OF APPROVAL

Protocol Title: ***"Prevalence of Hepatitis B Virus (HBV) and Malaria Co-infection among Pregnant Women in Bono East Region of Ghana."***

Proposed Site: ***Bono East Region.***

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 29th August 2023 from the Bono East Regional Health Directorate (study site) indicating approval for the conduct of the study in the Region.
- A Completed CHRPE Application Form.
- Participant Information Leaflet and Consent Form.
- Research Protocol.
- Questionnaire and Interview Guide.

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 December 2023** to **10th December 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
Tel: +233 (0) 3220 63248 **Mobile:** +233 (0) 20 5453785 **Email:** chrpe.knust.kath@gmail.com/chrpe@knust.edu.gh

APPENDIX IX: Introductory Letter to the Health Facilit

OUR CORE VALUES
- **People-Centered**
- **Team work**
- **Innovation**
- **Discipline**
- **Integrity**

My Ref: GHS/BE-RHD/RU/RD.01.24/003
Your Ref:

GHANA HEALTH SERVICE
Your Health Our Concern

Regional Health Directorate
Ghana Health Service
P. O. BOX KH 155
Kintampo, BE
Ghana

Tel: 0506202600
Fax:
E-mail: rdhs.ber@ghs.gov.gh

18th January, 2024.

INTRODUCTORY LETTER

I write to introduce to you Mr. Dennis Bardoe, an MPhil student at the department of Public Health Education, Faculty of Environmental and Health Education, Akenten Appiah-Menka, AAMUSTED-Mampong Campus of the erstwhile University of Education, Winneba. He is undertaking research titled: **"Prevalence of Hepatitis B Virus (HBV) and Malaria Co-infection among Pregnant Women in Bono East Region".**

This study will be cross-sectional study aimed at determining the prevalence of HBV and Malaria co-infection among pregnant women in selected district that conduct deliveries and antenatal care in the region.

The findings of the study will provide empirical data on the above-mentioned health issue among pregnant women.

I would be much grateful if he is given the necessary assistance and support to facilitate the data collection process.

Thank you.

DR. FRED ADOMAKO-BOATENG
REGIONAL DIRECTOR OF HEALTH SERVICE
BONO EAST REGION