SCHOOL OF PUBLIC HEALTH

COLLEGE OF HEALTH SCIENCES

UNIVERSITY OF GHANA

ASSESSING THE EFFECTS OF ANAEMIA AND COVID-19 INFECTION ON PREGNANCY OUTCOMES IN PREGNANT WOMEN IN ACCRA, GHANA

BY

MARUMBO EVE CHIRWA

(10932286)

A DISSERTATION SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PUBLIC HEALTH DEGREE

DECEMBER, 2022

DECLARATION

I, MARUMBO EVE CHIRWA, declare that this submission is my original work, and has not been presented for a degree to any university or published anywhere. Every material cited that is not my own work has been dully acknowledged.

M Chirwa

…… DATE: 29th January 2023

MARUMBO EVE CHIRWA

(STUDENT)

…….. DATE: 30th January 2023

DR. EMEFA MODEY

(SUPERVISOR)

DEDICATION

I dedicate this work to my daughter, NOVAHIWA.

ACKNOWLEDGEMENT

Many people helped me along the way of pursuing my masters' studies, and I would like to take a moment to appreciate and thank them.

First, I would like to thank my supervisor, Dr. Emefa Modey, for the guidance and support throughout my study period. I would not have made it without your help, you went above and beyond to help me reach this far.

To my family and friends, I am grateful for your encouragement, knowledge shared, emotional, financial, and social support, your patience and understanding.

Finally, to my daughter, Novahiwa, your calmness helped me through the dark times. I celebrate this degree with you because you earned it too.

ABSTRACT

Introduction: Anaemia is a significant public health issue around the globe, especially in underdeveloped nations, including Ghana, where the prevalence is high. Poor intrauterine growth, a higher chance of preterm birth, miscarriage, and low birth weight rates are all linked to anaemia during pregnancy. As a result, there is an increase in the rate of newborn mortality as well as perinatal morbidity and mortality.

Comorbidities like hypertension and anaemia in pregnant women puts them at greater risk of experiencing poor pregnancy outcomes, like preterm births. Recently, COVID-19 has been reported to have an impact on hemoglobin levels in patients. The existence of other comorbidities in pregnant women who are infected with COVID-19 could expose them to poor pregnancy outcomes more than those who are not, but little knowledge exists regarding this association.

Objective: to assess the effects of anaemia and COVID-19 on pregnancy outcomes in Accra, Ghana.

Methods: This is a secondary data analysis on 211 participants recruited as part of the COVID-19 and pregnancy study who were eligible for analysis. Descriptive analyses were performed to show frequency distribution of the various categories. At the bivariate level, *t-test* and multiple logistic regression were used to determine differences between groups and associations between background factors and anaemia. The data was analyzed in STATA version 16.

Results: The prevalence of anaemia in pregnancy was 24.1% and that of COVID-19 among unvaccinated pregnant women was 57.6%. There was no significant difference in mean haemoglobin levels among pregnant women who were exposed and unexposed to COVID-19 at enrollment and delivery Pr(|T| > |t|) = 0.06. The findings also showed that for women who were anemic at enrollment, their odds of being anemic at delivery were almost 5 times higher than those who were not anemic at enrollment (OR 4.9, CI:2.02-12.05, p<0.001). The results also show that with each unit increase in a woman's age at pregnancy, there was a 1.05 increase in the odds of developing anaemia at delivery (OR=1.05, CI:1.01-1.10) p<0.04) when controlling for parity, place of residence, number of fetuses, educational level, and COVID-19 exposure status. Although age and anaemia status at enrolment was significantly associated with anaemia at delivery there was no significant association between anaemia at delivery and COVID-19 on pregnancy outcomes.

Recommendation: Based on these findings, it is recommended that to avert anaemia in pregnancy, programmes and ANC services that routinely monitor hemoglobin levels should be strengthened. More research needed with larger samples sizes to be conducted in relation to anaemia and COVID-19 in pregnant women.

TABLE OF CONTENT

Contents

DECLARATION i

DEDICATION ii

ACKNOWLEDGEMENT iii

ABSTRACT iv

TABLE OF CONTENT iv

LIST OF TABLES viii

LIST OF FIGURES ix

LIST OF ABBREVIATIONS ix

CHAPTER ONE 1

1.0 INTRODUCTION 1

1.1 Background of the study 1

1.2 Statement of the problem 4

1.3 Justification 4

1.4 Objectives of the study 5

1.5 Research questions 6

1.7 Chapter summary and proposal outline 6

CHAPTER TWO 7

2.0 LITERATURE REVIEW 7

2.1 Introduction 7

2.2 Global Prevalence of anaemia in pregnancy 7

2.4. Anaemia in Ghana 9

2.5 Prevalence of anaemia among COVID-19 exposed and unexposed pregnant women 9

2.6 Association between anaemia and COVID-19 in pregnant women 10

2.7 Effects of anaemia on pregnancy outcomes in pregnant women infected with COVID-19 11

2.8 Comment on Literature 13

2.9 Conceptual Framework 13

..... 13

Figure 1 14

CHAPTER THREE 16

3.0 METHODS 16

3.1 Introduction 16

3.2 Study design 16

3.3 Study site description 17

3.4 Study population 18

3.5 Inclusion and exclusion criteria 18

3.6 Description of study variables 19

3.6 Sample size determination 20

3.8 Sampling method 21

3.9 Data collection procedures and tools 21

3.10 Quality control and assurance 21

3.10.1 Data management and analysis 21

3.10.2 Study limitations 22

3.10.3 Ethical issues 22

CHAPTER FOUR 25

4.0 RESULTS 25

4.1 Introduction 25

4.2 Socio-demographic characteristics of study participants 25

4.4 Hemoglobin levels at enrollment and delivery 31

At enrollment, the mean hemoglobin level among the exposed group was 10.4g/dL (SD ±0.9), ranging from 7.8 g/dL to 14.5g/dL. Among the unexposed group, mean hemoglobin level was 10.2g/dL (SD±0.9) ranged from 7.9 g/dL to 12.9 g/dL. During delivery the mean Hb level was 10.9 g/dL (SD±1.1) and ranged from 8g/dL to 14.4g/dL in the exposed group, while in the unexposed group the mean hemoglobin level was 11g/dl (SD±1.3) and they ranged from 8.3 to 14.4 g/dL. The overall prevalence of anaemia in pregnancy was 34.1% and the prevalence of COVID-19 among anaemic pregnant women was 63% (table 4). ... 31

4.5 Pregnancy outcomes among study participants 32

4.6 Factors associated with anaemia at delivery. 34

CHAPTER FIVE 37

5.0 DISCUSSION 37

5.1 Introduction 37

5.2 The Prevalence of anaemia among pregnant women 37

5.3 Prevalence of COVID-19 among pregnant women 39

5.4 Hemoglobin levels of women exposed and unexposed to COVID-19 at delivery and the risk factors for anaemia at delivery 40

5.5 Pregnancy outcomes in anemic women exposed to COVID-19 41

CHAPTER SIX 42

6.0 CONCLUSION AND RECOMMENDATION 42

6.1 Conclusion 42

6.2 Recommendations 42

REFERENCES 44

LIST OF TABLES

Table 1 : Description of variables….....19

Table 2: Characteristics of unvaccinated pregnant women enrolled in the study……...…...28

Table 3: Hemoglobin levels among pregnant women by Covid-19 exposure status…….....30

Table 4: Pregnancy outcomes by COVID-19 exposure status among anemic pregnant women at enrollment…….....30

Table 5: Difference in Hemoglobin levels among exposed and unexposed pregnant women enrolled….....32

Table 6: Multiple Logistic regression of factors associated with anaemia at delivery……...33

LIST OF FIGURES

Figure 1: Conceptual framework …….15

Figure 2: Prevalence of anaemia……33

Figure 3: Prevalence of COVID-19 exposure…….34

LIST OF ABBREVIATIONS

ANC	Antenatal Care
COVID-19	Corona Virus Disease 2019
GDHS	Ghana Demographic Health Survey
GHS	Ghana Health Service
Hb	Haemoglobin
KBTH	Korlebu Teaching Hospital
MTCT	Mother to Child Transmission
RT- PCR	Reverse Transcription Polymerase Chain Reaction
SARS-CoV-2	Severe Acute Respiratory Coronavirus-2
WHO	World Health Organization
WMA	World Medical Association

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

According to the World Health Organisation (WHO), anaemia, also known as low hemoglobin concentration, is a disorder where there are fewer red blood cells than normal, and it causes symptoms, such as weakness, exhaustion, lightheadedness, and shortness of breath, among others (WHO, 2015). Anaemia in pregnancy is defined by the WHO as having a haemoglobin (Hb) concentration below 11.0 g/dl (WHO, 2015). Based on a measurement of the haemoglobin level, it is divided into three categories; mild, moderate, and severe. Hb levels range from 10.0 to 10.9 g/dL for mild anaemia to 7-9.9 g/dL for moderate anaemia to 7 g/dL for severe anaemia in pregnancy (WHO ,2015). Anaemia mostly affects young children and pregnant women (WHO, 2020). It is estimated globally that in 2019, the prevalence of anaemia in women of reproductive age was 29.9%, where 29.6% was among non-pregnant women and 36.5 % was in pregnant women (WHO, 2021). Anaemia is more prevalent in underdeveloped nations where there is an inadequate diet, a lack of prenatal vitamins, and inadequate consumption of iron and folic acid (WHO, 2021).

Anaemia in women of reproductive age is a significant public health issue around the globe, especially in underdeveloped nations where the prevalence is highest (Black *et al.*, 2013; WHO, 2015). Poor intrauterine growth, a higher chance of preterm birth, miscarriage, and low birth weight rates are all linked to anaemia during pregnancy(Parks *et al.*, 2019). As a result, there is an increase in the rate of newborn mortality as well as perinatal morbidity and mortality.

The prevalence of anaemia in pregnancy varies greatly among affluent nations, including the United States, Australia, Singapore, and China, with rates ranging from 18%, 20%, 67.8%, and 70%, respectively (Kassa *et al.*, 2017). As the pregnancy proceeds in gestational age, the rates of anaemia rise across the trimesters because metabolic needs are higher (Fakher *et al.*, 2015; Khambalia, *et al.* 2015).

Anaemia in pregnancy is responsible for about half of the global maternal deaths (Dodzo, 2022). In low-income countries (LICs), anaemia in pregnancy contributes indirectly to 25% of maternal mortality and 30% of neonatal deaths. In India, anaemia is a serious public health concern with approximately 50% and 51% of pregnant women in India and Uttar Pradesh identified as anaemic according to the National Family Health Survey-4 (2016/16) (Devi *et al*2020).

The prevalence of anaemia in pregnancy was estimated to be 45% according to the Ghana Demographic and Health Survey (GDHS) (GDHS, 2015). The recent survey has estimated that 51% of pregnant women in Ghana are anaemic (GDHS, 2022) Depending on the degree of the anaemia, maternal anaemia is linked to a number of negative events that can affect a mother's health, the course of the pregnancy, and the health of the fetus (Kozuki, Lee, & Katz, 2012).

