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HIV AND COVID-19 INFECTION AND ITS EFFECT ON NEONATAL OUTCOMES IN THE GREATER ACCRA REGION OF GHANA

BY

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(10932020)

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DECLARATION

I hereby declare that this study report is the result of my own research and references made to the works of other researchers have been duly acknowledged. This dissertation has neither been presented whole nor in part to any academic institution for the award of any degree.

……………………………………………… 30/01/2023

Emanuel Sahr Nyuma ……………………………………………

Date

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Dr. Emefa Judith Modey ……………………………………………

(Academic Supervisor) Date

DEDICATION

To my family, without whose help, prayer, and support this work, and many other things, would not have been possible.

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ABSTRACT

Background: Amid the COVID-19 pandemic, people living with HIV experience more severe outcomes and have higher comorbidities from COVID-19 than non-HIV individuals. Pregnant women are a vulnerable group in this population because of their reduced immunity.

Objective: This study seeks to ascertain the effect of HIV and COVID-19 infection in neonatal outcomes in the Greater Accra Region of Ghana using Apgar score

Methodology: This study is an analysis of secondary data of 37 pregnant women from a longitudinal cohort study of 1,444 pregnant women. Frequencies and percentages were used to describe the categories. Multivariate regression analysis was employed to determine the effect of COVID-19 exposure on Apgar scores. Data was analysed using STATA version 16 software.

Results: The prevalence of HIV among pregnant women in the Greater Accra Metropolis was 2.57%. Approximately 49% of babies were born to mothers exposed toCovid-19 and 51% were born to mothers who were not exposed to Covid-19. The median gestational age at delivery was 40 weeks. Pre-term births were recorded among unexposed mothers only and were approximately 8.1%. A total of 91.9% term births were recorded with a higher proportion from exposed mothers (48.6%) than unexposed mothers (43.2%). Approximately 43.2% of babies born from covid-19 exposed mothers were of normal birth weight. An estimated 5.4% of babies born to covid exposed mothers were underweight. The mean Apgar scores recorded at 1 minute and 5 minutes are 7.2 and 8.3 respectively (p-value, 0.044). All babies admitted to NICU were born to covid exposed mothers. The average Apgar1minute scores was 3.16 (AOR = 3.16, 95%CI (0.12-2.18)) higher among children born through emergency caesarean section compared to those born via Spontaneous vaginal delivery. Apgar 5minute scores was 2.27 (AOR = 2.27, 95%CI (0.02-1.64))

higher among children born through emergency caesarean section compared to those born via Spontaneous vaginal delivery.

Conclusion: These findings suggest that COVID-19 did not adversely affect Apgar scores of babies born to mothers with HIV. The management of HIV women in labour with indication for c-section contributes to a higher neonatal Apgar score.

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LIST OF ACRONYMS

WHO	World Health Organization
SSA	Sub-Saharan Africa
HIV	Human Immunodeficiency Virus
ART	Anti-retroviral drug
MOH	Ministry of Health
GHS	Ghana Health Service

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Study

Childbirth is a landmark event and powerful human experience that is of physiological, psychological, and social importance (Nelson, 2020). Al-Sheyab et al. (2020) attribute the negative impact of neonatal outcomes such as preterm, stillbirth low birth weight (LBW), and more to shortcomings on the part of medical professionals, whiles Ezechi et al. (2013) oppose this assertion because it links the aforementioned issue to some other health issues such as HIV/AIDS which has significantly affected neonatal outcomes for over three decades now.

Human Immunodeficiency Virus (HIV) is an infection of serious public health concern with about 37.7 million people living with the virus globally as of 2020, and about 25.4 million (68%) of them living in Sub-Saharan Africa (SSA) (Unicef, 2018). Globally, women and girls remain the most vulnerable group with a reported prevalence of 52% (Unicef, 2018; WHO, 2016). Women and girls accounted for 53% of all new infections globally and 63% in Sub-Saharan Africa by 2020. By securing the availability of anti-retroviral medications and effective preventive measures, the World Health Organization has assured that HIV infections might be reduced by 2030 (UNAIDS, 2020). These efforts underline the UNICEF commitment to place the health of the mother first in curbing the epidemic in the first decade of a child’s life (UNICEF, 2014). Despite these developments, there is still little integration between HIV and Maternal and Child Health (MCH) services in Ghana as well as other sub-Saharan African nations. Therefore, opportunities to enhance women's and children's health by addressing comorbidity factors are missed (Kendall et al., 2014).

maternal HIV infection has been associated with adverse pregnancy outcomes such as preterm birth, low birth weight, small for gestational age and stillbirth, especially in Sub-Saharan Africa (Xiao et al., 2015),. Preterm birth constitutes the second leading cause of death in children under five years (WHO, 2012). HIV triggers a severe inflammatory response in utero, which results in a strong, unscheduled immune response which in turn causes severe inflammation leading to premature birth (Gyebi et al., 2020).

Likewise, COVID-19, a major health condition, has been found capable of affecting neonatal outcomes globally (Montes et al., 2020). Viruses from this family have inflicted a range of viral infections, including Middle East Respiratory Syndrome (MERS) and severe acute respiratory syndrome (SARS) (Narang et al., 2020). Respiratory droplets and direct contact remain the main route of COVID-19 transmission. While the spectrum of the disease severity ranges from mild to critical, most are mild. The majority of the fatal cases occur in patients with advanced age or underlying comorbidities (Chaubey et al., 2021). However, to this date, the COVID-19 mortality rate is greater than MERS and SARS combined and has a global Case Fatality Rate of about 6.4% (Iftikhar et al., 2021; Kotlar et al., 2021).

Pregnancy by its reduced immunity places pregnant women at risk for COVID-19 infection (Fenizia et al., 2020). Pregnant women may experience severe symptoms such as hypoxia, hypotension, electrolyte imbalances, and placental hypoperfusion, which can result in foetal distress, preterm labour, miscarriage, or foetal death, as per limited data (Fenizia et al., 2020; Juan et al., 2020; Mehta et al., 2020). Preliminary evidence from other coronaviruses (i.e., SARS and MERS) has suggested that pregnant women are more likely to have severe manifestations of the disease, morbidity, and mortality compared to non-pregnant women (Galang et al., 2020; Khalili et al., 2020). Information about the different routes (transplacental, perinatal, intrapartum, and postnatal) and risks of transmission of COVID-19 to new-born infants is based on case series (Blitz et al., 2021). It has been suggested that around the period of pregnancy, SARS-CoV-2 infection may cause foetal growth distress, premature labour, respiratory distress, thrombocytopenia accompanied by abnormal liver function, and even death among neonates (Villar et al., 2021).

Nevertheless, the information on health outcomes of neonates of such pregnancies where the mother was affected by COVID-19 with or without HIV, has not been properly elucidated. Such information will be needful in the management of pregnancies of COVID-19-exposed pregnant mothers who are either HIV positive or not. This study seeks to determine the prevalence of HIV in pregnant women and also, examine neonatal complications based on COVID exposure status.

1.2 Problem Statement

The effects of HIV infection on pregnancy outcomes have been mainly studied in high-income countries, where both disease burden and health systems are significantly different compared with those in the African region (Christopoulos et al., 2015). Several studies conducted in Sub-Saharan Africa (SSA) have reported that HIV-infected women are at increased risk of maternal anaemia and adverse pregnancy outcomes such as stillbirth, low birth weight, and preterm new-borns (Fishel et al., 2014). In addition, children born to HIV-infected mothers are at increased risk of mortality regardless of their HIV-infectious status (Filteau, 2009). The mothers' immune function is strongly disrupted and early foetal growth and development are impaired (Twabi et al., 2020). Also, there are inconsistent reports on how antiretroviral therapy (ARTs) affects pregnancy outcomes (Stinson et al., 2013). The HIV epidemic in Sub-Saharan Africa has significantly shaped the rate of adverse pregnancy outcomes (WHO, UNICEF, UNAIDS, 2008).

Establishing the impact of HIV infection on maternal and infant health is particularly challenging in SSA because of the presence of factors associated with both HIV infection and adverse pregnancy outcomes such as malnutrition, anaemia and other frequent concurrent infections such as syphilis and malaria. It has been estimated that approximately one million pregnancies per year are co-infected with malaria and HIV in SSA (Uneke & Ogbonna, 2009). Because of the presence of confounding factors, the impact of HIV infection on pregnancy outcomes is likely more significant in women from low-income countries compared to those from developed regions. Evidence from Ghana on the effects of HIV on neonatal outcomes is limited, the few available highlight low birth weight, retention in HIV care, and adherence to ART among postpartum women living with HIV in Ghana (Sakyi et al., 2020).

In the midst of the COVID-19 pandemic, UNAIDS reports that people living with HIV experience more severe outcomes and have higher comorbidities from COVID-19 than people not living with HIV. Pregnant women are a vulnerable group in this population because of their reduced immunity (UNAIDS, 2020). Among COVID-19 pregnant women, neonatal outcomes commonly observed include miscarriage, preterm birth and others. The effect of COVID-19 on neonatal outcomes of mothers with HIV remains a gap in the scientific literature which this study sought to address. This could potentially pose a challenge to the health system already struggling with COVID-19 and contribute to increased mortality and morbidity rates.

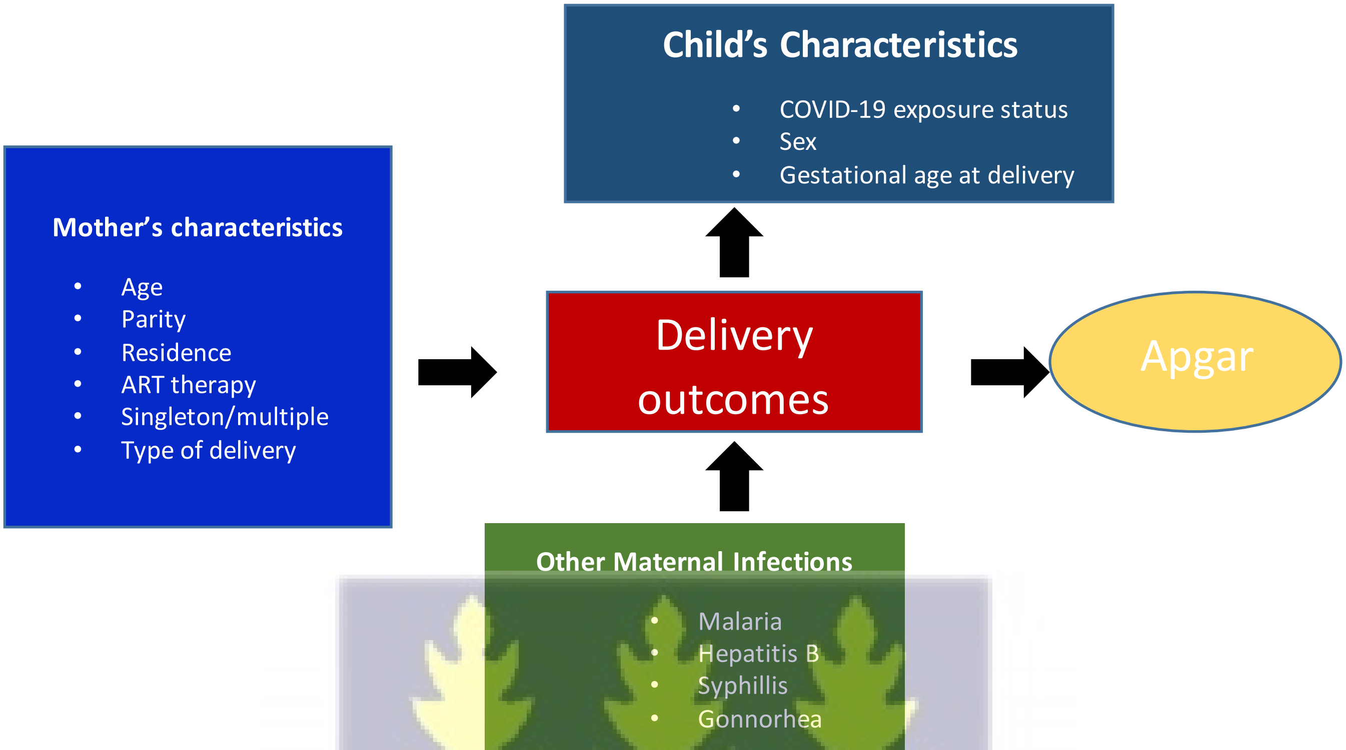
1.3. Justification

There remains a vast vacuum in the current scientific literature on how the co-infection of HIV and SARS-CoV-2 (COVID-19) affects pregnancy and neonatal outcomes. Scientifically, it is not well understood how COVID-19 infections affect neonatal outcomes of pregnant women, whiles for HIV, few studies have shown an increased risk of preterm birth, still birth, and mother-to-child transmission among others. Many of the previous studies on maternal HIV status and its infect on neonatal outcomes have been carried out in developed countries. However, there is a need to better understand the impact of these two public health threats on neonatal outcomes.

Undoubtedly, the Apgar score is a useful tool for monitoring the foetal to neonatal transition and describing the condition of the new-born shortly after birth to highlight a need for emergency care or not. This study seeks to understand how the Apgar is particularly affected in neonates born to mothers infected with either HIV or COVID-19 or both (coinfection). Moreover, a better understanding of maternal HIV status and COVID-19 exposure as major causes for adverse or undesirable maternal neonatal outcomes is of great importance for the prevention of miscarriages, abortions, preterm births and other potential adverse outcomes of pregnancy.

Therefore, identifying these outcomes as early as possible is of utmost importance for early intervention to save lives (both mother and baby). The neonatal outcomes of pregnant women with HIV infection as well as exposure to COVID-19 in Ghana are sparse in scientific literature. Understanding how HIV infection and COVID-19 affect neonatal outcomes is crucial to public health practice and policy guidance in the country (Ibrahim & Keefe, 2014). It is important to understand the effects and identify appropriate strategies to mitigate these problems. Knowledge of the potential complications and best practices to manage neonatal outcomes would contribute greatly to improved interventions, guidelines, and policies for maternal and newborn health among HIV and non-HIV-positive women globally

1.4 Conceptual Framework



Adopted from Sanghita Bhattacharyya (2015)

Figure 1. *A conceptual framework illustrating the concept of maternal characteristics and infections on possible delivery and neonatal outcomes (The APGAR SCORE).*

The ultimate aim of this study is to assess the effect of COVID-19 on the APGAR scores of mothers living with HIV. The conceptual framework describes the Apgar score as a possible adverse neonatal outcome among pregnant women with certain characteristics and infections, particularly, HIV and COVID-19 exposure. The independent variables are neonatal outcomes (APGAR scores) while the dependent variables in this study include the mothers' characteristics (Age, Parity, Residence, HIV status, ART therapy, Singleton/multiple birth and type of delivery). Maternal infections or diseases are potential influencing variables in this study. The black arrows indicate the directions of the framework. In this framework, maternal characteristics (Age, Parity, Residence, HIV status, ART therapy, Singleton/multiple birth and type of delivery) influenced by maternal infections or diseases are the primary potential influencers of delivery outcomes. The delivery outcomes can either indirectly affect the child's characteristics which in turn affects neonatal outcomes or directly affect neonatal outcomes. (APGAR scores)

1.5 Study Objectives

1.5.1 General Objectives

The general objective of this study is to ascertain the effect of COVID-19 on neonatal outcomes using the APGAR score in pregnant women with HIV in the Greater Accra Region. Using data from a prospective cohort study investigating maternal, pregnancy and neonatal outcomes for women and neonates infected with SARS-CoV-2 in Ghana: Adaptation of World Health Organization Protocol

1.5.2 Specific Objectives

The specific objectives of this study include;

1. To determine the prevalence of HIV infection in pregnant women.
2. To determine the prevalence of COVID exposure among pregnant women
3. To assess the effect of COVID-19 infection on the APGAR score of neonates of HIV-positive mothers.
4. To estimate the average difference between Apgar scores of neonates born to HIV mothers by covid exposure

1.5.3 Research Questions

1. What is the prevalence of HIV infection among pregnant women?
2. What is the prevalence of COVID-19 exposure amongst pregnant women living with HIV?

3. What is the effect of COVID-19 infection on the APGAR score of neonates of HIV-positive mothers?
4. What is the average difference between Apgar scores of neonates born to HIV mothers by covid exposure?

1.6 Organization of Study

This current dissertation will be organized into six different chapters. Chapter one provided the research introduction which entails the background of the study, statement of the problem, research objectives, research questions, justification, and conceptual framework of the study. Chapter two reviewed the relevant theoretical and empirical published literature on how covid-19 and HIV infection on neonatal outcomes using the APGAR score. The third chapter outlined the methodology; which includes the study population, study design, sample size, sampling and data collection tools, and data collection procedure as well as addressing the ethical considerations and the data analysis for the study. The fourth chapter reported the results and the data analysis outcome for the data obtained. The fifth chapter presents the discussions for the study. Chapter six provides the summary, conclusions and recommendations drawn from the study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

In this chapter of the study, the literature review synthesizes important literature related to maternal Human Immunodeficiency Virus (HIV) infection and COVID-19 exposure and the possible effect on neonatal outcomes (APGAR Scores). The review focused on the burden of the diseases globally, regionally, and locally (Ghana).

To access relevant data for the research, a thorough electronic database search was conducted. Search terms that are significant to the general and specific objectives of the research were utilized. Relevant journals were searched for publications in English with no time limit, and no limitation to geography for the researcher to access a variety of resources. Journal articles were sorted electronically via an online database searching these included; JOURNALS, PUBMED, MEDLINE, GOOGLE SCHOLAR, etc. Bearing in mind the nature of the research topic which is evidence-based, further information was sorted from World Health Organization (WHO), United Nations Population Fund (UNFPA), and other United Nations agencies.

2.2 Background of Human Immuno-deficiency virus

HIV was first recognized as the cause of AIDS by French researchers at the Pasteur institute in 1983 and by American researchers Gallo and associates in 1984 (Danziger, 1997; Wain-Hobson et al., 1991; Vahlne, 2009). The advanced stage of HIV is known as Acquired Immunodeficiency Syndrome (AIDS), and the period it takes for an infected person to develop the disease (AIDS) is between 9 months to 20 years (Talbot, 2006). It was earlier reported that the epidemic is more prevalent among commercial sex workers, drivers, patients with sexually transmitted infections, and homosexual men (Gangakhedkar et al., 1997). HIV type-1 or retrovirus infection caused a progressive decrease in the number of CD4 T helper cells over years of infection and consequently leads to a reduction in immunity and predisposes to opportunistic infections and neoplastic disease (Haynes et al., 1996).

HIV can be transmitted through unprotected sexual intercourse with an infected person. This could be through virginal or anal sex (Kumarasamy et al., 2003). Other possible transmission routes include; sharing needles and syringes used by an infected individual, other infected shapes instruments, and HIV-positive pregnant women infecting their unborn foetus through the umbilical cord, during labour and breastfeeding (Gangakhedkar et al., 1997). The introduction of antiretroviral drugs (ARTs) has helped in the reduction of the progress and multiplication of the virus at the individual level but is limited at the population level (United Nations Programme on HIV/aids. UNAIDS, 2021).

2.2.1 Global Burden of HIV Infection

The Human Immunodeficiency Virus remains a global burden with an almost forty (40) years long-standing history of infecting an estimated total of 70 million people and is responsible for 35 million deaths as a result of HIV/AIDS (WHO, 2016). The current global HIV/AIDS statistics estimate 37.7 million HIV-infected people in the world, 53% of people living with HIV were women and girls, 1.8 million were children aged l 1-15 years old, the majority are living in Sub-Saharan Africa (United Nations Programme on HIV/aids. UNAIDS, 2021). The prevalence of HIV varies from one country to another; however, the vast majority of cases are found in low and middle-income countries, especially in Africa. In 2016, Sub-Saharan Africa account for 25.5 million cases of HIV as compared with 6.7 million in Asia and 4.2 million in Europe and America (WHO, 2016). HIV affects people of all ages, sex, and race. The top ten countries with the highest prevalence of HIV in the world are found in Africa, are Swaziland at 27%, followed by Lesotho at 25%, Botswana at 21.9%, South Africa at 18.9%, Namibia at 13.8%, Zimbabwe at 13.5%, Zambia 12.4%, Mozambique 12.3%, Malawi 9.2% and Uganda 6.5% (World Bank Group, 2017).

2.2.2 HIV Situation in Ghana

The first case of HIV in Ghana was recorded in march 1986. By the end of 1986, a total of 42 cases were officially reported (Nketiah-Amponsah & Afful-Mensah, 2013). According to the Ghana Demographic Health Survey 2014 (Survey, 2014), 2.0% of Ghanaian adults between the ages of 15-49 years are HIV positive. The incidence is higher in women (2.8%) than in men (1.1%) (World Health Organization, 2016). In Ghana, the focus over the years has been on the prevention of HIV through protective sex, blood transfusion and mother-to-child transmission, with the idea that through these routes over 90% of HIV transmission occurred (Commission, 2017).

Although the prevalence of HIV has reduced in Ghana from 2.4% in 2016 to 2.1% in 2017, the incidence of HIV continues to increase by 36% to 1.5% from 1.1% during the same year period (Owusu, 2020). The prevalence of HIV among women aged 15-49 years from 2003-2014 keep declining from 2.1% in 2003 to 2.0% in 2014 and a corresponding reduction was noticed in men of the same age group (ONUSIDA, 2017). However, to achieve the joint United Nations program on HIV/AIDS 90-90-90 target by 2020, Ghana needs to work extremely hard on further reduction (Levi et al., 2016). This includes among other things expanded testing services throughout the country, to ensure early diagnosis and people made to be aware of their status (Li J, et.al., 2012).

2.3 HIV infection and its effect on pregnancy

Maternal HIV infection has been proven to be strongly associated with unfavourable pregnancy outcomes ranging from low birth weight (LBW) (baby weighing less than 2500g or 2.5kg), small for gestational age (SGA) and stillbirth, especially in low and middle-income countries (Ezechi et al., 2013; Yang et al., 2019). It was estimated in 2020 that 32.4 million infants (27% of live births) were born small for gestational age (SGA) in Sub-Saharan Africa and of whom 10.6 million were born at term and low birth weight (LBW) (Xiao et al., 2015). HIV-positive mothers are a special population, who can infect their foetus and new-born babies during pregnancy, delivery, or through breastfeeding with a total transmission rate between 15% and 45%, without any intervention (Filteau, 2009). Mother-to-child transmission (MTCT) of the human immunodeficiency virus (HIV) is the main route of acquiring the virus in children (Stinson et al., 2013).

Thus far, conflicting results have been reported regarding the association between maternal HIV infection and adverse pregnancy outcomes (LBW, preterm birth, low Apgar score) (Rasmussen et al., 2020; Twabi et al., 2020). There are some studies indicating that maternal HIV infection could possibly increase the risk of LBW and preterm birth (ONUSIDA, 2017; Twabi et al., 2020), whilst, others like Stinson et.al., 2013 reported no significant association between HIV-positive pregnant mothers and LBW, prematurity.

2.4 Background of SARS-COV-2 (COVID-19)

Severe acute respiratory syndrome (SARS) is a disease that was first reported in the Guangdong Province in China in the year 2003 (Vijayanand et al., 2004). The virus spread quickly in almost 30 countries in the world and resulted in approximately 8000 cases and 770 deaths (NHS, 2019). It is believed that the natural reservoir of SARS-CoV is bats, with little evidence showing that civet cats and raccoon dogs are possible intermediate sources of the disease (L. F. Wang & Eaton, 2007).

The Coronavirus 2019 (SARS-CoV-2), officially known as COVID-19 is very similar to the SARS-CoV and MERS-CoV with 85% and 50% nucleotide identity respectively (Janghorban, 2020; Morang'a et al., 2022). COVID-19 is a new virus that causes serious pulmonary and extra pulmonary disease conditions and death (Kotlar et al., 2021). Just like SARS, SARS-CoV-2 also surfaced in China in the city of Wuhan, Hubei province. It is the third outbreak of coronavirus in less than 20 twenty years after SARS in 2002 and MERS in 2012 (Muralidar et al., 2020). The typical symptoms of the disease include fever, cough, shortness of breath, loss of smell and taste and fatigue (Capobianco et al., 2020). In most cases, infected people are asymptomatic whiles others present with mild symptoms that progress to a very severe Acute Respiratory Distress Syndrome (ARDS), which hastens a cytokine storm (Galang et al., 2020; Wilson & Wilson, 2021). The complications of COVID-19 include; pneumonia, septic shock, multiple organ failure, and death (Chenneville et al., 2020). COVID-19 like any other infectious disease has an incubation period which is five days ranging from 2-14 days and the transmission from an infected individual to a non-infected person is via droplets which are produced by coughing, sneezing and through speech (Iftikhar et al., 2021).

2.4.1 Global Burden of COVID-19 Infection

As the virus assumed its global pandemic status in 2020, the ongoing spread of COVID-19 at a rapid rate contrasted with past pandemics has brought the entire world to a standstill, as countries have to lockdown, restrictions on the movement of people, cancellation of social gatherings and closer of educational institutions and workplaces in other to prevent further spread (WHO, 2020).

It is approximated that COVID-19 has infected over 25 000 000 people and is responsible for 840 000 deaths worldwide, which resulted in a 3.4% case fatality rate (CFR) in the mid of 2020, Africa (with 17% of the world's population) accounting for 4% of the total confirmed cases and 3% of death from COVID-19 and CFR of 2.1, which is low as compared with a worldwide estimate(UNAIDS, 2020). The African continent is among the least affected continent in the world for there are numerous explanations namely limited testing, young population and few aged people, favorable climate, and adherence to COVID-19 measures among others (Bwire et al., 2022; Oleribe et al., 2021).

2.4.2 COVID-19 situation in Ghana

The Coronavirus disease 2019 (COVID-19) outbreak in Ghana just like any other country in the world is part of the ongoing global pandemic caused by the SARS-CoV-2 (Morang'a et al., 2022). The COVID-19 pandemic started slowly in Ghana, as the country recorded its first case on March 12, 2020, from traveling foreign nationals from Norway and Turkey (Agbozo & Jahn, 2021; Sarkodie et al., 2021). Since then, the number of cases continues to rise and spread to the regions and districts. The president declared on the 23rd March

2020 a Public Health Emergency of National Concern and the Ministry of Health instituted a series of emergency pandemic preparedness activities such as; a partial lockdown of two major cities (Greater Accra and Kumasi), a ban on public gathering and close of school to prevent and protect Ghanaians against COVID-19 (Leah & Frimpong, 2020; Sibiri *et al*., 2020;). The Kotoko International Airport and all airports and land borders were closed to all international travel effective 22nd March 2020, and testing and contact tracing were enhanced. The airport was later re-opened in September of that same year after months of closure with strict measures; travellers needed to provide a certificate of negative proof of COVID-19 test taken 72 hours before arrival in the country(Asante et al., 2020).

Ghana's cumulative SARS-Cov2 (COVID-19) cases in September 2021, stood at 127,482 with 3088 active cases and a total of 1156 death. By the end of 2021 and the start of 2022, 1.23 million Ghanaians have received vaccine doses with 376,000 fully vaccinated with the AstraZeneca vaccine through the COVAX initiative(Asante et al., 2020; Sarkodie et al., 2021). In Ghana like many other countries in Africa, compliance with prescribed preventive measures has been very challenging with an average low within communities.

2.5 COVID-19 infection and its effect on pregnancy

Over the past decades, the world has experienced the emergence of several infectious diseases with severe fetal effects on humans such as the pandemic HINI in 2009, the influenza virus, the severe respiratory syndrome coronavirus (SARS-Cov2), the Middle East respiratory syndrome coronaries Ebola virus and zika virus (Kotlar et al., 2021). However, understanding how these infections affect women during pregnancy and their fetus is of great importance (Yuan, 2021). Several studies have shown that pregnant women and their unborn fetuses are particularly vulnerable to these viral outbreaks with worse maternal and neonatal outcomes such as abortion, preterm birth, stillbirth and birth defects (Galang et al., 2020; Janghorban, 2020).

Even though there is some literature on the susceptibility and severity of coronavirus 2019 (COVID-19) in pregnancy, from studies done on other severe coronavirus infections (SARS or MERS), there is no factual evidence showing the effect of the virus in pregnant women (Galang et al., 2020; Wei et al., 2021). From what is known so far, the novel coronavirus 2019 has affected more men than women (Iftikhar et al., 2021). Among the millions of women infected, some studies suggest that pregnant women and their foetus are particularly susceptible to coronavirus 2019 because of certain physiological changes in cardiorespiratory and immune system which may result in alteration of normal physiology in response to COVID-19 infection in pregnancy (Cordie, AbdAllah, et al., 2021; UN Joint Programme on HIV/AIDS (UNAIDS), 2020). Janghorban 2020, reported that pregnant women have compromised immunity which predisposes them to severe infections like SARS-CoV-2 as compared to non-pregnant women (Janghorban, 2020). Thus far there is no clear scientific evidence to justify a potential vertical transmission of the virus in utero (Morang'a et al., 2022). It is however possible for the foetus to be exposed during the period of critical development in utero and remains unclear for adverse pregnancy outcomes (Wei et al., 2021). Relatively, there have been few cases recorded in neonates and children but they seem to have an encouraging clinical outcome as compared to other vulnerable groups (Janghorban, 2020). As a result of the coronavirus 2019, health facilities and staff were overwhelmed by the number of confirmed cases which affected other services like antenatal care thereby increasing the vulnerability of pregnant women (Wilson & Wilson, 2021).

2.6 HIV and COVID-19 Co-infection

As COVID-19 was declared a pandemic by WHO in March 2020, the quick spread from one continent to another has had a colossal burden on the global healthcare delivery program, especially for chronic illnesses (WHO, 2020). People living with HIV are particularly susceptible during this period, this could be a result of drug-drug interaction with ARTs, and compromised immune systems (Magnani et al., 2022). Elderly people and individuals with comorbidities such as hypertension, heart failure, cancer, chronic kidney diseases, cardiovascular conditions, diabetes and obesity are more vulnerable to severe acute respiratory syndrome (SARS-CoV-2) morbidity and mortality (Barbera et al., 2021; UN Joint Programme on HIV/AIDS (UNAIDS), 2020).

There is however a gap in the scientific literature on the possible impact of HIV status on COVID-19 exposure based on severe consequences (Chenneville et al., 2020). Due to the immunocompromised state of people living with HIV/AIDS (PLWHA), such individuals are more susceptible to the coronavirus 2019 and have a greater chance of presenting severe symptoms when infected with COVID-19 (Ssentongo et al., 2021; UNAIDS, 2020). Evidence shows that PLWHA (with lower CD4 counts) and as well as those that are not on ART are at greater risk of manifesting severe symptoms of coronavirus 2019 (Luan et al., 2021; May & Fullilove, 2022).