In addition to the physiological changes that take place during pregnancy, other demographic factors such as maternal education, income, place of residence including residing in malaria-endemic areas and poor dietary intake have been known to contribute to the development of anaemia in pregnancy (Lebso, Anato, & Loha, 2017). This explains why prevalence is very high in developing countries (Fondjo, 2020; Osarfo, Ampofo, & Tagbor, 2022). The WHO recommends that health providers check the Hb levels of pregnant women during their visits to antenatal (WHO, 2018). Two recommendations are introduced to prevent anaemia in pregnancy. These are intermittent iron and folic acid supplementation for menstruating women living in settings where the prevalence of

anaemia is 20% or higher; and daily iron and folic acid supplementation for pregnant women as part of antenatal (WHO, 2018)

The emergence of SARS CoV 2 (COVID-19) pandemic triggered numerous changes that have had an impact on the overall health, including the prevalence of anemia in pregnant women. The pandemic directly and indirectly affected the operations of health systems and other social institutions, greatly affecting access to essential services, such as antenatal care services (Gill, Adenan, Ali, & Ismail, 2022; Menendez, Gonzalez, Donnay & Leke, 2020). The pandemic contributed to interruptions in pregnant women's access to ANC services, and other social services like marketing, making them miss out on routine preventive therapies as well as not accessing nutritious foods (UNICEF, 2021).

Data on the effects of COVID-19 infection on pregnancy outcomes are scarce. But according to the few reviews and studies that have been published, COVID-19 infection during pregnancy has been linked to an increase in caesarean sections (,Toro *et al* 2021; Wang *et al.*, 2021) and preterm birth for women with infection in the second and third trimesters, as well as miscarriages in women with first trimester COVID-19 infection (Lassi, Ali, Das, Salam, Padhani, Irfan, & Bhutta, 2021).

Comorbidities like hypertension and anaemia in pregnant women puts them at greater risk of experiencing poor pregnancy outcomes, such as preterm births (Auger, Bhutta, Park, & Luo, 2011). COVID-19 has been reported to have an impact on hemoglobin levels in patients (Bergamaschi *et al.*, 2021; Zuin, Rigatelli, Quadretti, Fogato, Zuliani & Roncon, 2021). The existence of other comorbidities in pregnant women who are infected with COVID-19 could expose them to poor pregnancy outcomes more than those who are not (Ren *et al.*, 2020), but little knowledge exists regarding this association.

1.2 Statement of the problem

Anaemia among pregnant women is a major public health concern because it contributes to increased maternal mortality and poor birth outcomes (Haider *et al.,* 2013). In Ghana, anaemia in pregnancy is estimated to affect 41% of women in the reproductive ages and which 51% are pregnant women (GDHS, 2022). Pregnant women who are anaemic become more susceptible to different infections (Sohail *et al.*, 2015) which may also play a role in aggravating adverse impacts on pregnancy outcomes. The recent emergence of the COVID-19 pandemic, has been reported to contribute to adverse effects on pregnancy outcomes (Nayak *et al.*, 2020). In Ghana, the COVID-19 pandemic impacted on pregnant women's health care-seeking behaviour, with some skipping ANC visits to reduce the risk of infection (Moyer *et al.*, 2020), hence interrupting the standard care to be delivered. There is however paucity of data on the subject matter. Of the available data, it is revealed that COVID-19 infection during pregnancy could exacerbate adverse pregnancy outcomes. This is evident in preterm labour, premature rupture of membranes, stillbirth, abortions, caesarean sections(Akhtar *et al.,* 2020). A combination of anaemia and COVID-19 infection in pregnancy could worsen pregnancy outcomes. There is, therefore, a need to understand the effect of COVID-19 and anaemia on pregnancy outcomes to provide knowledge of the potential risks and outcomes and identify critical strategies necessary for the management of anaemia in pregnancy.

1.3 Justification

Anaemia in pregnancy coupled with COVID-19 is reported to increase the risk of poor pregnancy outcomes, and this is a public health concern. It is, therefore, important to assess the effects of anaemia and COVID-19 infection on pregnancy outcomes to enable stakeholders implement extra measures to improve the service provision to pregnant women during emergency situations like disease pandemics could be identified. Particularly of importance are strategies that could be

applicable in resource constrained settings. Such strategies when deployed could contribute to reducing maternal deaths and disabilities from the presence of the comorbidity. This information will also fill in the critical knowledge gaps and also assist policy and programme efforts to implement interventions or encourage strategies geared towards reduced maternal and neonatal morbidity and mortality.

Timely diagnosis and treatment of iron deficiency anaemia could not only prevent obstetric and perinatal complications but also prevent the development of severe symptoms of COVID-19. Knowledge on appropriate strategies, warning signs and management of severe cases could help avert negative outcomes such as pre-term rapture of membranes, low birth weight, still births, and maternal and perinatal mortality.

1.4 Objectives of the study

1.4.1 General objectives

To assess the effects of anaemia and COVID-19 exposure on pregnancy outcomes among pregnant women in Accra, Ghana

1.4.2 Specific objectives

1. To assess the prevalence of anaemia and COVID-19 among pregnant women in Accra, Ghana
2. To determine the association between COVID-19 exposure and hemoglobin levels in pregnant women in Accra.

3. To assess the effects of anaemia on pregnancy outcomes in pregnant women exposed to COVID-19

1.5 Research questions

1. What is the prevalence of anaemia and COVID-19 among pregnant women in Accra?
2. What is the association between COVID-19 exposure and hemoglobin levels among pregnant women in Accra?
3. What are the effects of anaemia on pregnancy outcomes among COVID-19 exposed women in Accra.

1.7 Chapter summary and proposal outline

Three chapters make up the organization of the proposal. The study's background, problem description, justification, goals, and research questions are all covered in the first chapter. The second chapter analyzes pertinent research-related literature. The methods are described in Chapter 3 along with the study design, target population, sample size, sampling method, data extraction tools, data processing and analysis, and any ethical concerns that might have arisen throughout the research.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter examines the body of research that has been done on the effects of anaemia and COVID-19 infection during pregnancy. The review concentrated on the prevalence of anaemia in pregnancy at the global, regional, and national levels, its causes, COVID-19 infection during pregnancy, and how each of these factors affects pregnancy outcomes both separately and jointly in Greater Accra, Ghana.

2.2 Global Prevalence of anaemia in pregnancy

Globally, about a third of the population is anaemic, according to literature, and the highest prevalence is in developing regions (WHO, 2015). In pregnancy, anaemia remains a public health issue globally, leading to severe maternal and fetal consequences. This varies in different parts of the world. It is estimated that 48.1 % of pregnant women are anemic globally (WHO, 2015).

In the United States of America (USA), the prevalence of anaemia during pregnancy was found to be low at 2.7% (Sharma *et al.*, 2021). In Asia, the prevalence of anaemia was found to be higher at 25.7%, with 52% having depleted iron stores (Srour, Aqel, Srour, Younis, & Samarah, 2018). In China, it was reported that the overall prevalence of anaemia among pregnant women was 19.9%, with mild anaemia being the highest (15.9%) (Zhao, Jing, Liu, & Liu, 2018). These differences could be due to different settings and study designs.

2. 3 Prevalence of anaemia in Africa

The WHO estimates that an average of 56% of pregnant women suffer from anaemia in developing countries (WHO, 2015). In sub-Saharan Africa, the burden of anaemia is highest, with 57% of pregnant women being anaemic. For example, in Eastern African countries, the prevalence is reported to be 33.9%; in Western sub-Saharan Africa it was 39.3% (WHO, 2015; Liyew *et al.*, 2021; Fite *et al.*, 2021).

The prevalence of anaemia was found to be 7.9% overall in a study conducted in Tigrai, Ethiopia, by Berhe *et a, 2017l.* Additionally, mild and moderate anaemia were discovered to be 62.5% and 37.5%, respectively (Berhe *et al.*, 2019). Furthermore, a facility-based cross-sectional study in Bangladesh that looked at the prevalence of anaemia among pregnant women and its contributing factors found that the total frequency was 58.9%. Mild, moderate, and severe anaemia were found to be present in 36.3%, 62.4%, and 1.3% of cases, respectively (Ahmed *et al.*, 2019). According to a cross-sectional survey, anaemia was prevalent in Pakistan at 57.7%. The study suggested that dietary supplements should be made available, especially in marginalized populations, to improve the nutritional status of women (Ullah *et al.*, 2019). Another a cross-sectional study conducted on 250 women admitted to the Tikur Anbessa Specialized Hospital in Ethiopia to determine the prevalence of anaemia, reported that the prevalence was 4.8%, and that most of the women were found to be aware of anaemia and to be taking their supplements of iron and folic acid (Nasir, Fentie, & Adisu, 2020). A facility-based cross-sectional survey found that 24.1% of pregnant women in southern Ethiopia had anaemia and mild anaemia was present in the majority of pregnant women (62.2%) (Kare & Gujo, 2021). The prevalence of anaemia during pregnancy was reported to be 32.9% in Northwest Ethiopia, with 50.7% of pregnant women having moderate anaemia (Eteffa *et al.*, 2022).

2.4. Anaemia in Ghana

The Ghana Demographic and Health Survey (2022) estimates the overall prevalence of anaemia among women to be 41%, and among pregnant women the prevalence is 51% (GDHS, 2022). A cross-sectional study conducted in a private hospital in the Greater Accra region of Ghana among 200 pregnant women found tthe prevalence of anaemia to be 51% with 60.8% and 39.2% mild and moderate cases, respectively (Acheampong *et al.*, 2018).

Additionally, a study conducted to assess the prevalence and maternal factors associated with anaemia in the Kassena-Nankana district showed that the overall prevalence of anaemia is at 42.7%. The study advocates for strengthening the primary health care system to improve early access to antenatal care for better health outcomes (Atindama *et al.*, 2019). Further, in Northern Ghana, the prevalence of anaemia was found to be 50.8% and 56% (Tibambuya, Ganle, & Ibrahim, 2019; Wemakor, 2019). A multi-center study conducted in the Greater Accra, Western and Ashanti Regions in Ghana showed that 42.4% of pregnant women had anaemia (Fondjo *et al.*, 2020). In the Kwabre East Municipality in the Ashanti Region of Ghana, anaemia in pregnancy prevalence was 11.4% (Akowuah, Owusu-Addo, & Opuni, 2022).

2.5 Prevalence of anaemia among COVID-19 exposed and unexposed pregnant women

It has been reported that the existence of COVID-19 infection in pregnancy contributes to anaemia as well. Several studies using different study designs have been conducted to find out the prevalence of anaemia among COVID-19 exposed pregnant women. In Pakistan, through a cross-sectional study, it was revealed that lower Hb levels were observed among pregnant women with COVID-19 than those without COVID-19 (Mari, Maheshwari, Shaikh, Syed, & Kumar, 2021). The frequency and severity of anaemia was also high among COVID-19 positive women. This finding forms a

basis for recommendations for healthcare workers to be vigilant of the haematological parameters of pregnant women especially during this time of COVID-19 (Mari *et al.*, 2021).

Similarly, in an observational study conducted in Italy to determine the prevalence, pathogenesis, and clinical significance among 206 COVID-19 patients and 71 COVID-19 negative persons, it was revealed that the prevalence of anaemia was high (61%) in those with COVID-19 compared to those without COVID-19 (45%). Females had lower haemoglobin levels as compared to males. Moreover, anaemia is a common manifestation among people with COVID-19 infection and negatively influences the quality of life (Bergamaschi *et al.*, 2021).

A case-control study conducted in Romania among pregnant women revealed that anaemia is more often prevalent in women with a history of COVID-19. The study indicated that the prevalence of anaemia among COVID-19 exposed women was 42.1% while the prevalence among COVID-19 unexposed stood at 29.3% with differing nutritional supplementation (Uta *et al.*, 2022).

Additionally, a retrospective case-control study conducted in a tertiary hospital in Delhi among women attending antenatal to determine the impact of COVID-19 on the prevalence, clinical profile and pregnancy outcomes of women with severe anaemia showed that the mean haemoglobin levels of those with COVID-19 and anaemia was significantly lower than those in the control group (Singh *et al.*, 2022). Using a prospective design, this current study would provide much accurate results as there will be reduced issues with recall bias and all confounding variables can be studied.