2.6.1 Healthcare delivery, HIV and COVID-19

There is currently less scientific evidence describing how co-infection with HIV/AIDS or COVID-19 during pregnancy affects pregnancy and neonatal outcomes. However, the United States Department of Health and Human Services recommends that all valid precautions or measures for non-pregnant women living with HIV/AIDS are equally applicable to pregnant women living with HIV/AIDS to prevent and treat Coronavirus 2019 (Cordie, Abdallah, et al., 2021).

The demands placed on the healthcare system due to SARS-CoV-2 have serious consequences on health care delivery, especially in terms of prevention, treatment and testing of HIV in pregnant women during antenatal clinics (Davies, 2015)(Narang et al., 2020). Other studies have also shown that ANC attendance during the COVID-19 pandemic has drastically reduced which can significantly increase vertical transmission of HIV or mother-to-child transmission among HIV-positive women (Magnani et al., 2022).

2.7 Neonatal Outcomes for Maternal HIV status and COVID-19 exposure

Data on maternal COVID-19 exposure and its effect on fetal/neonatal outcomes are rare, especially in the Sub-Saharan region where the novel virus coexists with HIV, Malaria and other infectious diseases of poverty (Narang et al., 2020). The outcomes observed in a general population of pregnant women diagnosed with SARS-Cov-2 infection are fetal distress and preterm deliveries which have been previously reported in pandemics such as Severe Acute Respiratory Syndromes (SARS) and Middle Eastern Respiratory Syndrome (MERS) (Capobianco et al., 2020)

2.7. 1 The APGAR score

The Apgar score is a comprehensive scoring system used by health care providers to evaluate new-borns as quickly as one minute and five minutes intervals after birth. This system was developed in 1952 by Dr. Virginia Apgar, who used her name as an acronym for each of the five components that are scored. Medical specialists globally have evaluated babies in their first stages of life using the scoring system (Nursing Times, 2019).

The physical condition of the new-born is evaluated using the one-minute Apgar score to ascertain how the newborn endures in the new environment for the first time outside the mother's womb. The result will indicate whether immediate or late medical attention will be necessary. This is then followed by the five minutes Apgar score which is used to evaluate the effectiveness of the resuscitation done in the first minute, studies have suggested that all babies be given an Apgar score at 10 minutes, irrespective of their scores at one and five minutes respectively. These scores are given at birth by skilled personnel (doctors, nurses and midwives) (Nall, 2018; Rüdiger & Konstantelos, 2015)

A total Apgar score between 7 and 10 is regarded as "normal," and any figure below seven (7) denotes less vitality for the baby. Score 4 to 5 is considered "moderate normal" and therefore promising, and 0 and 3 are problematic. It signals a need for more management, typically in the form of breathing support. The overall combined Apgar score is 17 (i.e., Expanded (7) and Specified (10), which signifies a baby who does not require any interventions and gets all the points. For a baby who fails to respond to interventions, the score is 0 (Persson et al., 2018).

Table 2.1: The APGAR Scoring System. Apgar (1985)

	Score		
Parameter	**0**	**1**	**2**
Appearance (Skin Color)	Bluish grey or Pale	Normal colour but hands & feet are bluish (Cyanotic)	Normal colour all over but hands& feet are pink (Completely pink)
Pulse (Heart Rate)	Absent (No pulse)	Below 100 beats per minute (Slow, irregular)	Above 100 beats/minute (Good, Crying)
Grimace (Reflex Irritability)	Absent (Floppy)	Facial or minimal movement (Grimace to stimulation)	Prompt response to stimulation (Pulls away, sneezes, coughs, or cries with stimulation)
Activity (Muscle tone)	Absent (No movement)	Arms and legs with little movement	Active spontaneous movement
Respiration (Breathing rate and effort)	Absent (No breathing)	Slow or irregular breathing (Weak cry)	Normal rate and effort (vigorous or good cry)

However, there are numerous risk factors associated with a low Apgar score, such as perinatal hypoxia, congenital infections, maternal fever during labour, chorioamnionitis, abnormalities, and preterm birth. In depressed infants, scoring is repeated every five minutes as needed. An Apgar score of 0 is regarded as still birth (Calmes & Calmes, 1985). Hence a 5-minute Apgar score of less than 7 may be interpreted as the presence of asphyxia and as such, the baby requires intensive care and resuscitation immediately. A low score does not mean that the baby is unhealthy but rather that baby needs some immediate medical care, such as suctioning of the airways or oxygen to help him or her breathe better. A slightly low score, especially at one minute is common with babies born after a high-risk pregnancy, through a C-section, and after complicated labour and delivery, etc.

Meanwhile, there is a paucity of current literature concerning maternal HIV status and COVID-19 exposure and its possible neonatal outcomes such as the Apgar score. There are several studies, on maternal HIV status and its neonatal outcomes but only a few are focused on Apgar score together with other neonatal outcomes (Ezechi et al., 2013; Li et al., 2020; Mellqvist et al., 2021; Mu et al., 2021; Rasmussen et al., 2020). Also, there are very limited data on maternal COVID-19 exposure and its effect on neonatal outcomes in both developed and developing country settings/Ghana (KC et al., 2020; Philip & Puzhakkal, 2021; Salvatore et al., 2020; Smith et al., 2020). The degree of theoretical interest and analytical depth varies across these studies and there is no explicit concentration on the Apgar score in particular.

By examining neonatal outcomes of HIV-infected mothers and as well as COVID-19-exposed pregnant women, the work presented in this dissertation aims to highlight the effect of HIV and COVID-19 coinfection on neonatal outcomes with a particular focus on the Apgar score. This work presents evidence from a premier longitudinal cohort study to explore neonatal outcomes of HIV and COVID-19 coinfection in Ghana: a developing country setting

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter details the methods used in conducting the original prospective cohort study and the methods employed in this cross-sectional study. It includes information on the study area, the study design, the study population, the sampling and sampling techniques, sample size, data collection as well as the data analysis approach and ethical considerations are present in this chapter.

3.2 Study Design

This study was secondary analysis of data from a prospective or longitudinal cohort study. The cohort study was designed to recruit women based on covid-19 exposure status from 5 health facilities in Accra. Women were recruited and followed up till 6 weeks after delivery. Ultrasound were repeated to assess IUGR. Repeated antibody test, laboratory evaluation of the neonate (Including testing for SARS-CoV-2 antibodies, HIV and Syphilis). Six weeks after the end of the pregnancy, information on the newborn and woman was collected. All biological sampling for SARS_CoV-2 RNA (umbilical cord, breast milk, neonatal nasopharyngeal swab and anal swab) were conducted.

3.3 Study Area

This study was designed and conducted in areas with an ongoing COVID-19 outbreak; defined as areas where disease surveillance detected community transmission of the SARS-CoV-2 virus. Stratified Sampling Techniques were used in selecting the study sites.

Greater Accra Region was designated as the study area because it is the epicenter of COVID-19 in Ghana. Health care facilities were selected based on high antenatal clinic attendance and delivery rates.

3.3.0 Description of selected study sites

Five facilities were designated as primary Covid-19 treatment centres at regional, district, and secondary levels in the Grater Accra region. They include; Korle-Bu Teaching Hospital, Greater Accra Regional Hospital, Tema General Hospital, Ga West Municipal Hospital (Amasaman), and Shai-Osudoku District Hospital served as study sites. Their descriptions are provided below.

3.3.1 Korle-Bu Teaching Hospital (KBTH)

The Korle Bu Teaching Hospital is a designated COVID-19 primary treatment center. It was founded in 1923 and became a teaching hospital in 1962 when the University of Ghana Medical School was established. The hospital has grown from a small facility to a major tertiary referral centre not only in Ghana but in other West African countries such as Togo, Ivory Coast, Liberia, and Sierra Leone to name but a few. Korle Bu's initial bed capacity was increased by the addition of new structures such as Child Health, Maternity, Medical, and Surgical Blocks. The hospital is currently Africa's third-largest referral centre with 2,000 beds, 21 clinical and diagnostic departments, and an average outpatient attendance of 1,500, with approximately 250 inpatient admissions.

The KBTH's obstetric unit is Ghana's largest single antenatal, delivery, and postnatal care center, with approximately 13,000 antenatal attendants and 10,000 deliveries per year. The unit has 265 beds spread across six floors. Each floor is overseen by a team of five obstetric consultants, ten residents at various levels of training, five house-officers, 20 midwives, and other support personnel. There are two labour wards, each with 18 delivery beds. Critically ill obstetric patients who require mechanical ventilation and intensive care are transferred to one of the hospital's two centralized intensive care units (ICU). Monday through Friday, with an average daily attendance of approximately 80 antenatal and postnatal patients. More than 80% of antenatal attendees are high-risk obstetric patients.

3.3.2 Greater Accra Regional Hospital (GARH)

The Greater Accra Regional Hospital is the region's referral center and tertiary facility designated as a Covid-19 treatment primary center. The GARH sees over 7,000 deliveries per year. The total number of births recorded in 2019 and 2020 was 7,635 and 7,299, respectively. This facility provides all methods of family planning, comprehensive abortion care, and reproductive health services. The facility primarily serves urban residents. The hospital has been expanded to 420 beds and serves the residents of the Greater Accra region. Nima, Mamobi, Kanda, Accra New Town, Kotobabi, Osu, La, Adabraka, Achimota, Airport residential area, and Accra Central are among the hospital's immediate catchment areas. As a result, the Greater Accra Regional Hospital is one of the country's leading hospitals.

3.3.3 Tema General Hospital

The Tema General Hospital is the city's largest medical facility in the Greater Accra Region, the Tema General Hospital is also a designated COVID-19 primary treatment center. It is bounded in the northeast by the Dangme West District, in the south-west by the Ledzokuku Krowor Municipality, in the north-west by Adentan Municipality and Ga East Municipality, in the north by the Akuapim South District, and in the south by the Gulf of Guinea. The hospital serves the entire urban population of 292,773 people in Tema

Metropolis. There are 89,924 females between the reproductive ages of 15 and 49 years. The Metropolis has a Total Fertility Rate of 2.3 and a General Fertility Rate of 68.3 births per 1000 women aged 15-49 years. Annually, there are over 4,000 deliveries at the Tema General Hospital. Total births recorded in 2019 and 2020 were 5,711 and 4,862 respectively.

The Tema General Hospital's Obstetric and Gynecological department is led by a team of one obstetric consultant, two specialists, eight medical officers, two to five house officers, and other support staff. The facility provides all Reproductive Health services. The hospital has 168 beds and 18,428 antenatal attendants.

3.3.4 Ga West Municipal Hospital (Amasaman)

Amasaman is home to the Ga West Municipal Hospital. It was also designated as the Greater Accra Region's COVID-19 primary treatment center. The hospital serves the surrounding districts and towns by providing both preventive and curative health care. The projected population of Ga West Municipality in 2018 was estimated to be around 219,788, with a 3.4 percent annual growth rate. The municipality is bordered to the east by Ga East and the Accra Metropolitan Assembly, to the north by Akuapem South, and the south and west by Ga South. Every month, the hospital receives at least forty (40) referrals (hospital OPD records). Community-Based Health Planning and Services (CHPS) compounds, health centers, private health facilities, district hospitals, and maternity homes are among the health facilities.

All methods of family planning are available, as are comprehensive abortion care services. The Ga West Hospital sees over 4,000 deliveries per year. The facility primarily serves urban residents. The Ga West Municipal Hospital sees over 4,000 deliveries per year12. The total number of births in 2019 and 2020 was 4,462 and 4,263 respectively.

3.3.5 Shai-Osudoku District Hospital

The Shai Osudoku District Hospital is located in Dodowa, the district's capital. North Tongu District borders the district to the north-east, Yilo and Akwapim Districts to the north-west, North Akwapim District to the west, Kpone- Katamanso District to the south, Ningo-Prampram District to the south, and Ada West District to the east. In mid-2009, the facility was upgraded to a district hospital. It has a 125-bed capacity and is the district's only major government health institution.

The facility serves a primarily rural population of 70,252 people. There are maternity and child welfare services available. It has participated in numerous research studies and has been selected as a trial site for the National Health Insurance-National Malaria Treatment Policy, Population-Based Influenza Surveillance with the NMIMR, NAMRU (USA), CDC, and Antibiotic Resistance in UTI - ADMER (Netherlands)/UG. Over 4,000 deliveries are made at the hospital each year. The total number of births recorded in 2019 and 2020 was 4,025 and 4,392, respectively.

Figure 2: Map of Ghana

Figure 3: Map of the selected study sites

3.4 Study Population

The study population consisted of 1,444 pregnant women who were attending any of the five clinics for ANC care either exposed to COVID-19 or not. The participant's data were collected from the prospective cohort study from the five selected treatment centers in the Greater Accra region, Ghana.

3.5.0 Inclusion and Exclusion Criteria

3.5.1 Inclusion Criteria

The inclusion criteria for this study comprised of the following:

1. All pregnant women with HIV infection with or without COVID-19 infection up to 2 days postpartum/pregnancy termination at the time of enrolment within the Greater Accra region who attended antenatal care at the study sites.
2. All pregnant women with co-morbidities of HIV and COVID-19 were eligible for this study.
3. All pregnant women who met the first and second criteria for inclusion and gave their consent to participate in the study were included in this study.

3.5.2 Exclusion Criteria

The exclusion criteria for this study comprised of the following:

1. Women who delivered outside the Greater Accra Region were excluded from this study.
2. Pregnant women who were negative for both HIV and SARS-CoV-2 were excluded from this study.
3. All pregnant women who met the first and second criteria for inclusion and did not give their consent to participate in the study were excluded from this study.

3.6 Sampling Method/Technique

This study employed a purposive sampling method. Every pregnant woman either been exposed to COVID-19 infection or not but is HIV positive and has attended ANC and been delivered in health facilities in the Greater Accra Region was selected to participate in the study. A participant who was recruited after they consented to take part in the prospective cohort study will be considered in this study. Exposed status consisted of pregnant women who had tested positive by PT-PCR or Antigen test and/or IgG/IgM for SARS-CoV-2 during screening/ Participants enrolled as unexposed were crossed over to the exposed group if there was evidence of seroconversion or positive PT-PCR for SARS_CoV-2 after study enrolment. Unexposed status also consisted of women who had a negative testing for SARS CoV-2 IgG/IgM at time of study entry and at end points (End of pregnancy and/or within 48 hours postpartum).

3.7 Sample Size Determination

The sample size determination for the prospective cohort study was done using the Statical statistical module in the Epi Info software. The sample size calculated for this study was based on independent experimental (exposed) and control (unexposed) arms.

However, the sample size depended on the number of participants who completed the study. There were three principles generally need to be specified to determine the appropriate sample size: these included; the level of precision, the level of confidence or risk, and the degree of variability in the attributes being measured

For the analysis of HIV mothers only, a total of 37 women drawn from the overall sample of 1,444 was used. Mothers with HIV who were exposed to COVID-19 were 18 whereas 19 were not.

3.8 Description of study variables

The independent variables applied in this study were; Mother's age, marital status, educational level, gravidity, parity, HIV status, and COVID-19 exposure. The dependent variables in this study were Apgar scores, neonatal outcomes (Still birth, preterm birth, term birth)

3.9 Data Collection Technique

Data were extracted from the main database of the ongoing prospective cohort study into an excel sheet.