2.6 Association between anaemia and COVID-19 in pregnant women

Multiple studies conducted in Romania, India and China provide evidence of higher levels of anaemia in women with exposure to COVID-19 (Chen *et al.*, 2021; Sinchikhin, Stepanyan, Atueva, Nasri, & Sinchikhina 2021; Uta *et al.*, 2022). Women exposed to COVID-19 who developed

anaemia were subjected to developing additional infections such as pneumonia compared to women who did not have COVID-19 exposure (Chen *et al.*, 2021).

Laboratory tests for iron deficiency revealed significantly lower levels in relation to COVID-19 exposure, and COVID-19 infection was associated with worsening anaemia among pregnant women, according to a case-control study carried out in a tertiary hospital in Timisoara, Romania, to ascertain the impact of nutritional supplementation for iron deficiency anaemia in correlation with the status of COVID-19 infection (Uta *et al.*, 2022).

On the other hand, anaemia in pregnant COVID-19-infected women had no effect on maternal and neonatal outcomes, according to Chavan, Ammara, Kapote, Deshmukh, and Sakhalkar's retrospective observational study carried out in Mumbai (Chavan, *et al.*, 2022).

2.7 Effects of anaemia on pregnancy outcomes in pregnant women infected with COVID-19

Pregnant women with COVID-19 infection have a higher risk of preterm labor and c-section deliveries, according to the clinical manifestations of the infection in the pregnant population, the implications, and sequelae of the infection throughout pregnancy, and the results of live births (Hapshy, Aziz, Kahar, Khanna, Johnson, & Parmar, 2021). In this study, pregnant women were identified as a high-risk population and provided with the necessary care since they were found to be at a greater risk for adverse outcomes from COVID-19 infection.

In addition, a case-control research carried out in a tertiary hospital in Romania showed that anaemic pregnant women with COVID-19 infection have a substantial correlation with puerperal infection, emergency c-section, and tiny for-gestational-age babies (Uta *et al.*, 2022). Another case-control study conducted in a tertiary hospital in Romania revealed that there is a strong association between anaemic pregnant women with COVID-19 infection and puerperal infection, emergency c-section,

and babies being smaller than the gestational age (Uta *et al.*, 2022). Specifically, the study revealed that puerperal infections occurred more in mothers with anaemia (52.5%) than those without anaemia (27.3%). Also, 42.6% of pregnancies from women with COVID-19 and anaemia were delivered with emergency c-section compared to 18.2% of the comparison group. On foetal growth, 35.0% of women with anaemia and COVID-19 had fetuses which were smaller than their gestation age compared to 14.5% of the same effect in women with COVID-19 infection without anaemia (Uta *et al.*, 2022).

Uta *et al.* (2022) alludes the importance of screening all pregnant women for iron deficiency, especially those at risk for complications. The study also recommended the intensification of iron folate supplementation to promote the normal development and growth of the foetus and avoid further complications due to COVID-19 pandemic (Uta *et al.*, 2022). Additionally, an observational study conducted on people with COVID-19 infection and those without COVID-19 infection revealed that mortality rates were higher among those with COVID-19 and anaemia (Bergamaschi *et al.*, 2021).

To add, a retrospective case-control study conducted in a tertiary hospital in Delhi among women attending antenatal to determine the impact of COVID-19 on the prevalence, clinical profile and pregnancy outcomes of women with severe anaemia indicated that the odds of foetal growth restriction was 48% higher among the cases than the controls. Also, the odds ratio of complications such as low birth weight was 4.84 times higher in the cases than the controls (Singh *et al.*, 2022).

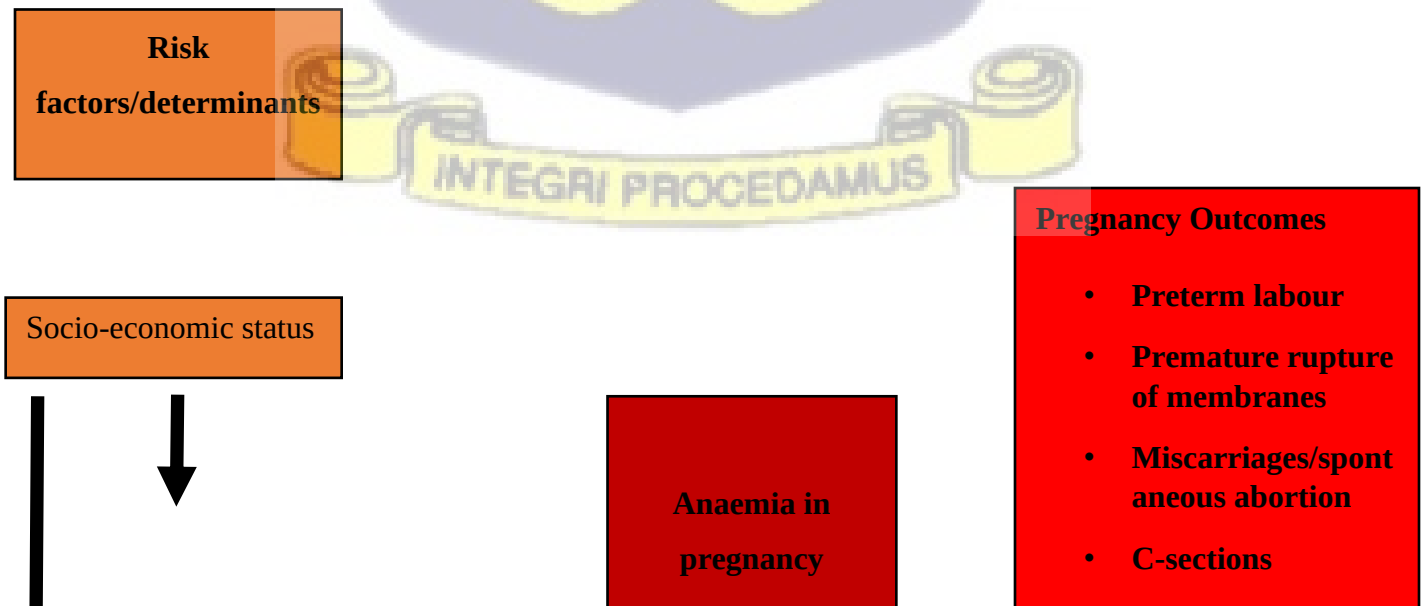
In India, 61% of pregnant women diagnosed with Covid-19 delivered via c-section and 38.8% of the neonates were underweight. Of the neonates, 20% suffered intrauterine growth restriction, 22.4% were preterm and 3.4% stillborn. Although no maternal death was recorded, the study concluded that maternal and neonatal outcomes were affected by anaemia in COVID-19 pregnant women, of

significance included c/section delivery, low birth weight babies, intrauterine growth restrictions and stillbirths (Chavan *et al.*, 2022).

2.8 Comment on Literature

A number of study designs have been used to accomplish the diverse goals. These have included observational studies like, retrospective, case-control, cross-sectional studies (Bergamaschi *et al.*, 2021;Singh *et al.*, 2022; Uta *et al.*, 2022). Identifying the appropriate strategies for early intervention and management of anaemia in pregnancy complicated by COVID-19 is more critical as the pandemic continues to affect women and their newborns globally. Additionally, of the reported studies, there is no study that used prospective cohort study to identify the effects of anaemia and COVID-19 infection on pregnancy outcomes. Most of them were cross-sectional, case series or case-control.

2.9 Conceptual Framework



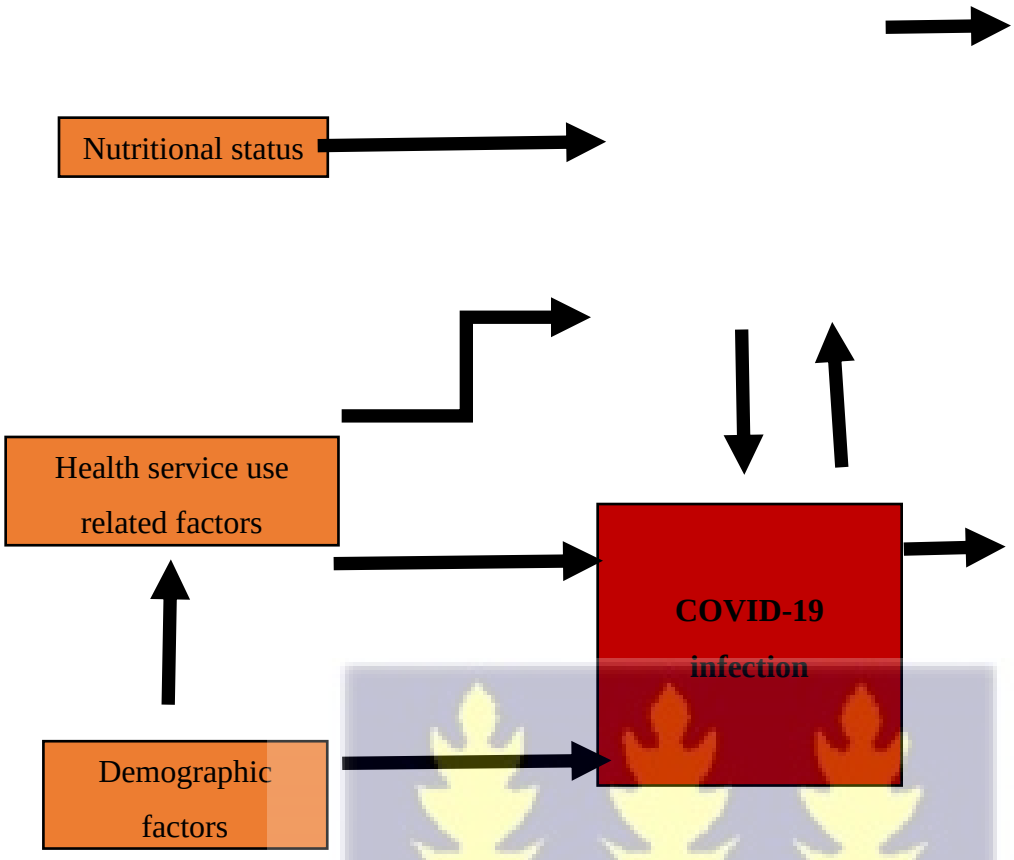


Figure 1. Adapted from Tamirat *et al.* (2021)

Several factors are known to contribute to anaemia as well as COVID-19 infection during pregnancy, this can be directly or indirectly. For example, socio-economic status, demographic, nutritional status and health service utilization play a role in predisposing them to the two conditions (Adam, Ibrahim, and Elhardello 2018; Woldegebriel *et al.* 2020;Fite, Assefa, & Mengiste, 2021; Sigler *et al.* 2021)

Anaemia and COVID-19 infection in pregnancy have been reported to be contributing factors to adverse outcomes of pregnancy like stillbirth, preterm labour, low birth weight and intrauterine growth restriction, just to mention a few, and it is a public health issue. Additionally, anaemia in pregnancy predisposes the mother to infections because there is immunity dysfunction, and these

infections may go to placenta, for example malaria, hence affecting the fetus. Infections may lead to poor intake of foods by altering maternal appetite, leading to low maternal weight gain. This eventually contributes to poor pregnancy outcomes like prematurity and low birth weight (Nair *et al.* 2018; Tamirat *et al.* 2021; Zhang *et al.* 2021)

2.10 Conclusion

To sum up, the prevalence of anaemia among pregnant women is a global issue of public health importance. The prevalence remains high in developing countries, including Ghana. In the woke of the COVID-19 pandemic, the burden is compounded in women who have both COIVD-19 and anaemia. Such women are simultaneously at greater risk of maternal complications. There is an increased prevalence and likelihood of anaemia in women with COVID-19 than those without COVID-19 infection. Pregnant women with COVID-19 infection and anaemia were found to have an increased risk of preterm labour, c-section, low birth weight babies, small-for-gestational-age fetus, intrauterine growth restriction, preterm and stillborn. Timely diagnosis and treatment of iron deficiency anaemia could not only prevent obstetric and perinatal complications, but also prevent the development of severe symptoms of COVID-19. Few studies have reported that maternal and neonatal outcomes were unaffected by anaemia in COVID-19 pregnant women. However, maternal mortality rates are found to be higher among women those with COVID-19 and anaemia.