3.10 Quality control and assurance

The data extracted were stored under an excel spreadsheet with a passcode. Only the researcher and the Data management team had access to electronic files for this study and ensured the data is well protected.

3.11 Data management and Analysis

Data was exported to STATA version 17.0 for analysis. At the univariate level, descriptive statistics were performed to describe the study sample to relevant variables. Frequencies and percentage distribution were used to describe variables such as maternal age, gestational age, birth weight, marital status, education status, Parity, medical history, mode of delivery, and pregnancy complications. For comparisons of means of outcome variables (birth weight, gestation length, and Apgar score in multiple groups, the box and whisker technique was used. Multivariate linear regression was also used to determine the strength of association of COVID-19 on Apgar scores and other neonatal outcomes.

3.12 Ethical Considerations

Ethical approval for the Covid-in-pregnancy study was sought following the Ghana Health Service Ethical Review Committee, Korle-Bu Teaching Hospital Institutional Review Board, and the University of Ghana College of Health Sciences Ethical Review Board. The generic protocol was approved by WHO Research Ethics Review Committee. Permission to use the data generated from the mother study was sought from the UGSPH Hub.

3.12.1 Confidentiality/Privacy

Respondents were assured that under no condition whatsoever will their names or any other contacts be linked to the data analysis and dissemination of the findings of the study. Participants were assigned codes as identities instead of names in the data collection and analysis process.

3.12.2 Informed consent/withdrawal

Participants were informed and reminded of voluntary participation. They were informed of their right to refuse to participate or withdraw from the study. Participants were informed that they could opt-out at any stage of the study without any punishment, intimidation, or loss of benefit.

3.12.3 Benefit/Risk

There were no direct benefits for participants in the study. However, the information this study obtained would be used to provide recommendations to the authorities that would aid in improving pregnancy outcomes among HIV-positive women and COVID-19-exposed pregnant women.

3.12.4 Conflict of interest

There were no financial or other personal considerations that may be compromised in conducting the study. Therefore, there are no issues of conflict of interest throughout the study.

3.13 Study limitations

Due to the analysis being embedded in the cohort study, the study's scope will be limited to the Greater Accra Region.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter present to findings of the study. It illustrates the characteristics of the participants and highlights the key findings along three broad areas among the women studied:

- Background characteristics of women
- Background characteristics of neonates born to HIV mothers.
- Neonatal outcomes.

4.1 Background Characteristics of women

A total of 37 eligible women with HIV were included in the analysis out of 1,444 women recruited for the Covid and pregnancy study. This represented a prevalence of 2.6% HIV in pregnant women in Accra. Among the 37 eligible women, ages ranged from 20 to 46 years with a mean of 32 ± 0.86 years. Approximately 49% of HIV mothers (N=18) had been exposed to covid-19 during pregnancy. The results of the analysis of the 37 women is presented in table 4.1 below. Mothers exposed to covid-19 were generally aged 31-35 years (21.6%) whereas unexposed mothers were younger and aged 26-35years (16.2%). Most mothers (62.2%) were currently married and about 43.2% of mothers had a secondary/high school education. Most mothers (91.1%) were living in urban areas with 42.8% and 48.6% being exposed and unexposed to covid-19 respectively. None of the mothers had a history of alcohol intake. Approximately 2.7% of exposed mothers and 5.4% of unexposed mothers had a history of hypertension respectively. Exposed mothers generally had 3 or more children (24.3%). Only 9.9% were not on antiretroviral drugs.

Table 4.1: Socio-demographic and clinical characteristics of HIV mothers based on Covid-19 exposure status

	Covid-19 Exposure		
Characteristics	**Yes n (%)**	**No n (%)**	**Total N (%)**
Age of Mothers at conception			
20-25	0 (0)	3 (8.1)	3(8.1)
26-30	5 (13.5)	6 (16.2)	11 (29.7)
31-35	8 (21.6)	5 (13.5)	13 (35.1)
36-40	4 (10.8)	4 (10.8)	8 (21.6)
40+	1 (2.7)	1 (2.7)	2 (5.4)
Marital Status			
Single	1 (2.7)	4 (10.8)	5 (13.5)
Currently Married	12 (32.4)	11 (29.7)	23 (62.2)
Co-habiting	4 (10.8)	4 (10.8)	8 (24.6)
Educational Status			
No formal schooling	2(5.4)	2 (5.4)	4 (10.8)
Less than Primary School	1 (2.7)	1 (2.7)	2 (5.4)
Primary School	5 (13.5)	6 (16.2)	11(29.7)
Secondary/High school	8 (24.6)	8 (24.6)	16 (43.2)
College/University	2 (5.4)	2 (5.4)	4 (10.8)
Place of residence			
Rural	3(8.1)	1 (2.7)	4 (10.8)
Urban	16 (43.2)	18 (48.6)	34(91.1)
Medical History			
Hypertension			
Yes	1 (2.7)	2 (5.4)	3 (8.1)
No	17 (45.9)	17 (45.9)	34(91.9)
Obstetric history			
Parity			
0-2	9 (24.3)	13 (35.1)	22 (59.5)
3+	9 (24.3)	6 (16.2)	15 (40.5)
Number of previous pregnancies beyond 22 weeks gestation			
0-2	10 (27.0)	13 (35.1)	23 (62.2)
3+	8 (21.6)	6 (16.2)	14 (37.8)
Number of the previous vaginal deliveries			
0-2	12 (32.4)	18 (48.6)	30 (81.1)
3+	6 (16.2)	1 (2.7)	7 (18.9)
Number of previous caesarean sections			
0	16 (43.2)	12 (32.4)	28 (75.7)

1	2 (5.4)	7 (18.9)	9 (24.3)
Antiretroviral drug status			
On antiretroviral	16 (43.2)	18 (48.6)	34 (91.9)
Not on antiretroviral	2 (5.4)	1(2.7)	3 (8.1)
Mode of Delivery			
Spontaneous vaginal	13 (37.84)	14 (35.13)	27 (72.97)
Planned caesarean	1(2.70)	3 (8.11)	4 (10.81)
Emergency caesarean	4(10.81)	2(5.41)	6 (16.22)
Pregnancy complication			
None	12 (32.4)	11 (29.7)	23 (62.2)
Gestational hypertension	1 (2.7)	1 (2.7)	2 (5.4)
Anaemia	5(13.5)	4 (10.8)	9 (24.3)
Hyperemesis	0(0)	1 (2.7)	1 (2.7)
Haemorrhage	0(0)	1 (2.7)	1(2.7)
Other	1(2.7)	1 (2.7)	2 (5.4)
TOTAL	18(49%)	19(51%)	37

**Marital status responses from 36 mother's due to one refusal to respond.*

**None of the 37 pregnant women responded yes to lifestyle factors (alcohol intake)*

4.2 Background Characteristics of neonates born to HIV mothers

The background characteristics of 37 (one death) neonates are presented in Table 4.2. The median gestational age at delivery was 40 weeks. Approximately 49% of babies were born to mothers with Covid-19 exposure. Pre-term births were recorded among unexposed mothers only and were approximately 8.1%. Term births were recorded with a distribution of 48.6% from exposed mothers and 43.2% from unexposed mothers respectively. c. Approximately 43.2% and 5.4% of babies born from covid-19 exposed mothers had a normal birth and were underweight respectively. Also, 2.7% of babies born from covid-19 unexposed mothers were underweight. The mean Apgar scores recorded at 1 minute and 5 minutes are 7.2 and 8.3 respectively (Table 4.2).

Table 4.2: Clinical characteristics of neonates born to HIV mothers based on Covid-19 exposure status

Characteristic	Covid-19 Exposure		
	Yes n (%)	**No n (%)**	**Total n (%)**
Gestational age			
<37 (Pre-term)	0 (0)	3 (8.1)	3(8.1)
37=/> (Term)	18 (48.6)	16 (43.2)	34 (91.9)
Neonatal complication			
Ventilator support	2 (5.4)	0 (0)	2 (5.4)
None	16 (43.2)	18 (48.6)	34 (91.9)
NICU Admission			
Yes	2 (5.4)	0 (0)	2 (5.4)
No	16 (43.2)	18(48.6)	34 (91.9)
Birth weight			
Normal	16 (43.2)	17 (45.9)	33 (89.2)
Underweight	2 (5.4)	1 (2.7)	3 (8.1)
Neonatal Outcome			
Live birth	18 (48.6)	18 (48.6)	36 (97.3)
Ectopic pregnancy	0 (0)	1 (2.7)	1 (2.7)

*One missing data for birth weight, NICU admission and Neonatal complication respectively.

4.3 Neonatal outcomes among babies born to HIV Mothers

About 5.4% of babies born to Covid-19 exposed mothers had ventilator support and were on NICU admission after their births respectively. Approximately 8.1% of pre-term birth was observed amongst the covid-19 unexposed mothers with none occurring in exposed mothers. The majority of neonates from exposed (43.2%) and unexposed (45.9%) mothers had a normal weight. About 5.4% of neonates from exposed mothers and 2.7% of neonates from unexposed mothers were underweight.

Table 4.3: Apgar scores of neonates born to HIV mothers based on Covid-19 exposure status

Apgar Score	COVID-19 EXPOSURE					
	Yes			No		
	Median	Mean	Total (%)	Median	Mean	Total (%)
Apgar score at 1min	8	12.4	18 (48.6%)	7	7.1	18 (48.6)
Apgar scored at 5mins	9	13.4	18 (48.6%)	8	8.2	18 48.6)

**One missing data for Apgar score*

The median Apgar scores recorded at 1 minute for both babies born from covid exposed and unexposed mothers were 8 and 7 respectively. Furthermore, Apgar scores recorded at 5 minutes for both babies born from covid exposed and unexposed mothers were 9 and 8 respectively.

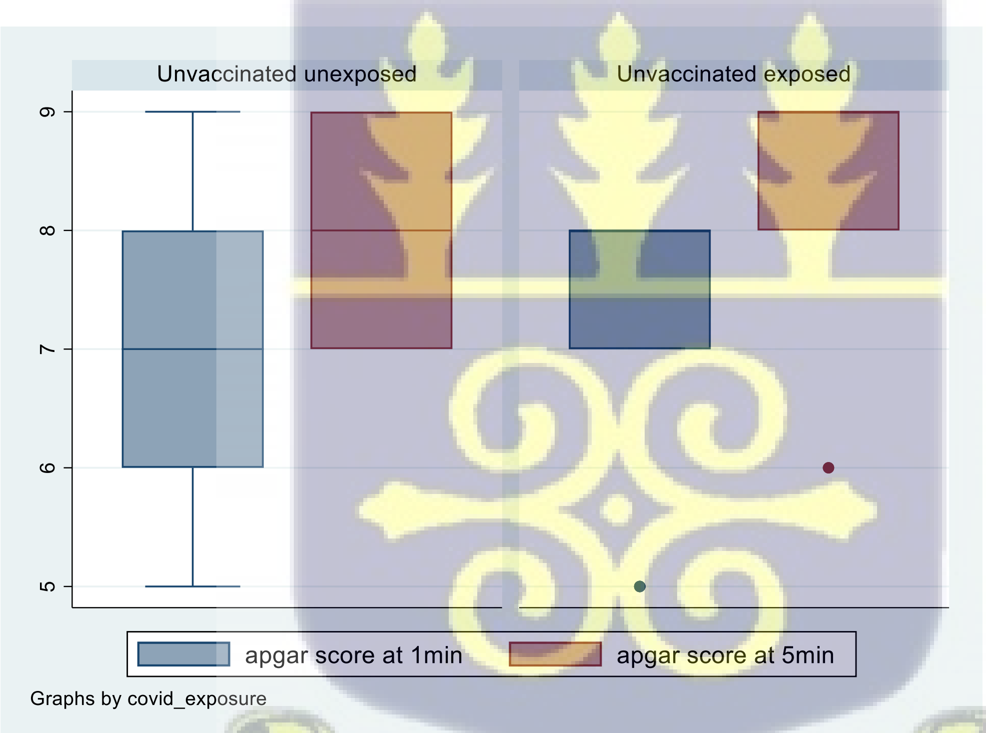


Figure 4: Box and Whisker plot of Apgar Scores for babies born the HIV mothers by COVID-19 exposure.

Factors associated with apgar score among neonates born to HIV women

From the multivariate analysis conducted, the average Apgar1minute scores were 3.16 (AOR = 3.16, 95%CI (0.12-2.18)) higher among children born through emergency c-section than those born via SVD when controlling for covid-19 status, gestational age at delivery and weight at birth (Table 4.4)Additionally, the average Apgar 5minute scores were 2.27 (AOR = 2.27, 95%CI (0.02-1.64)) higher among children born through emergency c-section than those born via SVD when controlling for covid-19 status, gestational age at delivery and weight at birth (Table 4.5).

Table 4.4: Effect of COVID-19 exposure on Apgar scores at 1 minute by background factors.

Dependent variable: Apgar score at 1minute	**COR**	**95% CI**		**P-value**	**AOR**	**95%CI**		**P-value**
		Lower	**Upper**			Lower	Upper	
Exposure								
Unvaccinated Unexposed	Ref				Ref			
Unvaccinated exposed	1.35	-0.43	1.02	0.411	1.20	-0.55	0.91	0.618
Gestational Age								
Pre-Term birth	Ref				Ref			
Term birth	3.56	-0.02	2.79	0.097	1.32	-0.92	1.70	0.549
Birth Weight								
Birthweight	1.0	-0.0007	0.0004	0.660	1.00	-0.0009	0.0002	0.214
Mode of delivery								
Spontaneous vaginal	Ref				Ref			
Planned caesarean	1.28	-0.86	1.36	0.649	1.84	-0.84	2.06	0.369
Emergency caesarean	**2.72**	**0.06**	**1.94**	**0.037***	**3.16**	**0.12**	**2.18**	**0.030***

Table 4.5: Effect of COVID-19 exposure on Apgar scores at 5 minutes by background factors.

Dependent variable: Apgar score at 5minutes	COR	95% CI		P-value	AOR	95%CI		P-value
		Lower	Upper			Lower	Upper	
Exposure								
Unvaccinated Unexposed	Ref				Ref			
Unvaccinated exposed	1.28	-0.32	0.81	0.388	1.23	-0.93	0.76	0.516
Gestational Age								
Pre-Term birth	Ref				Ref			
Term birth	2.29	-0.37	2.04	0.169	1.14	-0.65	1.40	0.464
Birth Weight								
Birthweight	1.00	-0.0006	0.0003	0.563	1.00	-0.0007	0.0001	0.183
Mode of delivery								
Spontaneous vaginal	Ref				Ref			
Planned caesarean	1.46	-0.50	1.26	0.384	1.92	-0.41	1.86	0.204
Emergency caesarean	**2.03**	**-0.03**	**1.45**	**0.059**	**2.27**	**0.02**	**1.64**	**0.044***

CHAPTER FIVE

5.0 Discussion

The findings from this study show that the prevalence of HIV among pregnant women in the Greater Accra Metropolis was 2.6%. This prevalence was lower compared to similar studies done in Nigeria (4%) (de Dieu Anoubissi et al., 2019), East Cameroon (9.7%), and North Cameroon (4.0%) respectively (de Dieu Anoubissi et al., 2019; Khanam, 2019). The low prevalence observed in this study could be due to the country's implementation of many programs to promote HIV prevention, particularly as part of routing ANC services for pregnant women. de Dieu Anoubissi et al. (2019) further report a higher prevalence in older pregnant women aged 36-45 years. Contrary to de Dieu Anoubissi's report, this study found a high prevalence among relatively younger mothers aged 31-35 years.

Exposure to COVID-19 was observed in 49% of pregnant women living with HIV. Both exposed and unexposed mothers showed similar clinical characteristics such as medical history, smoking history and number of live births. This finding is consistent with other studies carried out between Covid-19 exposed and unexposed pregnant women (Kasraeian et al., 2022; Rachmayanti & Wisnubroto, 2022). The coronavirus disease could pose an additional threat to pregnant women than to the general adult population as there is increased oxygen consumption and lower functional residual capacity during pregnancy (S. shuai Wang et al., 2020). Additionally, pregnant women with HIV would be more vulnerable since they have a suppressed immune system (Zhao et al., 2020). With close to half of pregnant women with HIV being vulnerable, it is important to take necessary precaution to keep this population safe. Although vaccines are available for COVID-19 and are recommended for pregnant women, antiviral specific drugs of high efficacy and potency are not readily available (Tavilani et al., 2021). Therefore, it is essential that pregnant women, especially those with underling conditions such as HIV are educated more the preventive and management guidelines.

About 24.3% of HIV mothers who were exposed to Covid-19 had three children. It is worth noting that a high parity increases the chance of health-related problems such as anemia (Koullali et al., 2020). This trend can be observed in this study as 13.5% and 10.8% of mothers with covid exposure and unexposed have symptoms of anemia respectively.

Approximately 21.6% of COVID-19-exposed pregnant women are in the age range of 31-35 encouragingly, women of these ages have been observed to be at lower risk of complications during labour (Rachmayanti & Wisnubroto, 2022). It could also be plausible that this lowered risk could account for the higher apgar scores among neonates born through emergency c-section than SVD.

Babies born to mothers who had Covid-19 exposure had a higher median Apgar score at both 1 and 5 mins than the mean Apgar scores of babies born to mothers without Covid-19 exposure. This implies that Covid-19 exposure in mothers did not have an adverse effect on the neonates' Apgar scores. Other studies have reported high average Apgar scores among neonates born to women with Covid-19 exposure and Covid-19 pneumonia (Chen et al., 2020; Liu et al., 2020). However, this finding could be a result of mothers being asymptomatic and thus, had no effect on apgar scores. About 5.4% of neonates were on ventilator support and were on NICU admissions respectively. This suggests that COVID-

19 exposure could possibly have an effect neonatal outcome. However, this finding could occur as a result of an HIV co-morbidity present in these mothers

These findings suggest that women with a history of COVID-19 exposure in pregnancy should be managed well to enable their neonates have good Apgar scores. It however highlights the positive outcomes with reference to the apgar score of neonates born via emergency C-section to HIV mothers.

CHAPTER SIX

The study's major conclusions are outlined in this chapter, along with the suggestions that have been made for the many involved parties and stakeholders.

6.1 Conclusion

These findings suggest that close to half of HIV pregnant women were exposed to covid-19. It also shows that the management of women and new-borns regardless of COVID-19 exposure in pregnancy who are delivered by emergency caesarean led to higher Apgar 5 and Apgar1 scores compared to those born via spontaneous vaginal delivery

6.2 Recommendation

- Health workers should continue with the current protocol for managing pregnant women with HIV during childbirth as it yield positive apgar score as an outcome.
- Education and increased awareness of health workers on HIV and COVID-19 infections and other infectious diseases should be encouraged.
- Nationwide research will be relevant owing to the small number of participants in this study.

6.3 Further research

This study was limited in assessing Covid-19 outcomes of neonates. Also, further studies should explore the vertical transmission of Covid-19 as a possible neonatal outcome by assessing placental swabs after child birth and other possible transmission routes. Also, this study should be replicated in other regions in Ghana.

REFERENCES

Agbozo, F., & Jahn, A. (2021). COVID-19 in Ghana: challenges and countermeasures for maternal health service delivery in public health facilities. *Reproductive Health*, *18*(1), 1–5. https://doi.org/10.1186/s12978-021-01198-5

Al-Sheyab, N. A., Khader, Y. S., Shattnawi, K. K., Alyahya, M. S., & Batieha, A. (2020). Rate, Risk Factors, and Causes of Neonatal Deaths in Jordan: Analysis of Data From Jordan Stillbirth and Neonatal Surveillance System (JSANDS). *Frontiers in Public Health*, *8*(October), 1–10. https://doi.org/10.3389/fpubh.2020.595379

Asante, I. A., Adusei-Poku, M., Bonney, H. K., Bonney, E. Y., Odoom, J. K., Obodai, E., Aboagye, J., Kotey, E. N., Nyarko, S., Boatemaa, L., Magnusen, V., Lamptey, H., Kyei, G. B., & Ampofo, W. K. (2020). Molecular diagnosis for the novel coronavirus SARS-CoV-2: Lessons learnt from the Ghana experience. *Ghana Medical Journal*, *54*(4), 77–85. https://doi.org/10.4314/GMJ.V54I4S.12

Barbera, L. K., Kamis, K. F., Rowan, S. E., Davis, A. J., Shehata, S., Carlson, J. J., Johnson, S. C., & Erlandson, K. M. (2021). HIV and COVID-19: review of clinical course and outcomes. *HIV Research and Clinical Practice*, *22*(4), 102–118. https://doi.org/10.1080/25787489.2021.1975608

Blitz, M. J., Gerber, R. P., Gulersen, M., Shan, W., Rausch, A. C., Prasannan, L., Meirowitz, N., & Rochelson, B. (2021). Preterm birth among women with and without severe acute respiratory syndrome coronavirus 2 infection. *Acta Obstetricia et Gynecologica Scandinavica*, *100*(12), 2253–2259. https://doi.org/10.1111/aogs.14269

Bwire, G., Ario, A. R., Eyu, P., Ocom, F., Wamala, J. F., Kusi, K. A., Ndeketa, L., Jambo, K. C., Wanyenze, R. K., & Talisuna, A. O. (2022). The COVID-19 pandemic in the African continent. *BMC Medicine*, *20*(1), 1–23. https://doi.org/10.1186/S12916-022-02367-4/FIGURES/12

Calmes, H., & Calmes, S. H. (1985). *2 . 9 Development of the ApgarScore*.

Capobianco, G., Saderi, L., Aliberti, S., Mondoni, M., Piana, A., Dessole, F., Dessole, M., Luigi, P., Dessole, S., & Sotgiu, G. (2020). *Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19 . The COVID-19 resource centre is hosted on Elsevier Connect , the company ' s public news and information . January*.

Chaubey, I., Vignesh, R., Babu, H., Wagoner, I., Govindaraj, S., & Velu, V. (2021). SARS-CoV-2 in Pregnant Women: Consequences of Vertical Transmission. *Frontiers in Cellular and Infection Microbiology*, *11*(September), 1–9. https://doi.org/10.3389/fcimb.2021.717104

Chen, H., Guo, J., Wang, C., Luo, F., Yu, X., Zhang, W., Li, J., Zhao, D., Xu, D., Gong, Q., Liao, J., Yang, H., Hou, W., & Zhang, Y. (2020). Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. *The Lancet*, *395*(10226), 809–815. https://doi.org/10.1016/S0140-6736(20)30360-3

Chenneville, T., Gabbidon, K., Hanson, P., & Holyfield, C. (2020). The impact of COVID-19 on HIV treatment and research: A call to action. *International Journal of Environmental Research and Public Health*, *17*(12), 1–14. https://doi.org/10.3390/ijerph17124548

Christopoulos, K. A., Olender, S., Lopez, A. M., Lekas, H. M., Jaiswal, J., Mellman, W., Geng, E., & Koester, K. A. (2015). Retained in HIV Care But Not on Antiretroviral Treatment: A Qualitative Patient-Provider Dyadic Study. *PLoS Medicine*, *12*(8), 1–19. https://doi.org/10.1371/journal.pmed.1001863

Commission, G. A. (2017). *Ghana AIDS Commission National and Sub-National HIV and AIDS Estimates and Projections 2017 Report*. 12.

Cordie, A., Abdallah, M., Vergori, A., Kharono, B., Karkouri, M., & Esmat, G. (2021). Human immunode fi ciency virus (HIV) and coronavirus disease 2019 ; impact on vulnerable populations and harnessing lessons learnt from HIV programmes. *New Microbes and New Infections*, *41*, 100857. https://doi.org/10.1016/j.nmni.2021.100857

Cordie, A., AbdAllah, M., Vergori, A., Kharono, B., Karkouri, M., & Esmat, G. (2021). Human immunodeficiency virus (HIV) and coronavirus disease 2019; impact on vulnerable populations and harnessing lessons learnt from HIV programmes. *New Microbes and New Infections*, *41*, 2019–2022. https://doi.org/10.1016/j.nmni.2021.100857

Danziger, R. (1997). HIV and the blood supply: An analysis of crisis decisionmaking. In *Social Science & Medicine* (Vol. 45, Issue 12). https://doi.org/10.1016/s0277-9536(97)90039-3

Davies, M. A. (2015). Research gaps in neonatal HIV-related care. *Southern African Journal of HIV Medicine*, *16*(1), 1–6. https://doi.org/10.4102/sajhivmed.v16i1.375

de Dieu Anoubissi, J., Gabriel, E. L., Nde, C. K., Fokam, J., Tseuko, D. G., Messeh, A., Moussa, Y., Nkenfou, C. N., Bonono, L., Billong, S. C., & Nfetam, J. B. E. (2019). Factors associated with risk of HIV-infection among pregnant women in Cameroon: Evidence from the 2016 national sentinel surveillance survey of HIV and syphilis. *PLoS ONE*, *14*(4), 21–30. https://doi.org/10.1371/journal.pone.0208963

Ezechi, O. C., Gab-Okafor, C. V., Oladele, D. A., Kalejaiye, O. O., Oke, B. O., Ohwodo, H. O., Adu, R. A., Ekama, S. O., Musa, Z., Onwujekwe, D. I., David, A. N., & Ujah, I. A. (2013). Pregnancy, obstetric and neonatal outcomes in HIV positive Nigerian women. *African Journal of Reproductive Health*, *17*(3), 160–168. https://doi.org/10.1016/s0020-

7292(12)60669-9

Fenizia, C., Biasin, M., Cetin, I., Vergani, P., Mileto, D., Spinillo, A., Gismondo, M. R., Perotti, F., Callegari, C., Mancon, A., Cammarata, S., Beretta, I., Nebuloni, M., Trabattoni, D., Clerici, M., & Savasi, V. (2020). Analysis of SARS-CoV-2 vertical transmission during pregnancy. *Nature Communications*, *11*(1). https://doi.org/10.1038/s41467-020-18933-4

Filteau, S. (2009). The HIV-exposed, uninfected African child. *Tropical Medicine and International Health*, *14*(3), 276–287. https://doi.org/10.1111/j.1365-3156.2009.02220.x

Fishel, J. D., Ren, R., Barr�re, B., & Croft, T. N. (2014). Child survival by HIV status of the mother: Evidence from DHS and AIS surveys . *DHS Comparative Reports No. 35* , *September*.

Galang, R. R., Chang, K., Strid, P., Snead, M. C., Woodworth, K. R., House, L. D., Perez, M., Barfield, W. D., Meaney-Delman, D., Jamieson, D. J., Shapiro-Mendoza, C. K., & Ellington, S. R. (2020). Severe coronavirus infections in pregnancy: A systematic review. *Obstetrics and Gynecology*, *136*(2), 262–272. https://doi.org/10.1097/AOG.0000000000004011

Gangakhedkar, R. R., Bentley, M. E., Divekar, A. D., Gadkari, D., Mehendale, S. M., Shepherd, M. E., Bollinger, R. C., & Quinn, T. C. (1997). Spread HIV infection in married monogamous women in India. *Journal of the American Medical Association*, *278*(23), 2090–2092. https://doi.org/10.1001/jama.278.23.2090

Gyebi, P. O., Kwara, A., & Surkan, P. J. (2020). *among postpartum women living with HIV in Ghana*. *23*(2), 433–444. https://doi.org/10.1007/s10461-018-2194-2.Low

Haynes, B. F., Pantaleo, G., & Fauci, A. S. (1996). Toward an understanding of the correlates of protective immunity to HIV infection. *Science*, *271*(5247), 324–328.

https://doi.org/10.1126/science.271.5247.324

Iftikhar, S., Ghias, M., Shahid, S., Ali, M. R., Hassan, M. U., & Numan, A. (2021). Clinical and biochemical indicators of disease severity and neurological findings in COVID-19: A study of King Edward Medical University (KEMU), Pakistan. *Pakistan Journal of Pharmaceutical Sciences*, *34*(1), 275–281. https://doi.org/10.36721/PJPS.2021.34.1.SUP.275-281.1

Janghorban, R. (2020). *Title : Impact of COVID-19 infection on maternal and neonatal outcomes : a review of 287 1 . PhD in Reproductive Health , Assistant Professor , Department of Midwifery , School of Nursing and Midwifery , Iranshahr University of Medical Sciences , Iranshah*. 1–26.

Juan, J., Gil, M. M., Rong, Z., Zhang, Y., Yang, H., & Poon, L. C. (2020). Effect of coronavirus disease 2019 (COVID-19) on maternal, perinatal and neonatal outcome: systematic review. *Ultrasound in Obstetrics and Gynecology*, *56*(1), 15–27. https://doi.org/10.1002/uog.22088

Kasraeian, M., Zare, M., Vafaei, H., Asadi, N., Faraji, A., Bazrafshan, K., & Roozmeh, S. (2022). COVID-19 pneumonia and pregnancy; a systematic review and meta-analysis. *Journal of Maternal-Fetal and Neonatal Medicine*, *35*(9), 1652–1659. https://doi.org/10.1080/14767058.2020.1763952

KC, A., Gurung, R., Kinney, M. V., Sunny, A. K., Moinuddin, M., Basnet, O., Paudel, P., Bhattarai, P., Subedi, K., Shrestha, M. P., Lawn, J. E., & Målqvist, M. (2020). Effect of the COVID-19 pandemic response on intrapartum care, stillbirth, and neonatal mortality outcomes in Nepal: a prospective observational study. *The Lancet Global Health*, *8*(10), e1273–e1281. https://doi.org/10.1016/S2214-109X(20)30345-4

Kendall, T., Danel, I., Cooper, D., Dilmitis, S., Kaida, A., Kourtis, A. P., Langer, A., Lapidos-

Salaiz, I., Lathrop, E., Moran, A. C., Sebitloane, H., Turan, J. M., Watts, D. H., & Wegner, M. N. (2014). Eliminating preventable HIV-related maternal mortality in Sub-Saharan Africa: What do we need to know? *Journal of Acquired Immune Deficiency Syndromes*, *67*, S250–S258. https://doi.org/10.1097/QAI.0000000000000377

Khalili, J. S., Zhu, H., Mak, N. S. A., Yan, Y., & Zhu, Y. (2020). Novel coronavirus treatment with ribavirin: Groundwork for an evaluation concerning COVID-19. *Journal of Medical Virology*, *92*(7), 740–746. https://doi.org/10.1002/jmv.25798

Khanam, S. (2019). Prevalence of Hiv Infection Among Pregnant Women Attending Ajiko Medical Clinic, Damaturu, Nigeria. *Journal of Clinical Research In HIV AIDS And Prevention*, *3*(4), 7–9. https://doi.org/10.14302/issn.2324-7339.jcrhap-19-2746