CHAPTER THREE

3.0 METHODS

3.1 Introduction

This chapter explains the study site, study population, inclusion and exclusion criteria, study design, sample size, sampling method as well as how data analysis was done.

3.2 Study design

This study used secondary data from a prospective cohort study of COVID-19 and pregnancy outcomes, which was conducted in Greater Accra, Ghana. The primary investigation looked at maternal, pregnancy, and neonatal outcomes for women infected with SARS-Cov-2 in Ghana. It was a prospective longitudinal open cohort study. Then enlisted pregnant women who had been exposed to SARS-CoV-2 or had not, and they followed them for six weeks after giving birth or terminating the pregnancy. Based on the results of Wantai SARS Cov-2 Antibody ELISA testing for IgG/IgM antibodies for group assignment and by RT-PCR or Antigen assays when practical,

subjects were divided into exposed and unexposed groups. Instead of diagnosing women, the Wantai Antibody test was being utilized to place them in the right study group.

If a pregnant woman tested positive for Wantai SARS Cov-2 IgG/IgM antibodies (or RT-PCR or Antigen test) before or up until 2 days after pregnancy termination, she was added to the cohort's exposed group. To eliminate false positives from the enrollment tests, pregnant women in the exposed group completed IgG/IgM antibody testing at least once prior to birth. Also included in the exposed group were expectant mothers who had documented evidence of RT-PCR for SARS-CoV-2 RNA or Antigen testing during the current pregnancy. In addition to the results of the PCR or Antigen tests, antibody testing was conducted. After negative antibody testing, pregnant women were added to the (SARS-CoV-2 negative) unexposed group. In the second and third trimesters, pregnant women in the unexposed group were retested to identify those who seroconvert.

3.3 Study site description

The main study which we used data from was conducted in five facilities in the Greater Accra Region of Ghana. This was the epicentre of COVID-19 in Ghana. The selected facilities involved are listed in the table below with their respective characteristics:

Table.1. Description of study settings

SITE	**# Deliveries/Births**	**COVID-19 Centre**	**Population served**
KBTH	10,000 deliveries in a year	Covid-19 treatment centre	Urban

Greater Accra Regional Hospital	Over 7,000 Deliveries and 7,299 deliveries in 2020	Covid-19 treatment centre	Urban
Tema General Hospital	Over 4,000 deliveries, and 4,862 deliveries in 2020	COVID-19 treatment centre	Urban
GaWest Municipal Hospital	Over 4,000 deliveries, 4,263 in 2020	COVID-19 treatment centre	Urban
Shai-Osudoku District Hospital	Over 4,000 deliveries, 4,392 in 2020	?	Rural

3.4 Study population

All expecting mothers who were exposed to COVID-19 and had anaemia were included in the study population. Additionally, all anemic pregnant women who were not infected with COVID-19 were used as a reference group. All participant information gathered from the five chosen healthcare facilities' prospective cohort study was used.

3.5 Inclusion and exclusion criteria

3.5.1 Inclusion criteria

We used data from all pregnant women with anaemia and COVID-19 exposure/infection who were up to 2 days postpartum or who had their pregnancy terminated at the time of enrollment. Additionally, pregnant women with additional co-morbidities participated in the study. The trial also included expectant women with anaemia who had not been exposed to COVID-19. The study included all individuals who gave their consent and were registered in the prospective cohort trial.

3.5.2 Exclusion criteria

The main study excluded those who delivered outside Greater Accra Region.

3.6 Description of study variables

Table 2. Description of variables

NO.	VARIABLE	OPERATIONAL DEFINITION	TYPE OF VARIABLE	MEANS OF MEASUREMENT/SOURCE
1	Age	Age of mother in years	Independent	Quantitative data was collected from the study participants
2	Marital status	Marital status of the pregnant mother	Independent	
3	Occupation	Occupation of pregnant mother	Independent	
4	Education level	Highest level of education	Independent	
5	Level of income	Income level of pregnant women	Independent	Quantitative data was collected from the participants
6	COVID-19 infection status	COVID-19 test status	Independent	
7	Gravidity	Number of pregnancies the mother has had including the current one	Independent	
8	Parity	Number of children the woman has had including the current one	Independent	

9	Residence	Residency of the woman	Independent	
10.	Haemoglobin level	Haemoglobin level of the woman	Independent	
11	Birth weight	Birth weight of the baby	Dependent	Quantitative data collected from the main study
12	Pre-term labour	Labour that begins early before 37 weeks of pregnancy	Dependent	Quantitative data that was collected from the main study
13	Premature rapture of membranes	Premature rapture of the amniotic sac before labour begins	Dependent	
14	Miscarriage/ spontaneous abortion	Loss of a woman's pregnancy at less than 20 weeks gestation	Dependent	
15	stillbirth	Death of a baby in the uterus at more than 20 weeks gestation.	Dependent	

3.6 Sample size determination

As a secondary data analysis study, the sample size that was finally analyzed was 211 anaemic participants and this was extracted from the main study involving 1,286 participants who had complete data.

3.8 Sampling method

This study used secondary data from a prospective study. This main study employed a purposive sampling method. Every woman who was pregnant and either been exposed to COVI-19 infection or not but was anaemic and attended ANC and had been delivered in health facilities in the Greater Accra Region was selected to participate in the study. Pregnant women who were recruited after they had consented to take part in the main study were included in the final data analysis of the study.

3.9 Data collection procedures and tools

Data were not primarily collected, rater the researcher used secondary data. Data for anaemic and COVID-19 infected pregnant women were extracted from the main database of the prospective cohort study into using an excel sheet which included variables of interest.

3.10 Quality control and assurance

3.10.1 Data management and analysis

Final data were imported into STATA version 16 for analysis. Descriptive analysis was performed to describe the study sample in relation to relevant variables. Frequencies and percentage frequency distribution with corresponding 95% interval estimate were used to determine the effect of anaemia on pregnancy outcomes among pregnant women with COVID-19 exposure as against pregnant women with COVID-19 non-exposures. Two-way sample t-test was performed to identify the mean difference in haemoglobin levels at enrollment and at delivery. Multiple logistic regression was used to identify factors associated with anaemia in pregnancy and finally Fischer's exact test was performed to quantify the effect of anaemia and COVID-19 on pregnancy outcomes.

3.10.2 Study limitations

Participates with incomplete data were dropped hence limiting the number of participants who were eligible to be included in this study. The scope of the study was limited to only the Greater Accra Region and in selected hospitals within the region.

3.10.3 Ethical issues

Ethical approval for the main study where we got the data was sought in accordance with 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. The World Medical Association (WMA) Declaration of Helsinki (Ethical Principles for Medical Research Involving Human Subjects), which was endorsed by the 64th WHA General Assembly in Fortaleza in October 2013 was a commitment made by both the sponsor and the investigators.

3.10.4 Consenting process

All study participants in the main study provided written informed consent and/or assent. Without receiving consent, assent, or surrogate consent, women were not allowed to participate in the study. The protocol included guidelines for best practices for various procedures. A trained member of the investigative team discussed the study's objectives prior to the pregnant woman's first interview, and signed informed permission was obtained upon study enrollment.

3.10.5 Benefits and risks for study subjects

The main advantage of the main study was to better inform, counsel, and manage medical care for women who were pregnant or intended to get pregnant in an area where COVID-19 was an outbreak. The expected knowledge includes, but was not limited to, pregnancy outcomes, the presentation and

severity of COVID-19 throughout pregnancy, the incidence of symptomatic and asymptomatic infections, and the possibility for teratogenicity and MTCT. Because all participants got routine medical treatment, this study was not intended to directly benefit participants.

3.10.6 Privacy/confidentiality

Codes were used to identify participants instead of names in the data collection and analysis process to ensure confidentiality.

3.10.7 Data Security

Data extracted were stored under an excel spreadsheet with a key and password. Only the researcher gained access to electronic files for this study.

3.10.8 Voluntary consent/withdrawal

Participants in the main study were informed that participating in the study was voluntary. They had a right to refuse to participate or withdraw from the study without any punishment, intimidation, losing any benefit or whatsoever.

3.10.9 Benefit/Risk

In the main study there were no direct benefits for participants in the study. However, the information that was obtained was to provide some recommendations to the authorities that would aid in improving pregnancy outcomes among anemic, but COVID-19 exposed pregnant women within Greater Accra Region and beyond.

3.10.10 Compensation

Study participants in the main study were not compensated for participating in the study.

3.10.11 Conflict of interest

There were no financial and other personal considerations that would have compromised conducting the study. Therefore, there were no issues of conflict of interest throughout the study.

CHAPTER FOUR

4.0 RESULTS

4.1 Introduction

This chapter presents the results of the study, and it illustrates the socio-demographic characteristics of the participants, prevalence of anaemia and COVID-19 exposure and pregnancy outcomes among anemic pregnant women exposed and unexposed to COVID-19.

4.2 Socio-demographic characteristics of study participants

The researcher analyzed data from 211 pregnant women who were anaemic from 1,286 women who had complete data from an overall of 1,444 recruited women.

Table 3 presents the socio-demographic characteristics of 211 pregnant women aged between 15 and 49 years, among whom 133 (63%) were exposed to COVID-19. The mean age of the participants was 30.7 (SD ± 6.2), with minimum age of 15 years and maximum of 49 years. 28% of the participants who were exposed to COVID-19 were within the 30-34 age group . Collectively, most (52.6%) of the study participants had completed secondary level of education, this was distributed as 34.6% and 18% respectively. A total of 165 (78.2%) of the study participants were currently married, the majority of which (66%) were among the exposed group.

In terms of obstetric history, 45.% of the study participants were multigravidas, of which 28.9% were in the exposed group, additionally, 17.5%of the primigravidae were in the exposed group. Regarding previous caesarean section delivery about 11.4% of the study participants who were exposed to COVID-19 have had 1 previous c/section and 6.64% of the same group had between 2 and 3 Caesarean Section deliveries before. Current obstetric history shows that the majority (97%) of the participants had singleton gestation of which 61% were in the exposed group, and in the same

exposed group 4 of the study participants had twin gestation. 160 of the participants (75.8%) delivered at term (37 weeks and above) and 46.5% of them were in the exposed women, and for the 23% who delivered prematurely, 16.1% were in the exposed group. Regarding medical history, very few of study the participants in both groups reported a history of diabetes (2.4%), hypertension (2.9%), and malaria (2.8%) prior to pregnancy.

Table 3: Socio-demographic, obstetric and clinical characteristics of unvaccinated pregnant presenting with anaemia at enrollment.

Characteristics	**COVID-19 exposure status**		
	Unvaccinated Exposed n(%)	**Unvaccinated Unexposed n(%)**	**Total**
(Mean/median) Age	30	31.3	
Age-group			
15-19	2(0.95)	6(2.8)	8(3.8)
20-24	15(7.1)	13(6.2)	28(13.3)
25-29	33(15.6)	16(7.6)	49(23.2)
30-34	42(19.9)	17(8.1)	59(28)
35-39	36(17.1)	19(9)	55(26.1)
40-44	4(1.9)	6(2.8)	10(4.7)
44-49	1(0.5)	1(0.5)	2(1)

Gravidity			
Primigravida	37(17.54)	24(11.37)	61(28.91)
Secondgravida	35(16.59)	19(9)	54(25.59)
Multigravida	61(28.91)	35(16.59)	96(45.5)
Marital Status			
Single and separated	20(10.47)	18(8.53)	38(19)
Currently married	109(51.66)	56(26.54)	165(78.2)
Cohabitating/no response	4(1.4)	4(1.4)	8(2.8)
Completed Education			
None	8(3.79)	4(1.9)	12(5.69)
Less than primary	2(0.95)	2(0.95)	4(1.9)
Primary school	26(12.3)	20(9.48)	46(21.8)
Secondary school	73(34.6)	38(18.0)	111(52.6)
Tertiary	24(11.37)	14(6.64)	38(18.0)
Number of fetuses			
Singleton	129(61.1)	76(36.0)	205(97)

Twingestation	4(1.9)	2(0.95)	6(3)
Gestational age at delivery			
Preterm (33-36 weeks)	34(16.1)	15(7.1)	49(23.2)
Term (37week and above	98(46.45)	62(29.38)	160(75.8)
less than 33 weeks	1(0.47)	1(0.47)	2(1)
History of Diabetes			
Yes	3(1.4)	2(1)	5(2.4)
No	130(61.6)	76(36.0)	206(97.6)
History of Malaria			
Yes	4(1.9)	2(0.95)	6(2.9)
No	129(61.14)	76(36.02)	205(97.16)
History of Hypertension			
Yes	3(1.4)	3(1.4)	6(2.8)
No	130(61.6)	75(35.6)	205(97.2)
Previous c/section			
o	95(45.02)	64(30.33)	159(75.35)

1	24(11.37)	8(3.79)	32(15.17)
≥2	14(6.64)	6(2.84)	20(9.48)
Total	**133**	**78**	**211**

Mean age(years) 30.7 ± 6.2, Min: 15 & Max: 49

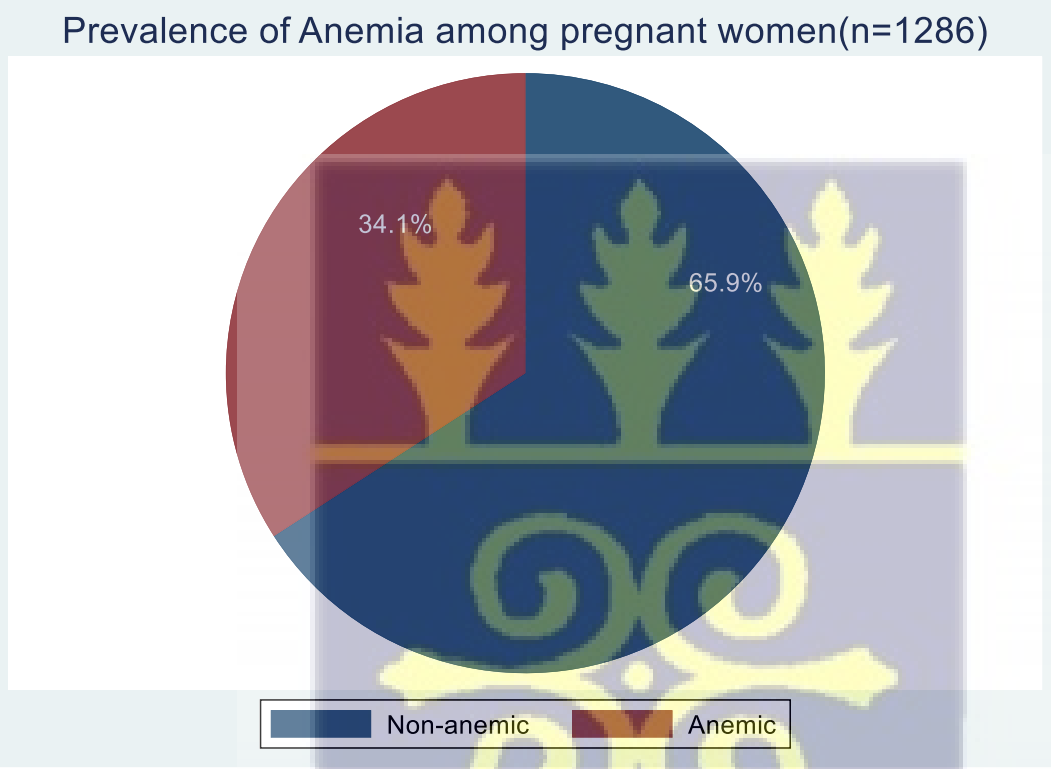


Figure 2. Prevalence of anaemia among pregnant women in Accra.

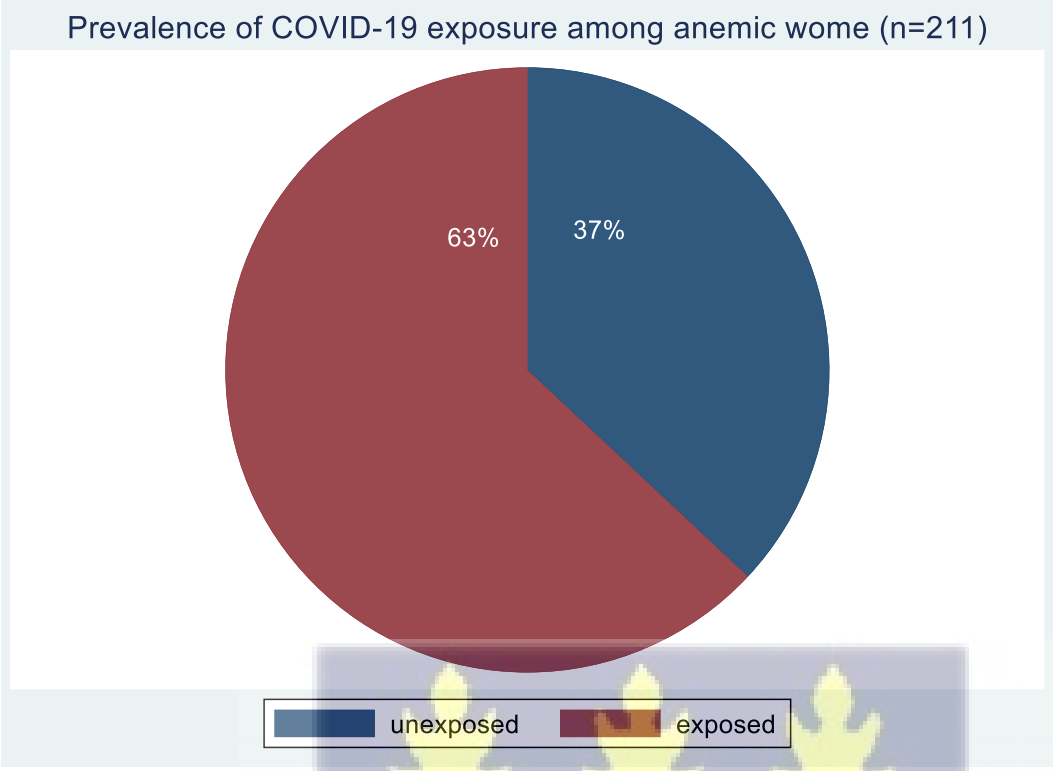


Figure 3. Prevalence of COVID-19 exposure among anemic women in Accra

4.3 Prevalence of COVID-19 and prevalence of anaemia in pregnant women in Accra

The prevalence of COVID-19 among pregnant women who were unvaccinated against COVID-19 was at 57.6 % (figure 3.) in Accra. The overall prevalence of anemia in pregnancy was 24.1% (Figure 2).

4.4 Hemoglobin levels at enrollment and delivery

At enrollment, the mean hemoglobin level among the exposed group was 10.4g/dL (SD ±0.9), ranging from 7.8 g/dL to 14.5g/dL. Among the unexposed group, mean hemoglobin level was 10.2g/dL (SD±0.9) ranged from 7.9 g/dL to 12.9 g/dL. During delivery the mean Hb level was 10.9 g/dL (SD±1.1) and ranged from 8g/dL to 14.4g/dL in the exposed group, while in the unexposed group the mean hemoglobin level was 11g/dl (SD±1.3) and they ranged from 8.3 to 14.4 g/dL. The overall prevalence of anaemia in pregnancy was 34.1% and the prevalence of COVID-19 among anaemic pregnant women was 63% (table 4).

Table 4: Hemoglobin levels among pregnant women by Covid-19 exposure status

Hemoglobin Measure (g/dL)		Exposed	Unexposed
Enrollment	Min	7.8	7.9
	Max	14.5	12.9
	Mean	10.4±0.9	10.2±0.9
Delivery	Min	8.3	8
	Max	14.4	13.9
	Mean	11.0±1.3	10.9±1.1
	Total	133	78

4.5 Pregnancy outcomes among study participants

Fischer's exact test analysis was carried out to find out the association between anaemia and COVID-19 and pregnancy outcomes. The results indicate that there is no significant association between pregnancy outcomes and exposure to COVID-19 among anemic pregnant women (Table 5).

Table 5: Pregnancy outcomes by COVID-19 exposure status among anemic pregnant women at enrollment

Variable	**Group assignment**		**P-value**
	Exposed	**Unexposed**	
Birth weight			0.645
Low birth weight	4	3	
Normal weight	116	72	
Macrosomia	10	3	
Mode of delivery			0.887
Spontaneous vaginal delivery	116	46	
vacuum extraction	14	5	
Planned C/s	59	19	
Emergency C/s	1	8	
Abortion			0.63
Yes	0	1	

No	78	132	
Still birth			0.63
Yes	1	0	
No	132	78	
PROM			0.62
Yes	2	2	
No	131	76	
Preterm labour			0.37
Yes	0	1	
No	133	77	
Gestational age delivery			0.33
Preterm	35	15	
Term	98	62	
22 weeks	1	0	
32 weeks	0	1	

Table 6: Difference in Hemoglobin levels among exposed and unexposed pregnant women enrolled

	N	Mean	SD	Difference	P-Value	Degrees of freedom
Exposed	133	-0.82	1.31	-0.32	0.62	209
Unexposed	78	-0.49	1.16			

A two-sample t-test was performed to compare the mean difference in hemoglobin levels among pregnant women by exposure to covid-19. The t-statistic was -1.86 with 209 degrees of freedom. The corresponding two-tailed p-value is Pr(|T| > |t|) = 0.06. The findings indicate that the mean difference of hemoglobin levels between women exposed and unexposed to covid-19 is not significantly different.

4.6 Factors associated with anaemia at delivery.

A multiple logistic regression was performed to identify factors associated with anaemia at delivery and background and obstetric factors assessed. The results showed that for women who were anemic at enrollment, their odds of being anemic at delivery were almost 5 times higher than those who were not anemic at enrollment, and this was statistically significant (OR 4.9, CI:2.02-12.05, p<0.000). The results also show that with each increase in a woman's age at pregnancy, there was a 1.05 increase in the odds of developing anaemia at delivery (OR=1.05, CI:1.01-1.10) p<0.04) when controlling for parity, place of residence, number of fetuses, educational level, and COVID-19 exposure status (Table 7).