Kotlar, B., Gerson, E., Petrillo, S., Langer, A., & Tiemeier, H. (2021). The impact of the COVID-19 pandemic on maternal and perinatal health: a scoping review. In *Reproductive Health* (Vol. 18, Issue 1). BioMed Central. https://doi.org/10.1186/s12978-021-01070-6

Koullali, B., Van Zijl, M. D., Kazemier, B. M., Oudijk, M. A., Mol, B. W. J., Pajkrt, E., & Ravelli, A. C. J. (2020). The association between parity and spontaneous preterm birth: A population based study. *BMC Pregnancy and Childbirth*, *20*(1), 1–8. https://doi.org/10.1186/s12884-020-02940-w

Kumarasamy, N., Solomon, S., Flanigan, T. P., Hemalatha, R., Thyagarajan, S. P., & Mayer, K. H. (2003). Natural history of human immunodeficiency virus disease in southern India. *Clinical Infectious Diseases*, *36*(1), 79–85. https://doi.org/10.1086/344756

Levi, J., Raymond, A., Pozniak, A., Vernazza, P., Kohler, P., & Hill, A. (2016). Can the UNAIDS 90-90-90 target be achieved? A systematic analysis of national HIV treatment cascades. *BMJ Global Health*, *1*(2), 1–10. https://doi.org/10.1136/bmjgh-2015-000010

Li, H., Liu, J., Tan, D., Huang, G., Zheng, J., Xiao, J., Wang, H., Huang, Q., Feng, N., Zhang, G., & Bakir, M. (2020). Maternal HIV infection and risk of adverse pregnancy outcomes in Hunan province, China: A prospective cohort study. *Medicine (United States)*, *99*(8). https://doi.org/10.1097/MD.0000000000019213

Liu, W., Wang, Q., Zhang, Q., & Chen, L. (2020). Coronavirus disease 2019 (COVID-19) during pregnancy: a case series. *Preprint*, *2019*(February), 1–28. https://www.preprints.org/manuscript/202002.0373/v1%0Awww.preprints.org

Luan, H., Song, I., Fiellin, D. A., & Ransome, Y. (2021). HIV Infection Prevalence Significantly Intersects With COVID-19 Infection At the Area Level: A US County-Level Analysis. *JAIDS Journal of Acquired Immune Deficiency Syndromes*, *88*(2), 125–131. https://doi.org/10.1097/qai.0000000000002758

Magnani, R. J., Wirawan, D. N., Agung, A., Sawitri, S., Agung, I. G., Mahendra, A., Susanti, D., Kadek, N., Dwi, A., Ds, U., Asanab, D., Yunus, J. O., Setiabudi, C. H., Nugroho, A., Widihastuti, A. S., & Mukuan, O. S. (2022). The short - term effects of COVID - 19 on HIV and AIDS control efforts among female sex workers in Indonesia. *BMC Women's Health*, 1–12. https://doi.org/10.1186/s12905-021-01583-z

May, D., & Fullilove, R. (2022). Depression, HIV, and COVID-19: A Deadly Trifecta. *Public Health Reports*, *137*(3), 420–424. https://doi.org/10.1177/00333549221074389

Mehta, N. S., Mytton, O. T., Mullins, E. W. S., Fowler, T. A., Falconer, C. L., Murphy, O. B., Langenberg, C., Jayatunga, W. J. P., Eddy, D. H., & Nguyen-Van-Tam, J. S. (2020). SARS-CoV-2 (COVID-19): What Do We Know about Children? A Systematic Review. *Clinical Infectious Diseases*, *71*(9), 2469–2479. https://doi.org/10.1093/cid/ciaa556

Mellqvist, H., Saggers, R. T., Elfvin, A., Hentz, E., & Ballot, D. E. (2021). The effects of exposure to HIV in neonates at a referral hospital in South Africa. *BMC Pediatrics*, *21*(1), 4–11. https://doi.org/10.1186/s12887-021-02969-6

Montes, M. T., Herranz-Rubia, N., Ferrero, A., Flórez, A., Quiroga, A., Gómez, A., Chinea, B., Gómez, C., Montaner, C., Sánchez, N., Rico, C. M., Segovia, C., Eiriz, D., Carrillo, E., Cañizares, E. M., Chattas, G., Mimón, Ii. I., Guerra, I. M., Del Río, L., … Jiménez, T. (2020). Neonatal nursing in the COVID-19 pandemic: can we improve the future? *Journal of Neonatal Nursing*, *26*(5), 247–251. https://doi.org/10.1016/j.jnn.2020.07.005

Morang'a, C. M., Ngoi, J. M., Gyamfi, J., Amuzu, D. S. Y., Nuertey, B. D., Soglo, P. M., Appiah, V., Asante, I. A., Owusu-Oduro, P., Armoo, S., Adu-Gyasi, D., Amoako, N., Oliver-Commey, J., Owusu, M., Sylverken, A., Fenteng, E. D., M'cormack, V. V., Tei-Maya, F., Quansah, E. B., … Awandare, G. A. (2022). Genetic diversity of SARS-CoV-2 infections in Ghana from 2020-2021. *Nature Communications*, *13*(1), 1–11. https://doi.org/10.1038/s41467-022-30219-5

Mu, Y., Li, M., Zhu, J., Wang, Y., Xing, A., Liu, Z., Xie, Y., Wang, X., & Liang, J. (2021). Apgar score and neonatal mortality in China: an observational study from a national surveillance system. *BMC Pregnancy and Childbirth*, *21*(1), 1–12. https://doi.org/10.1186/s12884-020-03533-3

Muralidar, S., Ambi, S. V., Sekaran, S., & Krishnan, U. M. (2020). The emergence of COVID-19 as a global pandemic: Understanding the epidemiology, immune response and potential therapeutic targets of SARS-CoV-2. *Biochimie*, *179*, 85–100. https://doi.org/10.1016/J.BIOCHI.2020.09.018

Nall, R. (2018). *Apgar Score: Chart, Definition, Normal, Baby, and More*. What Is the Apgar Score?

Narang, K., Enninga, E. A. L., Gunaratne, M. D. S. K., Ibirogba, E. R., Trad, A. T. A., Elrefaei, A., Theiler, R. N., Ruano, R., Szymanski, L. M., Chakraborty, R., & Garovic, V. D. (2020). SARS-CoV-2 Infection and COVID-19 During Pregnancy: A Multidisciplinary Review. *Mayo Clinic Proceedings*, *95*(8), 1750–1765. https://doi.org/10.1016/j.mayocp.2020.05.011

Nelson, A. M. (2020). The evolution of professional obstetric nursing in the United States (1880′s-present): Qualitative content analysis of specialty nursing textbooks. *International Journal of Nursing Studies Advances*, *2*(June), 100010. https://doi.org/10.1016/j.ijnsa.2020.100010

NHS. (2019). *SARS (severe acute respiratory syndrome) - NHS*.

Nketiah-Amponsah, E., & Afful-Mensah, G. (2013). A review of HIV/AIDS awareness and knowledge of preventive methods in Ghana. *African Journal of Reproductive Health*, *17*(4 Spec No), 69–82.

Nursing Times. (2019). *All newborns should get Apgar score at 10 minutes, say researchers | Nursing Times*.

Oleribe, O. O., Suliman, A. A. A., Taylor-Robinson, S. D., & Corrah, T. (2021). Possible reasons why sub-saharan africa experienced a less severe COVID-19 pandemic in 2020. *Journal of Multidisciplinary Healthcare*, *14*(November), 3267–3271. https://doi.org/10.2147/JMDH.S331847

ONUSIDA. (2017). Data 2017. *Programme on HIV/AIDS*, 1–248.

Owusu, A. Y. (2020). A gendered analysis of living with HIV/AIDS in the Eastern Region of Ghana. *BMC Public Health*, *20*(1), 1–15. https://doi.org/10.1186/s12889-020-08702-9

Persson, M., Razaz, N., Tedroff, K., Joseph, K. S., & Cnattingius, S. (2018). Five and 10 minute Apgar scores and risks of cerebral palsy and epilepsy: Population based cohort study in

Sweden. *BMJ (Online)*, *360*, 207. https://doi.org/10.1136/bmj.k207

Philip, A. C., & Puzhakkal, I. F. (2021). Regarding "Impact of COVID-19 Infection on Neonatal Birth Outcomes." *Journal of Tropical Pediatrics*, *67*(6), 1–8. https://doi.org/10.1093/tropej/fmab110

Rachmayanti, E., & Wisnubroto, C. (2022). *COVID-19 AND NEONATAL OUTCOMES*. *07*(02), 80–90.

Rasmussen, D. N., Vieira, N., Hønge, B. L., da Silva Té, D., Jespersen, S., Bjerregaard-Andersen, M., Oliveira, I., Furtado, A., Gomes, M. A., Sodemann, M., Wejse, C., & Unger, H. W. (2020). HIV-1 and HIV-2 prevalence, risk factors and birth outcomes among pregnant women in Bissau, Guinea-Bissau: a retrospective cross-sectional hospital study. *Scientific Reports*, *10*(1), 1–13. https://doi.org/10.1038/s41598-020-68806-5

Rüdiger, M., & Konstantelos, D. (2015). Apgar score and risk of cause-specific infant mortality. *The Lancet*, *385*(9967), 505–506. https://doi.org/10.1016/S0140-6736(15)60196-9

Sakyi, K. S., Lartey, M. Y., Kennedy, C. E., Dension, J. A., Mullany, L. C., Owusu, P. G., Sacks, E., Hurley, E. A., & Surkan, P. J. (2020). Barriers to maternal retention in HIV care in Ghana: Key differences during pregnancy and the postpartum period. *BMC Pregnancy and Childbirth*, *20*(1), 1–13. https://doi.org/10.1186/s12884-020-03067-8

Salvatore, C. M., Han, J. Y., Acker, K. P., Tiwari, P., Jin, J., Brandler, M., Cangemi, C., Gordon, L., Parow, A., DiPace, J., & DeLaMora, P. (2020). Neonatal management and outcomes during the COVID-19 pandemic: an observation cohort study. *The Lancet Child and Adolescent Health*, *4*(10), 721–727. https://doi.org/10.1016/S2352-4642(20)30235-2

Sarkodie, B., Asiedu-Bekoe, F., Laryea, D. O., Ampofo, W. K., Phillips, R. O., Samba, A., Aboagye, D. C., Nsiah-Asare, A., Asamoah-Baah, A., Odame, E., Ohene, S. A., Amoako,

Y. A., & Kuma-Aboagye, P. (2021). Overview of preparedness and response to COVID-19 in Ghana. *Ghana Medical Journal*, *55*(2), 38–47. https://doi.org/10.4314/gmj.v55i2s.6

Smith, V., Seo, D., Warty, R., Payne, O., Salih, M., Chin, K. L., Ofori-Asenso, R., Krishnan, S., Da Silva Costa, F., Vollenhoven, B., & Wallace, E. (2020). Maternal and neonatal outcomes associated with COVID-19 infection: A systematic review. *PLoS ONE*, *15*(6), 1–13. https://doi.org/10.1371/journal.pone.0234187

Ssentongo, P., Heilbrunn, E. S., Ssentongo, A. E., Advani, S., Chinchilli, V. M., Nunez, J. J., & Du, P. (2021). Epidemiology and outcomes of COVID-19 in HIV-infected individuals: a systematic review and meta-analysis. *Scientific Reports*, *11*(1), 1–12. https://doi.org/10.1038/s41598-021-85359-3

Stinson, K., Jennings, K., & Myer, L. (2013). Integration of Antiretroviral Therapy Services into Antenatal Care Increases Treatment Initiation during Pregnancy: A Cohort Study. *PLoS ONE*, *8*(5), 1–8. https://doi.org/10.1371/journal.pone.0063328

Survey, H. (2014). *Ghana*.

Talbot, M. (2006). HIV infection. *Clinical Evidence*, *15*, 937–954.

Tavilani, A., Abbasi, E., Kian Ara, F., Darini, A., & Asefy, Z. (2021). COVID-19 vaccines: Current evidence and considerations. *Metabolism Open*, *12*(September), 100124. https://doi.org/10.1016/j.metop.2021.100124

Twabi, H. S., Manda, S. O., & Small, D. S. (2020). Assessing the effects of maternal HIV infection on pregnancy outcomes using cross-sectional data in Malawi. *BMC Public Health*, *20*(1), 1–15. https://doi.org/10.1186/s12889-020-09046-0

UN Joint Programme on HIV/AIDS (UNAIDS). (2020). *Covid-19 and Hiv : 1 Moment 2 Epidemics*.

UNAIDS. (2020). *What people living with HIV need to know about HIV and COVID-19*. 19.

Unicef. (2018). *UNICEF: Working to end AIDS for every child*. 1–20.

UNICEF. (2014). 2014 Annual Results Report: HIV and AIDS. *Annual Results Report*, 78.

United Nations Programme on HIV/aids. UNAIDS. (2021). *UNAIDS data 2021*. 4–38.

Vahlne, A. (2009). A historical reflection on the discovery of human retroviruses. *Retrovirology*, *6*, 1–9. https://doi.org/10.1186/1742-4690-6-40

Vijayanand, P., Wilkins, E., & Woodhead, M. (2004). Severe acute respiratory syndrome (SARS): a review. *Clinical Medicine (London, England)*, *4*(2), 152–160. https://doi.org/10.7861/CLINMEDICINE.4-2-152

Villar, J., Ariff, S., Gunier, R. B., Thiruvengadam, R., Rauch, S., Kholin, A., Roggero, P., Prefumo, F., Do Vale, M. S., Cardona-Perez, J. A., Maiz, N., Cetin, I., Savasi, V., Deruelle, P., Easter, S. R., Sichitiu, J., Soto Conti, C. P., Ernawati, E., Mhatre, M., … Papageorghiou, A. T. (2021). Maternal and Neonatal Morbidity and Mortality among Pregnant Women with and without COVID-19 Infection: The INTERCOVID Multinational Cohort Study. *JAMA Pediatrics*, *175*(8), 817–826. https://doi.org/10.1001/jamapediatrics.2021.1050

Wang, L. F., & Eaton, B. T. (2007). Bats, Civets and the Emergence of SARS. *Wildlife and Emerging Zoonotic Diseases: The Biology, Circumstances and Consequences of Cross-Species Transmission*, *315*, 325. https://doi.org/10.1007/978-3-540-70962-6_13

Wang, S. shuai, Zhou, X., Lin, X. guang, Liu, Y. yan, Wu, J. li, Sharifu, L. M., Hu, X. lin, Rong, Z. hui, Liu, W., Luo, X. ping, Chen, Z., Zeng, W. jiang, Chen, S. hua, Ma, D., Chen, L., & Feng, L. (2020). Experience of Clinical Management for Pregnant Women and Newborns with Novel Coronavirus Pneumonia in Tongji Hospital, China. *Current Medical Science*, *40*(2), 285–289. https://doi.org/10.1007/s11596-020-2174-4

Wei, S. Q., Bilodeau-Bertrand, M., Liu, S., & Auger, N. (2021). The impact of COVID-19 on pregnancy outcomes: A systematic review and meta-analysis. *Cmaj*, *193*(16), E540–E548. https://doi.org/10.1503/cmaj.202604

WHO, UNICEF, UNAIDS, U. (2008). HIV transmission through breastfeeding: a review of available evidence: 2007 update. *Reproductive Health Matters*, *7*(14), 188–189.

WHO. (2012). *WHO HIV Drug Resistance Report 2012*. 84.