Table 7: Multiple Logistic regression of factors associated with anaemia at delivery

Characteristic	Crude Odds Ratio	[95% Confidence Interval]		Adjusted Odds Ratio	[95% Confidence	Interval]
Anemic	4.569853	1.927424	10.83496	4.937365	2.022638-	12.05236
Age	1.053817	1.007386	1.102388	1.050904	1.002188-	1.101988
Gestational age at delivery	0.9874977	.8642236	1.128356	0.979306	0.8500477-	1.128219
Residence urban	1.051282	.5880947	1.879279	0.876948	0.4616899-	1.6657
Number of fetuses	1.504274	.2694287	8.398656			
Twin gestation				1.04218	0.1777618-	6.110082
Educational level	0.9867819	.7725651	1.260397			
Primary				0.758044	0.2178112-	2.638205
Secondary				0.769881	0.2444495-	2.424703

College/higher				0.800317	0.2216083-	2.890265
COVID-19 status	1.479808	.8416582	2.601805	1.66259	0.9096976-	3.038597

CHAPTER FIVE

5.0 DISCUSSION

5.1 Introduction

This study, which used secondary data from a cohort study which was conducted in Greater Accra, Ghana, aimed at assessing the effects of anaemia and COVID-19 and its effect on pregnancy outcomes. This chapter discusses the results, which include the prevalence of anaemia, the prevalence of COVID-19 in anaemic pregnant women, the effects that the two have on pregnancy outcomes just to mention a few.

5.2 The Prevalence of anaemia among pregnant women

The general prevalence of anaemia among pregnant women in the study was found to be 34.1%, which is similar to the results which were found in a study that was conducted in Ghana, in 2019 that revealed a prevalence of 33% among pregnant women (Kofie *et al.* 2019). Another study in the same country showed that the prevalence of anaemia in pregnancy ranged from 37% to 63% by trimesters (Pobee *et al.* 2021).

However, in other studies, the reported prevalence of anaemia is lower than what was found in this study. In Rwanda, for instance, the prevalence of anaemia in pregnant women was 19.2% (Habyarimana, Zewotir, & Ramroop, 2018). Another lower prevalence of pregnancy anaemia was reported in a follow-up study conducted in Tanzania, in which an 18% prevalence was reported (Stephen *et al.*, 2018). Other studies that were conducted at Aymiba Health Centre in Northwest Ethiopia (21.6%) and at Azezo Health Centre in northwest Ethiopia which reported the prevalence of anaemia among pregnant women to be 25.2%. In southern part of Ethiopia, one study found

similar results of 23.2%. Similar results were also reported in Uganda where the prevalence was 22.1%, and in China, a retrospective study found the prevalence of anaemia among pregnant to be 23.5%, which is similar to our findings (Asrie, 2017; Lebso *et al.*, 2017; Lin *et al.*, 2018; Obai *et al.*, 2016; Alem,2013).

Higher prevalence of anaemia in pregnancy,46%, was reported in a study conducted in Nigeria (Ejiofor, Ozokono, and Ugwu 2019). In Sierra Leona, the general prevalence of anaemia in pregnancy was reported to 52.9% according the DHS data analysis for 2019 (Arinda *et al.* 2022). Again, in rural India, the prevalence of anaemia among pregnant women was higher, 69%, than the findings of this study (Heesemann *et al.*, 2021). South Africa reported a 42.7% prevalence of anaemia in pregnancy (Tunkyi and Moodley, 2016) .

The prevalence of anaemia in pregnancy in this study is still high and it is a public health issue in Ghana. However, the differences that have been seen in the prevalence as compared to other countries could be attributed to geographical locations of the study sites, and due to the COVID-19 pandemic, which caused some disruption in health service utilization and access to standard Antenatal services were included. As reported by other studies, higher prevalence of anaemia in pregnancy is worrisome, as it could cause greater harm to pregnant women and the growing fetus, in terms of low birth weights, premature labour, postpartum hemorrhage, just to mention a few (Parks *et al.*, 2019; Smith *et al.*, 2019).

Considering that this study was conducted among COVID-19 exposed and unexposed pregnant women, we also found the prevalence of anaemia among COVID-19 exposed women to be 25.%. There is scanty data on studies about anaemia and COVID-19 in pregnant women. However, similar findings, though not in a pregnant population, were reported from a study which was conducted in Austria, where the prevalence of anaemia was 24.7% (Bellmann-Weiler *et al.* 2020).

In Pakistan, the prevalence of anaemia among pregnant women exposed to covid-19 was 32.6%. Even in non-pregnant populations, studies have shown that COVID-19 exposure increases the risk of developing anaemia. For example, in Iran, the prevalence of anaemia in COVID-19 exposed participants was 48.2% (Faghih Dinevari *et al.*, 2021). In Romania, the prevalence of anaemia among COVID-19 participants was 42.1%, which again is higher than our findings (Uta *et al.*, 2022). Additionally, in Ankara city, Turkey, the prevalence of anaemia in COVID-19 patients was 47.6% (Tezcan & Ciftci., 2021). The discrepancies in the findings could be because the study participants in our study did not have a severe infection after being exposed to COVID-19 compared to the populations which were included in other studies, where they even had hospitalized COVID-19 patients, the older ages and those with other morbidities. Nonetheless, because anaemia in pregnancy contributes to adverse events in pregnancy outcomes, it is important that haemoglobin levels of women of reproductive age should be routinely monitored preconceptionally to ensure that they have normal blood levels before and during pregnancy and if they are found to be anemic interventions should be taken, for example, provision of iron supplements. Managing anaemia in women of reproductive age will help avert the burden of neonatal and maternal morbidity and mortality.

5.3 Prevalence of COVID-19 among pregnant women

In the current study, the prevalence of COVID-19 among pregnant women was 63%. Notably, the findings in our study are higher compared to what was reported in other studies. For instance in a cross sectional study in Larkana, where they found the prevalence of COVID-19 in pregnancy at 19.1% (Mari *et al.*, 2021). Another study in Northern California reported a prevalence of 2.5% for COVID-19 among pregnant women, again far lower than our findings in this study (Ames *et al.*,

2021). A prevalence of 9% was reported in a systematic review and metanalysis (Allotey *et al.* 2020).

The high prevalence of covid-19 among the pregnant population could be a result of pregnancy being a period of reduced immunity as well as exposure to the virus within a health facility due to frequent antenatal visits.

5.4 Hemoglobin levels of women exposed and unexposed to COVID-19 at delivery and the risk factors for anaemia at delivery

There are limited articles reporting on hemoglobin levels in COVID-19 pregnant women. The results reveal that there is no difference in hemoglobin levels of women who are exposed to COVID-19 and those who are unexposed to COVID-19 at delivery time. These findings are similar to what was reported in a follow up study in Romania where the Hb levels in COVID-19 exposed and unexposed participants were not significantly different when the pregnancies were at term (Covali *et al.*, 2022). Another follow-up study in Italy showed that the difference in Hb levels at enrollment at completion of the study had no evidence of significant differences in the Hb levels, however this study was conducted in positive to COVID-19, unlike in this study which focused on exposure and not active infection (Lanini *et al.*, 2020).

The results have also revealed that pregnant women who are anemic at enrollment were at a greater risk of remaining anemic during delivery time. There is scanty data showing the risk of being anemic during first and second trimester and remaining anemic during labor. However, what has been reported in other studies reveals that anaemia in third trimester/delivery is higher. For example, in a longitudinal study that was conducted in Ghana, it was found that in the third trimester, more women were anemic (Pobee *et al.*, 2021). In Bangladesh, a cross-sectional study showed that most pregnant women were anemic during third trimester (Sabina Azhar, Islam, and Karim 2021). Similar findings

were also recorded in Ethiopia where a community based cross-sectional study showed that during third trimester, anaemia is prevalent (Alene and Mohamed Dohe, 2015).

5.5 Pregnancy outcomes in anemic women exposed to COVID-19

This study found that there was no significant association between pregnancy outcomes among anemic pregnant women regardless of COVID-19 exposure status. The findings are, however, contrary to what has been reported in other studies which show that there anaemia in COVID-19 exposed pregnant women contributed to poor pregnancy outcomes. In Romania, Uta and colleagues found that comorbidity of anaemia and COVID-19 contributed to intrauterine growth restriction and birth through c/section (Uta *et al.*, 2022). A high rate of still births was reported in Delhi, India, among women who had COVID-19 compared to those who were not (Kumar *et al.* 2021). In the same country, Singh *et al.*, (2022) reported that COVID-19 and anaemia were associated with low birth weight babies and another study found that more women who had COVID-19 delivered through c/sections (Nayak *et al.*, 2020).

These differences in the findings could indicate that anemic women who have been exposed to COVID-19 experience similar pregnancy outcomes as unexposed women, as we might have expected. This study is one of the novel studies in relation to pregnancy outcomes in anemic and COVID-19 exposed pregnant women. Therefore, more research is needed to assess effects of anaemia and COVID-19 in pregnant women both in developing and developed world with larger samples.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

From the findings of the study, it can be concluded that prevalence of anaemia among pregnant women in Accra is still high and remains a public health concern because anaemia in pregnancy contributes to adverse events in pregnancy outcomes. The prevalence of COVID-19 among pregnant women was found to be high in this study. Anaemia status earlier on in pregnancy was found to increase anaemia at delivery which could result in birth complications. Additionally, there was no association between COVID-19 exposure and haemoglobin levels among pregnant women and the existence of the two did not have an effect on the outcomes of the pregnancy.

6.2 Recommendations

The following recommendations have been made based on the findings of the study to help reduce the prevalence of anaemia and COVID-19 in pregnancy, and prevent poor pregnancy outcomes.

Public health practice (Maternal and child health)

- Women of reproductive age should be routinely monitored for anaemia (right from preconception) and during pandemics, extra attention should be paid to these vulnerable people.
- For women who are anaemic during pregnancy, drastic interventions should be implemented to reverse dropping hemoglobin level, like oral or intravenous iron supplements where necessary.

Policy makers

- Reinforce guidelines and policies regarding care of pregnant women regardless of Covid-19 status.
- Government should ensure that enough health workers are available to work in all hospital departments during pandemics.

Research

- There is need to conduct more and diverse studies for further insight regarding COVID-19 and anaemia in pregnancy .

REFERENCES

Acheampong, K., Appiah, S., Baffour-Awuah, D., & Arhin, Y. S. (2018). Prevalence of anaemia among pregnant women attending antenatal clinic of a selected hospital in Accra, Ghana. *Int J Health Sci Res*, *8*(1), 186-193.

Adam, Ishag, Yassin Ibrahim, and Osama Elhardello. 2018. "Prevalence , Types and Determinants of Anaemia among Pregnant Women in Sudan : A Systematic Review and Meta-Analysis." 4–11.

Ahmed, S., Al Mamun, M. A., Mahmud, N., Farzana, N., Sathi, M. S. A., Biswas, B. K., ... & Ahmad, T. (2019). Prevalence and associated factors of Anaemia among pregnant women receiving antenatal care (ANC) at Fatima Hospital in Jashore, Bangladesh: a cross-sectional study. *Food and Nutrition Sciences*, *10*(9), 1056-1071.

Akhtar, H., Patel, C., Abuelgasim, E., & Harky, A. (2020). COVID-19 (SARS-CoV-2) infection in pregnancy: a systematic review. *Gynecologic and Obstetric Investigation*, *85*(4), 295-306.

Akowuah, J. A., Owusu-Addo, E., & Opuni, A. A. (2022). Predictors of Anaemia Prevalence Among Ghanaian Pregnant Women: A Cross-Sectional Study. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing*, *59*, 00469580221086919.

Atindama, S., Ayamba, E. Y., Agorinya, I., Alhassan, M., Kagura, J., Yidana, A., ... & Kaburise, M. B. (2019). Descriptive epidemiology of anaemia among pregnant women initiating antenatal care in rural Northern Ghana. *African Journal of Primary Health Care and Family Medicine, 11*(1), 1-7.

Auger, Nathalie, Thi U. N. Le, Alison L. Park, and Zhong Cheng Luo. 2011. "Association between Maternal Comorbidity and Preterm Birth by Severity and Clinical Subtype: Retrospective Cohort Study." *BMC Pregnancy and Childbirth* 11. doi: 10.1186/1471-2393-11-67.