WHO. (2016). Global Health Sector Strategy on HIV 2016-2021. In *World Health Organization* (Issue June 2016).

Wilson, M., & Wilson, P. J. K. (2021). Coronavirus Disease 2019 (COVID-19). *Close Encounters of the Microbial Kind*, *January*, 185–196. https://doi.org/10.1007/978-3-030-56978-5_12

World Bank Group. (2017). Annual Report. *The World Bank*, 80.

World Health Organization, W. (2016). World Health Organization (Who) Country Office for Ghana Annual Report 2015. *World Health Organization (Who) Country Office for Ghana Annual Report*, *3*(May), N0.2.

Xiao, P. L., Zhou, Y. B., Chen, Y., Yang, M. X., Song, X. X., Shi, Y., & Jiang, Q. W. (2015). Association between maternal HIV infection and low birth weight and prematurity: A meta-analysis of cohort studies. *BMC Pregnancy and Childbirth*, *15*(1). https://doi.org/10.1186/s12884-015-0684-z

Yang, M., Wang, Y., Chen, Y., Zhou, Y., & Jiang, Q. (2019). Impact of maternal HIV infection on pregnancy outcomes in southwestern China – A hospital registry based study. *Epidemiology and Infection*, *147*. https://doi.org/10.1017/S0950268818003345

Yuan, M. (2021). *Scholarship @ Western Investigating The Impact Of The COVID-19 Pandemic*

On Maternal Perceived Stress , Postpartum Depressive Symptoms , And Pregnancy Outcomes In London , Ontario : A One Health Approach.

Zhao, X., Jiang, Y., Zhao, Y., Xi, H., Liu, C., Qu, F., & Feng, X. (2020). Analysis of the susceptibility to COVID-19 in pregnancy and recommendations on potential drug screening. *European Journal of Clinical Microbiology and Infectious Diseases*, *39*(7), 1209–1220. https://doi.org/10.1007/s10096-020-03897-6

Agbozo, F., & Jahn, A. (2021). COVID-19 in Ghana: challenges and countermeasures for maternal health service delivery in public health facilities. *Reproductive Health*, *18*(1), 1–5. https://doi.org/10.1186/s12978-021-01198-5

Al-Sheyab, N. A., Khader, Y. S., Shattnawi, K. K., Alyahya, M. S., & Batieha, A. (2020). Rate, Risk Factors, and Causes of Neonatal Deaths in Jordan: Analysis of Data From Jordan Stillbirth and Neonatal Surveillance System (JSANDS). *Frontiers in Public Health*, *8*(October), 1–10. https://doi.org/10.3389/fpubh.2020.595379

Asante, I. A., Adusei-Poku, M., Bonney, H. K., Bonney, E. Y., Odoom, J. K., Obodai, E., Aboagye, J., Kotey, E. N., Nyarko, S., Boatemaa, L., Magnusen, V., Lamptey, H., Kyei, G. B., & Ampofo, W. K. (2020). Molecular diagnosis for the novel coronavirus SARS-CoV-2: Lessons learnt from the Ghana experience. *Ghana Medical Journal*, *54*(4), 77–85. https://doi.org/10.4314/GMJ.V54I4S.12

Barbera, L. K., Kamis, K. F., Rowan, S. E., Davis, A. J., Shehata, S., Carlson, J. J., Johnson, S. C., & Erlandson, K. M. (2021). HIV and COVID-19: review of clinical course and outcomes. *HIV Research and Clinical Practice*, *22*(4), 102–118. https://doi.org/10.1080/25787489.2021.1975608

Blitz, M. J., Gerber, R. P., Gulersen, M., Shan, W., Rausch, A. C., Prasannan, L., Meirowitz, N.,

& Rochelson, B. (2021). Preterm birth among women with and without severe acute respiratory syndrome coronavirus 2 infection. *Acta Obstetricia et Gynecologica Scandinavica*, *100*(12), 2253–2259. https://doi.org/10.1111/aogs.14269

Bwire, G., Ario, A. R., Eyu, P., Ocom, F., Wamala, J. F., Kusi, K. A., Ndeketa, L., Jambo, K. C., Wanyenze, R. K., & Talisuna, A. O. (2022). The COVID-19 pandemic in the African continent. *BMC Medicine*, *20*(1), 1–23. https://doi.org/10.1186/S12916-022-02367-4/FIGURES/12

Calmes, H., & Calmes, S. H. (1985). *2 . 9 Development of the ApgarScore*.

Capobianco, G., Saderi, L., Aliberti, S., Mondoni, M., Piana, A., Dessole, F., Dessole, M., Luigi, P., Dessole, S., & Sotgiu, G. (2020). *Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19 . The COVID-19 resource centre is hosted on Elsevier Connect , the company ' s public news and information . January*.

Chaubey, I., Vignesh, R., Babu, H., Wagoner, I., Govindaraj, S., & Velu, V. (2021). SARS-CoV-2 in Pregnant Women: Consequences of Vertical Transmission. *Frontiers in Cellular and Infection Microbiology*, *11*(September), 1–9. https://doi.org/10.3389/fcimb.2021.717104

Chen, H., Guo, J., Wang, C., Luo, F., Yu, X., Zhang, W., Li, J., Zhao, D., Xu, D., Gong, Q., Liao, J., Yang, H., Hou, W., & Zhang, Y. (2020). Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. *The Lancet*, *395*(10226), 809–815. https://doi.org/10.1016/S0140-6736(20)30360-3

Chenneville, T., Gabbidon, K., Hanson, P., & Holyfield, C. (2020). The impact of COVID-19 on HIV treatment and research: A call to action. *International Journal of Environmental*

Research and Public Health, *17*(12), 1–14. https://doi.org/10.3390/ijerph17124548

Christopoulos, K. A., Olender, S., Lopez, A. M., Lekas, H. M., Jaiswal, J., Mellman, W., Geng, E., & Koester, K. A. (2015). Retained in HIV Care But Not on Antiretroviral Treatment: A Qualitative Patient-Provider Dyadic Study. *PLoS Medicine*, *12*(8), 1–19. https://doi.org/10.1371/journal.pmed.1001863

Commission, G. A. (2017). *Ghana AIDS Commission National and Sub-National HIV and AIDS Estimates and Projections 2017 Report*. 12.

Cordie, A., Abdallah, M., Vergori, A., Kharono, B., Karkouri, M., & Esmat, G. (2021). Human immunode fi ciency virus (HIV) and coronavirus disease 2019 ; impact on vulnerable populations and harnessing lessons learnt from HIV programmes. *New Microbes and New Infections*, *41*, 100857. https://doi.org/10.1016/j.nmni.2021.100857

Cordie, A., AbdAllah, M., Vergori, A., Kharono, B., Karkouri, M., & Esmat, G. (2021). Human immunodeficiency virus (HIV) and coronavirus disease 2019; impact on vulnerable populations and harnessing lessons learnt from HIV programmes. *New Microbes and New Infections*, *41*, 2019–2022. https://doi.org/10.1016/j.nmni.2021.100857

Danziger, R. (1997). HIV and the blood supply: An analysis of crisis decisionmaking. In *Social Science & Medicine* (Vol. 45, Issue 12). https://doi.org/10.1016/s0277-9536(97)90039-3

Davies, M. A. (2015). Research gaps in neonatal HIV-related care. *Southern African Journal of HIV Medicine*, *16*(1), 1–6. https://doi.org/10.4102/sajhivmed.v16i1.375

de Dieu Anoubissi, J., Gabriel, E. L., Nde, C. K., Fokam, J., Tseuko, D. G., Messeh, A., Moussa, Y., Nkenfou, C. N., Bonono, L., Billong, S. C., & Nfetam, J. B. E. (2019). Factors associated with risk of HIV-infection among pregnant women in Cameroon: Evidence from the 2016 national sentinel surveillance survey of HIV and syphilis. *PLoS ONE*, *14*(4), 21–

30. https://doi.org/10.1371/journal.pone.0208963

Ezechi, O. C., Gab-Okafor, C. V., Oladele, D. A., Kalejaiye, O. O., Oke, B. O., Ohwodo, H. O., Adu, R. A., Ekama, S. O., Musa, Z., Onwujekwe, D. I., David, A. N., & Ujah, I. A. (2013). Pregnancy, obstetric and neonatal outcomes in HIV positive Nigerian women. *African Journal of Reproductive Health*, *17*(3), 160–168. https://doi.org/10.1016/s0020-7292(12)60669-9

Fenizia, C., Biasin, M., Cetin, I., Vergani, P., Mileto, D., Spinillo, A., Gismondo, M. R., Perotti, F., Callegari, C., Mancon, A., Cammarata, S., Beretta, I., Nebuloni, M., Trabattoni, D., Clerici, M., & Savasi, V. (2020). Analysis of SARS-CoV-2 vertical transmission during pregnancy. *Nature Communications*, *11*(1). https://doi.org/10.1038/s41467-020-18933-4

Filteau, S. (2009). The HIV-exposed, uninfected African child. *Tropical Medicine and International Health*, *14*(3), 276–287. https://doi.org/10.1111/j.1365-3156.2009.02220.x

Fishel, J. D., Ren, R., Barr�re, B., & Croft, T. N. (2014). Child survival by HIV status of the mother: Evidence from DHS and AIS surveys . *DHS Comparative Reports No. 35 , September*.

Galang, R. R., Chang, K., Strid, P., Snead, M. C., Woodworth, K. R., House, L. D., Perez, M., Barfield, W. D., Meaney-Delman, D., Jamieson, D. J., Shapiro-Mendoza, C. K., & Ellington, S. R. (2020). Severe coronavirus infections in pregnancy: A systematic review. *Obstetrics and Gynecology*, *136*(2), 262–272. https://doi.org/10.1097/AOG.0000000000004011

Gangakhedkar, R. R., Bentley, M. E., Divekar, A. D., Gadkari, D., Mehendale, S. M., Shepherd, M. E., Bollinger, R. C., & Quinn, T. C. (1997). Spread HIV infection in married monogamous women in India. *Journal of the American Medical Association*, *278*(23), 2090–2092. https://doi.org/10.1001/jama.278.23.2090

Gyebi, P. O., Kwara, A., & Surkan, P. J. (2020). *among postpartum women living with HIV in Ghana*. *23*(2), 433–444. https://doi.org/10.1007/s10461-018-2194-2.Low

Haynes, B. F., Pantaleo, G., & Fauci, A. S. (1996). Toward an understanding of the correlates of protective immunity to HIV infection. *Science*, *271*(5247), 324–328. https://doi.org/10.1126/science.271.5247.324

Iftikhar, S., Ghias, M., Shahid, S., Ali, M. R., Hassan, M. U., & Numan, A. (2021). Clinical and biochemical indicators of disease severity and neurological findings in COVID-19: A study of King Edward Medical University (KEMU), Pakistan. *Pakistan Journal of Pharmaceutical Sciences*, *34*(1), 275–281. https://doi.org/10.36721/PJPS.2021.34.1.SUP.275-281.1

Janghorban, R. (2020). *Title : Impact of COVID-19 infection on maternal and neonatal outcomes : a review of 287 1 . PhD in Reproductive Health , Assistant Professor , Department of Midwifery , School of Nursing and Midwifery , Iranshahr University of Medical Sciences , Iranshah*. 1–26.

Juan, J., Gil, M. M., Rong, Z., Zhang, Y., Yang, H., & Poon, L. C. (2020). Effect of coronavirus disease 2019 (COVID-19) on maternal, perinatal and neonatal outcome: systematic review. *Ultrasound in Obstetrics and Gynecology*, *56*(1), 15–27. https://doi.org/10.1002/uog.22088

Kasraeian, M., Zare, M., Vafaei, H., Asadi, N., Faraji, A., Bazrafshan, K., & Roozmeh, S. (2022). COVID-19 pneumonia and pregnancy; a systematic review and meta-analysis. *Journal of Maternal-Fetal and Neonatal Medicine*, *35*(9), 1652–1659. https://doi.org/10.1080/14767058.2020.1763952

KC, A., Gurung, R., Kinney, M. V., Sunny, A. K., Moinuddin, M., Basnet, O., Paudel, P., Bhattarai, P., Subedi, K., Shrestha, M. P., Lawn, J. E., & Målqvist, M. (2020). Effect of the COVID-19 pandemic response on intrapartum care, stillbirth, and neonatal mortality outcomes in Nepal: a prospective observational study. *The Lancet Global Health*, *8*(10), e1273–e1281. https://doi.org/10.1016/S2214-109X(20)30345-4

Kendall, T., Danel, I., Cooper, D., Dilmitis, S., Kaida, A., Kourtis, A. P., Langer, A., Lapidos-Salaiz, I., Lathrop, E., Moran, A. C., Sebitloane, H., Turan, J. M., Watts, D. H., & Wegner, M. N. (2014). Eliminating preventable HIV-related maternal mortality in Sub-Saharan Africa: What do we need to know? *Journal of Acquired Immune Deficiency Syndromes*, *67*, S250–S258. https://doi.org/10.1097/QAI.0000000000000377

Khalili, J. S., Zhu, H., Mak, N. S. A., Yan, Y., & Zhu, Y. (2020). Novel coronavirus treatment with ribavirin: Groundwork for an evaluation concerning COVID-19. *Journal of Medical Virology*, *92*(7), 740–746. https://doi.org/10.1002/jmv.25798

Khanam, S. (2019). Prevalence of Hiv Infection Among Pregnant Women Attending Ajiko Medical Clinic, Damaturu, Nigeria. *Journal of Clinical Research In HIV AIDS And Prevention*, *3*(4), 7–9. https://doi.org/10.14302/issn.2324-7339.jcrhap-19-2746

Kotlar, B., Gerson, E., Petrillo, S., Langer, A., & Tiemeier, H. (2021). The impact of the COVID-19 pandemic on maternal and perinatal health: a scoping review. In *Reproductive Health* (Vol. 18, Issue 1). BioMed Central. https://doi.org/10.1186/s12978-021-01070-6

Koullali, B., Van Zijl, M. D., Kazemier, B. M., Oudijk, M. A., Mol, B. W. J., Pajkrt, E., & Ravelli, A. C. J. (2020). The association between parity and spontaneous preterm birth: A population based study. *BMC Pregnancy and Childbirth*, *20*(1), 1–8. https://doi.org/10.1186/s12884-020-02940-w

Kumarasamy, N., Solomon, S., Flanigan, T. P., Hemalatha, R., Thyagarajan, S. P., & Mayer, K.