Adam, Ishag, Yassin Ibrahim, and Osama Elhardello. 2018. "Prevalence , Types and Determinants of Anemia among Pregnant Women in Sudan : A Systematic Review and Meta-Analysis." 4–11.

Akhtar, H., C. Patel, E. Abuelgasim, and A. Harky. 2020. "COVID-19 (SARS-CoV-2) Infection in Pregnancy : A Systematic Review." 295–306. doi: 10.1159/000509290.

Alene, Kefyalew Addis, and Abdulahi Mohamed Dohe. 2015. "Prevalence of Anemia and Associated Factors among Pregnant Women in an Urban Area of Eastern Ethiopia." *Anemia* 2014(May 2013). doi: 10.1155/2014/561567.

Allotey, John, Elena Stallings, Mercedes Bonet, Magnus Yap, Shaunak Chatterjee, Tania Kew, Luke Debenham, Anna Clavé Llavall, Anushka Dixit, Dengyi Zhou, Rishab Balaji, Siang Ing Lee, Xiu Qiu, Mingyang Yuan, Dyuti Coomar, Madelon Van Wely, Elizabeth Van Leeuwen, Elena Kostova, Heinke Kunst, Asma Khalil, Simon Tiberi, Vanessa Brizuela, Nathalie Broutet, Edna Kara, Caron Rahn Kim, Anna Thorson, Olufemi T. Oladapo, Lynne Mofenson, Javier Zamora, and Shakila Thangaratinam. 2020. "Clinical Manifestations, Risk Factors, and Maternal and Perinatal Outcomes of Coronavirus Disease 2019 in Pregnancy: Living Systematic Review and

Meta-Analysis." *The BMJ* 370. doi: 10.1136/bmj.m3320.

Arinda, Ivan Kato, Quraish Sserwanja, Kassim Kamara, David Mukunya, Napyo Agnes, Nsubuga Edirisa Juniour, Nuwahereza Christinah, Anitah Kagali, and Seungwon Lee. 2022. "Anemia and Associated Factors Among Lactating Women in Sierra Leone: An Analysis of the Sierra Leone Demographic and Health Survey 2019." *Nutrition and Metabolic Insights* 15. doi: 10.1177/11786388221105732.

Asrie, Fikir. 2017. "Prevalence of Anemia and Its Associated Factors among Pregnant Women Receiving Antenatal Care at Aymiba Health Center , Northwest Ethiopia." 35–40.

Auger, Nathalie, Thi U. N. Le, Alison L. Park, and Zhong Cheng Luo. 2011. "Association between Maternal Comorbidity and Preterm Birth by Severity and Clinical Subtype: Retrospective Cohort Study." *BMC Pregnancy and Childbirth* 11. doi: 10.1186/1471-2393-11-67.

Bellmann-Weiler, Rosa, Lukas Lanser, Robert Barket, Lukas Rangger, Anna Schapfl, Marc Schaber, Gernot Fritsche, Ewald Wöll, and Günter Weiss. 2020. "Prevalence and Predictive Value of Anemia and Dysregulated Iron Homeostasis in Patients with COVID-19 Infection." *Journal of Clinical Medicine* 9(8):1–11. doi: 10.3390/jcm9082429.

Bergamaschi, Gaetano, Federica Borrelli, Nicola Aronico, Marco Vincenzo, Chiara Barteselli, Stefania Merli, Ivan Pellegrino, Luigi Coppola, Elisa Maria Cremonte, Gabriele Croce, Francesco Mordà, Francesco Lapia, Sara Ferrari, Alessia Ballesio, Alessandro Parodi, Francesca Calabretta, Maria Giovanna Ferrari, Federica Fumoso, Antonella Gentile, and Federica Melazzini. 2021. "Anemia in Patients with Covid - 19 : Pathogenesis and Clinical Significance." 239–46. doi: 10.1007/s10238-020-00679-4.

Belay, A., Astatkie, T., Abebaw, S., Gebreamanule, B., & Enbeyle, W. (2022). Prevalence and factors affecting the utilization of antenatal care in rural areas of Southwestern Ethiopia. *BMC pregnancy and childbirth*, *22*(1), 1-8.

Bergamaschi, G., Borrelli de Andreis, F., Aronico, N., Lenti, M. V., Barteselli, C., Merli, S., ... & Di Sabatino, A. (2021). Anaemia in patients with Covid-19: pathogenesis and clinical significance. *Clinical and experimental medicine*, *21*(2), 239-246.

Berhe, B., Mardu, F., Legese, H., Gebrewahd, A., Gebremariam, G., Tesfay, K., ... & Adhanom, G. (2019). Prevalence of anaemia and associated factors among pregnant women in Adigrat General Hospital, Tigrai, northern Ethiopia, 2018. *BMC research notes*, *12*(1), 1-6.

Black, R.e.; Victora, C.g.; Walker, S.P.; Bhutta, Z.A.; Christian, P.; de Onis, M.; Ezzati, M.; Grantham McGregor, S.; Katz, J.;Martorell, R.; *et al.* Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 2013,382, 427–451.

Byamugisha, J., Adero, N., Kiwanuka, T. S., Nalwadda, C. K., Ntuyo, P., Namagembe, I., ... & Ononge, S. (2022). The effect of blister packaging Iron and Folate on adherence to medication and hemoglobin levels among pregnant women at National Referral Hospital antenatal clinics in a low to middle income country: a Randomised Controlled Trial (The IFAd Trial). *BMC pregnancy and childbirth*, *22*(1), 1-9.

Chavan, N. N., Ammara, U., Kapote, D., Deshmukh, P., & Sakhalkar, A. (2022). Study of maternal and foetal outcome in COVID-19 anaemic patients during COVID pandemic in a tertiary centre. *International Journal of Reproduction, Contraception, Obstetrics and Gynecology*, *11*(5), 1566.

Chen, C., Zhou, W., Fan, W., Ning, X., Yang, S., Lei, Z., & Zheng, C. (2021). Association of anaemia and COVID-19 in hospitalized patients. *Future Virology*, *16*(7), 459-466.

Covali, Roxana, Demetra Socolov, Razvan Socolov, Ioana Pavaleanu, Alexandru Carauleanu, Mona Akad, Vasile Lucian Boiculese, and Ana Maria Adam. 2022. "Complete Blood Count Peculiarities in Pregnant SARS-CoV-2-Infected Patients at Term : A Cohort Study." 1–17.

Devi, U. A., Sushma, H. P., Singh, L. R., Singh, M. R., Devi, A. B., Vanchhingpui, F., & Darshan, S. M. (2020). Impact of anaemia in pregnancy on feto-maternal outcome. *J Med Sci Clin Res*, 8, 83-93.

Di Toro, F., Gjoka, M., Di Lorenzo, G., De Santo, D., De Seta, F., Maso, G., ... & Ricci, G. (2021). Impact of COVID-19 on maternal and neonatal outcomes: a systematic review and meta-analysis. *Clinical Microbiology and Infection*, *27*(1), 36-46.

Dodzo, R. C., Ogunsakin, R. E., & Ginindza, T. G. (2022). Prevalence and associated risk factors for anaemia amongst pregnant women attending three antenatal clinics in Eswatini. *African journal of primary health care & family medicine*, *14*(1), e1–e9. https://doi.org/10.4102/phcfm.v14i1.3339

Ejiofor, Chukwunonso Collins, Rosemary Ujunwa Ozokono, and Joshua Izuchukwu Ugwu. 2019. "Prevalaence of Anaemia among Preganant Women Attending 82 Division Nigerian Army Hospitals, Enugu." *Gynecology and Obstetrics Research– Open Journal* 6(1):1–5. doi: 10.17140/goroj-6-148.

Eteffa, T., Arega, A., Abejie, B., Feyisa, W., & Alemnew, F. (2022). Prevalence of Anaemia and its Associated Factors among Antenatal Care Attendees in the Public Health Facilities of Pawi District, Northwest, Ethiopia, 2020. *J Nutri Med Diet Care*, *8*, 059.

Faghih Dinevari, Masood, Mohammad Hossein Somi, Elham Sadeghi Majd, Mahdieh Abbasalizad Farhangi, and Zeinab Nikniaz. 2021. "Anemia Predicts Poor Outcomes of COVID-19 in Hospitalized Patients: A Prospective Study in Iran." *BMC Infectious Diseases* 21(1):1–7. doi: 10.1186/s12879-021-05868-4.

Fite, Meseret Belete, Nega Assefa, and Bizatu Mengiste. 2021. "Prevalence and Determinants of Anaemia among Pregnant Women in Sub-Saharan Africa : A Systematic Review and Meta-Analysis." 1–11.*Arch Public Health* 79, 219. http://doi.org/10.1186/s13690-021-00711-3

Fondjo, L. A., Addai Mensah, O., Annani-Akollor, M. E., Quarshie, J. T., Boateng, A. A., Assafuah, S. E., & Owiredu, E. W. (2020). A multicenter study of the prevalence and risk factors of malaria and anaemia among pregnant women at first antenatal care visit in Ghana. *PLoS One*, *15*(8), e0238077.

GDHS. 2015. "Ghana Demographic Health Survey." Demographic and Health Survey 2014 530.

GDHS. 2022. "Ghana Demographic Health Survey." Demographic and Health Survey 2022.

Gill, Shameena, Alia Maisara Adenan, Adli Ali, and Noor Akmal Shareela Ismail. 2022. "Living through the COVID-19 Pandemic: Impact and Lessons on Dietary Behavior and Physical Well-Being." *International Journal of Environmental Research and Public Health* 19(2). doi:

10.3390/ijerph19020642.

Global Recommendations, and Routine Antenatal Care. 2018. "WHO Recommendations on Antenatal Care for a Positive Pregnancy Experience : Summary Highlights and Key Messages from the World Health Organization ' s 2016 Global Recommendations for Routine Antenatal Care." 10(January):1–10. doi: 10.1186/1742-4755-10-19.5.

Habyarimana, Faustin, Temesgen Zewotir, and Shaun Ramroop. 2018. "Spatial Distribution and Analysis of Risk Factors Associated with Anemia Among Women of Reproductive Age: Case of 2014 Rwanda Demographic and Health Survey Data." *The Open Public Health Journal* 11(1):425–37. doi: 10.2174/1874944501811010425.

Heesemann, Esther, Claudia Mähler, Malavika A. Subramanyam, and Sebastian Vollmer. 2021. "Pregnancy Anaemia , Child Health and Development : A Cohort Study in Rural India." 1–10. doi: 10.1136/bmjopen-2020-046802.

Haider, B. A., I. Olofin, M. Wang, D. Spiegelman, M. Ezzati, W. W. Fawzi. 2013. "Anaemia, Prenatal Iron Use, and Risk of Adverse Pregnancy Outcomes: Systematic Review and Meta-Analysis." *BMJ* 346: f3443. https://edoi.org/10.1136/bmj.f3443

Hapshy, V., Aziz, D., Kahar, P., Khanna, D., Johnson, K. E., & Parmar, M. S. (2021). COVID-19 and pregnancy: Risk, symptoms, diagnosis, and treatment. *SN comprehensive clinical medicine*, *3*(7), 1477-1483.

Itriago, E., Lingappan, K., Teruya, J., & Dinu, D. (2022). Hemolysis in Neonates Born to Mothers With History of SARS-CoV-2 Infection During Pregnancy: A Case Series. *International Journal of Clinical Pediatrics*, *11*(1), 27-32.