H. (2003). Natural history of human immunodeficiency virus disease in southern India. *Clinical Infectious Diseases*, *36*(1), 79–85. https://doi.org/10.1086/344756

Levi, J., Raymond, A., Pozniak, A., Vernazza, P., Kohler, P., & Hill, A. (2016). Can the UNAIDS 90-90-90 target be achieved? A systematic analysis of national HIV treatment cascades. *BMJ Global Health*, *1*(2), 1–10. https://doi.org/10.1136/bmjgh-2015-000010

Li, H., Liu, J., Tan, D., Huang, G., Zheng, J., Xiao, J., Wang, H., Huang, Q., Feng, N., Zhang, G., & Bakir, M. (2020). Maternal HIV infection and risk of adverse pregnancy outcomes in Hunan province, China: A prospective cohort study. *Medicine (United States)*, *99*(8). https://doi.org/10.1097/MD.0000000000019213

Liu, W., Wang, Q., Zhang, Q., & Chen, L. (2020). Coronavirus disease 2019 (COVID-19) during pregnancy: a case series. *Preprint*, *2019*(February), 1–28. https://www.preprints.org/manuscript/202002.0373/v1%0Awww.preprints.org

Luan, H., Song, I., Fiellin, D. A., & Ransome, Y. (2021). HIV Infection Prevalence Significantly Intersects With COVID-19 Infection At the Area Level: A US County-Level Analysis. *JAIDS Journal of Acquired Immune Deficiency Syndromes*, *88*(2), 125–131. https://doi.org/10.1097/qai.0000000000002758

Magnani, R. J., Wirawan, D. N., Agung, A., Sawitri, S., Agung, I. G., Mahendra, A., Susanti, D., Kadek, N., Dwi, A., Ds, U., Asanab, D., Yunus, J. O., Setiabudi, C. H., Nugroho, A., Widihastuti, A. S., & Mukuan, O. S. (2022). The short - term effects of COVID - 19 on HIV and AIDS control efforts among female sex workers in Indonesia. *BMC Women's Health*, 1–12. https://doi.org/10.1186/s12905-021-01583-z

May, D., & Fullilove, R. (2022). Depression, HIV, and COVID-19: A Deadly Trifecta. *Public Health Reports*, *137*(3), 420–424. https://doi.org/10.1177/00333549221074389

Mehta, N. S., Mytton, O. T., Mullins, E. W. S., Fowler, T. A., Falconer, C. L., Murphy, O. B., Langenberg, C., Jayatunga, W. J. P., Eddy, D. H., & Nguyen-Van-Tam, J. S. (2020). SARS-CoV-2 (COVID-19): What Do We Know about Children? A Systematic Review. *Clinical Infectious Diseases*, *71*(9), 2469–2479. https://doi.org/10.1093/cid/ciaa556

Mellqvist, H., Saggers, R. T., Elfvin, A., Hentz, E., & Ballot, D. E. (2021). The effects of exposure to HIV in neonates at a referral hospital in South Africa. *BMC Pediatrics*, *21*(1), 4–11. https://doi.org/10.1186/s12887-021-02969-6

Montes, M. T., Herranz-Rubia, N., Ferrero, A., Flórez, A., Quiroga, A., Gómez, A., Chinea, B., Gómez, C., Montaner, C., Sánchez, N., Rico, C. M., Segovia, C., Eiriz, D., Carrillo, E., Cañizares, E. M., Chattas, G., Mimón, Ii. I., Guerra, I. M., Del Río, L., … Jiménez, T. (2020). Neonatal nursing in the COVID-19 pandemic: can we improve the future? *Journal of Neonatal Nursing*, *26*(5), 247–251. https://doi.org/10.1016/j.jnn.2020.07.005

Morang'a, C. M., Ngoi, J. M., Gyamfi, J., Amuzu, D. S. Y., Nuertey, B. D., Soglo, P. M., Appiah, V., Asante, I. A., Owusu-Oduro, P., Armoo, S., Adu-Gyasi, D., Amoako, N., Oliver-Commey, J., Owusu, M., Sylverken, A., Fenteng, E. D., M'cormack, V. V., Tei-Maya, F., Quansah, E. B., … Awandare, G. A. (2022). Genetic diversity of SARS-CoV-2 infections in Ghana from 2020-2021. *Nature Communications*, *13*(1), 1–11. https://doi.org/10.1038/s41467-022-30219-5

Mu, Y., Li, M., Zhu, J., Wang, Y., Xing, A., Liu, Z., Xie, Y., Wang, X., & Liang, J. (2021). Apgar score and neonatal mortality in China: an observational study from a national surveillance system. *BMC Pregnancy and Childbirth*, *21*(1), 1–12. https://doi.org/10.1186/s12884-020-03533-3

Muralidar, S., Ambi, S. V., Sekaran, S., & Krishnan, U. M. (2020). The emergence of COVID-

19 as a global pandemic: Understanding the epidemiology, immune response and potential therapeutic targets of SARS-CoV-2. *Biochimie*, *179*, 85–100. https://doi.org/10.1016/J.BIOCHI.2020.09.018

Nall, R. (2018). *Apgar Score: Chart, Definition, Normal, Baby, and More*. What Is the Apgar Score?

Narang, K., Enninga, E. A. L., Gunaratne, M. D. S. K., Ibirogba, E. R., Trad, A. T. A., Elrefaei, A., Theiler, R. N., Ruano, R., Szymanski, L. M., Chakraborty, R., & Garovic, V. D. (2020). SARS-CoV-2 Infection and COVID-19 During Pregnancy: A Multidisciplinary Review. *Mayo Clinic Proceedings*, *95*(8), 1750–1765. https://doi.org/10.1016/j.mayocp.2020.05.011

Nelson, A. M. (2020). The evolution of professional obstetric nursing in the United States (1880′s-present): Qualitative content analysis of specialty nursing textbooks. *International Journal of Nursing Studies Advances*, *2*(June), 100010. https://doi.org/10.1016/j.ijnsa.2020.100010

NHS. (2019). *SARS (severe acute respiratory syndrome) - NHS*.

Nketiah-Amponsah, E., & Afful-Mensah, G. (2013). A review of HIV/AIDS awareness and knowledge of preventive methods in Ghana. *African Journal of Reproductive Health*, *17*(4 Spec No), 69–82.

Nursing Times. (2019). *All newborns should get Apgar score at 10 minutes, say researchers | Nursing Times*.

Oleribe, O. O., Suliman, A. A. A., Taylor-Robinson, S. D., & Corrah, T. (2021). Possible reasons why sub-saharan africa experienced a less severe COVID-19 pandemic in 2020. *Journal of Multidisciplinary Healthcare*, *14*(November), 3267–3271. https://doi.org/10.2147/JMDH.S331847

ONUSIDA. (2017). Data 2017. *Programme on HIV/AIDS*, 1–248.

Owusu, A. Y. (2020). A gendered analysis of living with HIV/AIDS in the Eastern Region of Ghana. *BMC Public Health*, *20*(1), 1–15. https://doi.org/10.1186/s12889-020-08702-9

Persson, M., Razaz, N., Tedroff, K., Joseph, K. S., & Cnattingius, S. (2018). Five and 10 minute Apgar scores and risks of cerebral palsy and epilepsy: Population based cohort study in Sweden. *BMJ (Online)*, *360*, 207. https://doi.org/10.1136/bmj.k207

Philip, A. C., & Puzhakkal, I. F. (2021). Regarding "Impact of COVID-19 Infection on Neonatal Birth Outcomes." *Journal of Tropical Pediatrics*, *67*(6), 1–8. https://doi.org/10.1093/tropej/fmab110

Rachmayanti, E., & Wisnubroto, C. (2022). *COVID-19 AND NEONATAL OUTCOMES*. *07*(02), 80–90.

Rasmussen, D. N., Vieira, N., Hønge, B. L., da Silva Té, D., Jespersen, S., Bjerregaard-Andersen, M., Oliveira, I., Furtado, A., Gomes, M. A., Sodemann, M., Wejse, C., & Unger, H. W. (2020). HIV-1 and HIV-2 prevalence, risk factors and birth outcomes among pregnant women in Bissau, Guinea-Bissau: a retrospective cross-sectional hospital study. *Scientific Reports*, *10*(1), 1–13. https://doi.org/10.1038/s41598-020-68806-5

Rüdiger, M., & Konstantelos, D. (2015). Apgar score and risk of cause-specific infant mortality. *The Lancet*, *385*(9967), 505–506. https://doi.org/10.1016/S0140-6736(15)60196-9

Sakyi, K. S., Lartey, M. Y., Kennedy, C. E., Dension, J. A., Mullany, L. C., Owusu, P. G., Sacks, E., Hurley, E. A., & Surkan, P. J. (2020). Barriers to maternal retention in HIV care in Ghana: Key differences during pregnancy and the postpartum period. *BMC Pregnancy and Childbirth*, *20*(1), 1–13. https://doi.org/10.1186/s12884-020-03067-8

Salvatore, C. M., Han, J. Y., Acker, K. P., Tiwari, P., Jin, J., Brandler, M., Cangemi, C., Gordon, L., Parow, A., DiPace, J., & DeLaMora, P. (2020). Neonatal management and outcomes during the COVID-19 pandemic: an observation cohort study. *The Lancet Child and Adolescent Health*, *4*(10), 721–727. https://doi.org/10.1016/S2352-4642(20)30235-2

Sarkodie, B., Asiedu-Bekoe, F., Laryea, D. O., Ampofo, W. K., Phillips, R. O., Samba, A., Aboagye, D. C., Nsiah-Asare, A., Asamoah-Baah, A., Odame, E., Ohene, S. A., Amoako, Y. A., & Kuma-Aboagye, P. (2021). Overview of preparedness and response to COVID-19 in Ghana. *Ghana Medical Journal*, *55*(2), 38–47. https://doi.org/10.4314/gmj.v55i2s.6

Smith, V., Seo, D., Warty, R., Payne, O., Salih, M., Chin, K. L., Ofori-Asenso, R., Krishnan, S., Da Silva Costa, F., Vollenhoven, B., & Wallace, E. (2020). Maternal and neonatal outcomes associated with COVID-19 infection: A systematic review. *PLoS ONE*, *15*(6), 1–13. https://doi.org/10.1371/journal.pone.0234187

Ssentongo, P., Heilbrunn, E. S., Ssentongo, A. E., Advani, S., Chinchilli, V. M., Nunez, J. J., & Du, P. (2021). Epidemiology and outcomes of COVID-19 in HIV-infected individuals: a systematic review and meta-analysis. *Scientific Reports*, *11*(1), 1–12. https://doi.org/10.1038/s41598-021-85359-3

Stinson, K., Jennings, K., & Myer, L. (2013). Integration of Antiretroviral Therapy Services into Antenatal Care Increases Treatment Initiation during Pregnancy: A Cohort Study. *PLoS ONE*, *8*(5), 1–8. https://doi.org/10.1371/journal.pone.0063328

Survey, H. (2014). *Ghana*.

Talbot, M. (2006). HIV infection. *Clinical Evidence*, *15*, 937–954.

Tavilani, A., Abbasi, E., Kian Ara, F., Darini, A., & Asefy, Z. (2021). COVID-19 vaccines: Current evidence and considerations. *Metabolism Open*, *12*(September), 100124. https://doi.org/10.1016/j.metop.2021.100124

Twabi, H. S., Manda, S. O., & Small, D. S. (2020). Assessing the effects of maternal HIV infection on pregnancy outcomes using cross-sectional data in Malawi. *BMC Public Health*, *20*(1), 1–15. https://doi.org/10.1186/s12889-020-09046-0

UN Joint Programme on HIV/AIDS (UNAIDS). (2020). *Covid-19 and Hiv : 1 Moment 2 Epidemics*.

UNAIDS. (2020). *What people living with HIV need to know about HIV and COVID-19*. 19.

Unicef. (2018). *UNICEF: Working to end AIDS for every child*. 1–20.

UNICEF. (2014). 2014 Annual Results Report: HIV and AIDS. *Annual Results Report*, 78.

United Nations Programme on HIV/aids. UNAIDS. (2021). *UNAIDS data 2021*. 4–38.

Vahlne, A. (2009). A historical reflection on the discovery of human retroviruses. *Retrovirology*, *6*, 1–9. https://doi.org/10.1186/1742-4690-6-40

Vijayanand, P., Wilkins, E., & Woodhead, M. (2004). Severe acute respiratory syndrome (SARS): a review. *Clinical Medicine (London, England)*, *4*(2), 152–160. https://doi.org/10.7861/CLINMEDICINE.4-2-152

Villar, J., Ariff, S., Gunier, R. B., Thiruvengadam, R., Rauch, S., Kholin, A., Roggero, P., Prefumo, F., Do Vale, M. S., Cardona-Perez, J. A., Maiz, N., Cetin, I., Savasi, V., Deruelle, P., Easter, S. R., Sichitiu, J., Soto Conti, C. P., Ernawati, E., Mhatre, M., … Papageorghiou, A. T. (2021). Maternal and Neonatal Morbidity and Mortality among Pregnant Women with and without COVID-19 Infection: The INTERCOVID Multinational Cohort Study. *JAMA Pediatrics*, *175*(8), 817–826. https://doi.org/10.1001/jamapediatrics.2021.1050

Wang, L. F., & Eaton, B. T. (2007). Bats, Civets and the Emergence of SARS. *Wildlife and Emerging Zoonotic Diseases: The Biology, Circumstances and Consequences of Cross-Species Transmission*, *315*, 325. https://doi.org/10.1007/978-3-540-70962-6_13

Wang, S. shuai, Zhou, X., Lin, X. guang, Liu, Y. yan, Wu, J. li, Sharifu, L. M., Hu, X. lin, Rong, Z. hui, Liu, W., Luo, X. ping, Chen, Z., Zeng, W. jiang, Chen, S. hua, Ma, D., Chen, L., & Feng, L. (2020). Experience of Clinical Management for Pregnant Women and Newborns with Novel Coronavirus Pneumonia in Tongji Hospital, China. *Current Medical Science*, *40*(2), 285–289. https://doi.org/10.1007/s11596-020-2174-4

Wei, S. Q., Bilodeau-Bertrand, M., Liu, S., & Auger, N. (2021). The impact of COVID-19 on pregnancy outcomes: A systematic review and meta-analysis. *Cmaj*, *193*(16), E540–E548. https://doi.org/10.1503/cmaj.202604

WHO, UNICEF, UNAIDS, U. (2008). HIV transmission through breastfeeding: a review of available evidence: 2007 update. *Reproductive Health Matters*, *7*(14), 188–189.

WHO. (2012). *WHO HIV Drug Resistance Report 2012*. 84.

WHO. (2016). Global Health Sector Strategy on HIV 2016-2021. In *World Health Organization* (Issue June 2016).

Wilson, M., & Wilson, P. J. K. (2021). Coronavirus Disease 2019 (COVID-19). *Close Encounters of the Microbial Kind*, *January*, 185–196. https://doi.org/10.1007/978-3-030-56978-5_12

World Bank Group. (2017). Annual Report. *The World Bank*, 80.

World Health Organization, W. (2016). World Health Organization (Who) Country Office for Ghana Annual Report 2015. *World Health Organization (Who) Country Office for Ghana Annual Report*, *3*(May), N0.2.

Xiao, P. L., Zhou, Y. B., Chen, Y., Yang, M. X., Song, X. X., Shi, Y., & Jiang, Q. W. (2015). Association between maternal HIV infection and low birth weight and prematurity: A meta-analysis of cohort studies. *BMC Pregnancy and Childbirth*, *15*(1).

https://doi.org/10.1186/s12884-015-0684-z

Yang, M., Wang, Y., Chen, Y., Zhou, Y., & Jiang, Q. (2019). Impact of maternal HIV infection on pregnancy outcomes in southwestern China – A hospital registry based study. *Epidemiology and Infection*, *147*. https://doi.org/10.1017/S0950268818003345

Yuan, M. (2021). *Scholarship @ Western Investigating The Impact Of The COVID-19 Pandemic On Maternal Perceived Stress , Postpartum Depressive Symptoms , And Pregnancy Outcomes In London , Ontario : A One Health Approach*.

Zhao, X., Jiang, Y., Zhao, Y., Xi, H., Liu, C., Qu, F., & Feng, X. (2020). Analysis of the susceptibility to COVID-19 in pregnancy and recommendations on potential drug screening. *European Journal of Clinical Microbiology and Infectious Diseases*, *39*(7), 1209–1220. https://doi.org/10.1007/s10096-020-03897-6