Jennifer L. Ames, Assiamira Ferrara, Lyndsay A. Avalos, Sylvia E. Badon, B. Greenberg, Monique M. Hedderson, Michael W. Kuzniewicz, Yinge Qian, Ousseny Zerbo, Yeyi Zhu, and Lisa A. Croen. 2021. "Sociodemographic Disparities in Infection among Insured Pregnant Women in Northern California." 1–16. doi: 10.1371/journal.pone.0256891.

Kalaivani, K. (2009). Prevalence & consequences of anaemia in pregnancy. *Indian J Med Res, 130*(5), 627-33.

Kare, A. P., & Gujo, A. B. (2021). Anaemia among pregnant women attending ante natal care clinic in Adare General Hospital, southern Ethiopia: prevalence and associated factors. *Health Services Insights*, *14*, 11786329211036303.

Kassa, G. M., Muche, A. A., Berhe, A. K., & Fekadu, G. A. (2017). Prevalence and determinants of anaemia among pregnant women in Ethiopia; a systematic review and meta-analysis. *BMC hematology*, *17*(1), 1-9.

Kozuki, N., Lee, A. C., & Katz, J. (2012). Child Health Epidemiology Reference G. Moderate to severe, but not mild, maternal anaemia is associated with increased risk of small-for-gestational-age outcomes. *Journal of Nutrition*, *142*(2), 358-62.

Kofie, Philip, Elvis E. Tarkang, Emmanuel Manu, Hubert Amu, Martin Amogre Ayanore, Fortress Aku, Joyce Komesuor, Martin Adjuik, Fred Binka, and Margaret Kweku. 2019. "Prevalence and Associated Risk Factors of Anaemia among Women Attending Antenatal and Post-Natal Clinics at a Public Health Facility in Ghana." 1–9. BMC Nutrition (2019) 5:40 https://doi.org/10.1186/s40795-019-0303-x

Kumar, Manisha, Manju Puri, Reena Yadav, Ratna Biswas, Meenakshi Singh, Vidhi Chaudhary, Nishtha Jaiswal, and Deepika Meena. 2021. "Stillbirths and the COVID-19 Pandemic :

Looking beyond SARS-CoV-2 Infection." (December 2020):76–82. doi: 10.1002/ijgo.13564.

Lassi, Z. S., Ana, A., Das, J. K., Salam, R. A., Padhani, Z. A., Irfan, O., & Bhutta, Z. A. (2021). A systematic review and meta-analysis of data on pregnant women with confirmed COVID-19: Clinical presentation, and pregnancy and perinatal outcomes based on COVID-19 severity. *Journal of Global Health*, 11.

Lebso, Meaza, Anchamo Anato, and Eskindir Loha. 2017. "Prevalence of Anemia and Associated Factors among Pregnant Women in Southern Ethiopia : A Community Based Cross-Sectional Study." 1–11. doi: 10.6084/m9.figshare.5616433.Funding.

Lestari, S., Fujiati, I. I., Keumalasari, D., Daulay, M., Martina, S. J., & Syarifah, S. (2018, March). The prevalence of anaemia in pregnant women and its associated risk factors in North Sumatera, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 125, No. 1, p. 012195). IOP Publishing.

Lin, Li, Yumei Wei, Weiwei Zhu, Chen Wang, Rina Su, Hui Feng, and Huixia Yang. 2018. "Prevalence , Risk Factors and Associated Adverse Pregnancy Outcomes of Anaemia in Chinese Pregnant Women : A Multicentre Retrospective Study." 1–8.

Liyew, L.A., Tessema, G.A., Alamneh. T.S., Worku, M.G., Teshale, A.B., Alem, A.Z., Tessema,Z. T., & , Yeshaw, Y., (2021). Prevalence and determinants of anaemia among pregnant women in East Africa *; A multi-level analysis of recent Demographic and Health*

Mari, Israt Saba, Monika Maheshwari, Shahida Shaikh, and Qararo Shah Syed. 2021. "Effects of

Novel Coronavirus 2019 Infection on Antenatal Hematological Parameters in Pregnant Women .” 15(11):3279–84.

Menendez, Clara, Raquel Gonzalez, France Donnay, and Rose G. F. Leke. 2020. “Avoiding Indirect Effects of COVID-19 on Maternal and Child Health.” *The Lancet Global Health* 8(7):e863–64. doi: 10.1016/S2214-109X(20)30239-4.

Mihaela Uta, Radu Neamtu, Elena Bernad, Adelina Geanina Mocanu, Adrian Gluhovschi, Alin Popescu, George Dahma, Catalin Dumitru, Lavinia Stelea, Cosmin Citu, Felix Bratosin, and Marius Craina. 2022. “The Influence of Nutritional Supplementation for Iron Deficiency Anemia on Pregnancies Associated With.” 1–11.

Monika, M., Maheshwari, M., Shaikh, S., Syed, Q. S., & Kumar, B. (2021). Effects of Novel Coronavirus 2019 Infection on Antenatal Hematological Parameters in Pregnant Women. *Pakistan Journal of Medical and Health Sciences*, 3279-3284.

Nair, Manisha, Marian Knight, Susan Robinson, Catherine Nelson-piercy, Simon J. Stanworth, David Churchill, and S Robinson. 2018. “Pathways of Association between Maternal Haemoglobin and Stillbirth : Path-Analysis of Maternity Data from Two Hospitals in England.” 1–8. doi: 10.1136/bmjopen-2017-020149.

Nasir, B. B., Fentie, A. M., & Adisu, M. K. (2020). Adherence to iron and folic acid supplementation and prevalence of anaemia among pregnant women attending antenatal care clinic at Tikur Anbessa Specialized Hospital, Ethiopia. *Plos one*, *15*(5), e0232625.

Nayak, Arun Harishchandra, Deepali Swapnil Kapote, Michelle Fonseca, Niranjan Chavan, Rahul Mayekar, Meenal Sarmalkar, and Amarjeet Bawa. 2020. “Impact of the Coronavirus Infection in Pregnancy: A Preliminary Study of 141 Patients.” *Journal of Obstetrics and Gynecology of*

India 70(4):256–61. doi: 10.1007/s13224-020-01335-3.

Obai, Gerald, Pancras Odongo, and Ronald Wanyama. 2016. "Prevalence of Anaemia and Associated Risk Factors among Pregnant Women Attending Antenatal Care in Gulu and Hoima Regional Hospitals in Uganda: A Cross Sectional Study." *BMC Pregnancy and Childbirth* 16(1):1–7. doi: 10.1186/s12884-016-0865-4.

Parks, S., M. K. Hoffman, S. S. Goudar, A. Patel, S. Saleem, S. A. Ali, R. L. Goldenberg, P. L. Hibberd, J. Moore, D. Wallace, E. M. Mcclure, and R. J. Derman. 2019. "Maternal Anaemia and Maternal, Fetal, and Neonatal Outcomes in a Prospective Cohort Study in India and Pakistan." 126(January 2008):737–43. doi: 10.1111/1471-0528.15585.Maternal.

Pobee, Ruth A., Jacob Setorglo Id, Moses Klevor Id, and Laura E. Murray-kolb Id. 2021. "The Prevalence of Anemia and Iron Deficiency among Pregnant Ghanaian Women , a Longitudinal Study." 1–14. doi: 10.1371/journal.pone.0248754.

Ren, Li Li, Ye Ming Wang, Zhi Qiang Wu, Zi Chun Xiang, Li Guo, Teng Xu, Yong Zhong Jiang, Yan Xiong, Yong Jun Li, Xing Wang Li, Hui Li, Guo Hui Fan, Xiao Ying Gu, Yan Xiao, Hong Gao, Jiu Yang Xu, Fan Yang, Xin Ming Wang, Chao Wu, Lan Chen, Yi Wei Liu, Bo Liu, Jian Yang, Xiao Rui Wang, Jie Dong, Li Li, Chao Lin Huang, Jian Ping Zhao, Yi Hu, Zhen Shun Cheng, Lin Lin Liu, Zhao Hui Qian, Chuan Qin, Qi Jin, Bin Cao, and Jian Wei Wang. 2020. "Identification of a Novel Coronavirus Causing Severe Pneumonia in Human: A Descriptive Study." *Chinese Medical Journal* 133(9):1015–24. doi: 10.1097/CM9.0000000000000722.

Sabina Azhar, Bably, Md Shofikul Islam, and Md Rezaul Karim. 2021. "Prevalence of Anemia and Associated Risk Factors among Pregnant Women Attending Antenatal Care in Bangladesh: A Cross-Sectional Study." *Primary Health Care Research and Development* 22. doi:

10.1017/S146342362100061X.

Sharma, A. J., Ford, N. D., Bulkley, J. E., Jenkins, L. M., Vesco, K. K., & Williams, A. M. (2021). Use of the electronic health record to assess prevalence of anaemia and iron deficiency in pregnancy. *The Journal of Nutrition*, *151*(11), 3588-3595.

Sinchikhin, S. P., Stepanyan, L. V., Atueva, L. M., Nasri, O., & Sinchikhina, E. S. (2021). Relationship between COVID-19 and iron deficiency anaemia in pregnant women. *Gynecology*, *23*(6), 592-596.

Singh, M., Puri, M., Chaudhary, V., Triveni, G. S., Kapur, A., Patel, M., & Kumari, V. (2022). Impact of covid 19 pandemic on maternofetal outcome in pregnant women with severe anaemia: a retrospective case control study. Authorea Preprints.

Srour, M. A., Aqel, S. S., Srour, K. M., Younis, K. R., & Samarah, F. (2018). Prevalence of anaemia and iron deficiency among Palestinian pregnant women and its association with pregnancy outcome. *Anaemia*, *2018*.

Sigler, Thomas, Sirat Mahmuda, Anthony Kimpton, Julia Loginova, Pia Wohland, and Elin Charles-edwards. 2021. "The Socio-Spatial Determinants of COVID-19 Diffusion : The Impact of Globalisation , Settlement Characteristics and Population." 1–14.

Simone Lanini, Chiara Montaldo Id, Emanuele Nicastri, Francesco Vairo, Chiara Agrati, Nicola Petrosillo, Paola Scognamiglio, Andrea Antinori, Vincenzo Puro, Antonino Di, Caro Id, Gabriella De Carli, Assunta Navarra, Alessandro Agresta, Claudia Cimaglia, Fabrizio Palmieri, Gianpiero D. Offizi, Luisa Marchioni, Gary Pignac Kobinger, Markus Maeurer, Enrico Girardi,

Rosaria Capobianchi, Alimuddin Zumla, Franco Locatelli, and Giuseppe Ippolito. 2020. "COVID-19 Disease — Temporal Analyses of Complete Blood Count Parameters over Course of Illness , and Relationship to Patient Demographics and Management Outcomes in Survivors and Non-Survivors : A Longitudinal Descriptive Cohort Study." 1–17. doi: 10.1371/journal.pone.0244129.

Smith, Catherine, Flora Teng, K. S. Joseph, and Emma Branch. 2019. "Maternal and Perinatal Morbidity and Mortality Associated With Anemia in Pregnancy." 134(6):1234–44. doi: 10.1097/AOG.0000000000003557.

Sohail, Mohammad, Shayan Shakeel, Shweta Kumari, Aakanksha Bharti, Faisal Zahid, Shadab Anwar, Krishn Pratap Singh, Mazahirul Islam, Ajay Kumar Sharma, Sneh Lata, Vahab Ali, Tridibes Adak, Pradeep Das, and Mohammad Raziuddin. 2015. "Prevalence of Malaria Infection and Risk Factors Associated with Anaemia among Pregnant Women in Semiurban Community of Hazaribag , Jharkhand , India." 2015.

Stephen, Grace, Melina Mgongo, Tamara Hussein Hashim, Johnson Katanga, Babill Stray-Pedersen, and Sia Emmanueli Msuya. 2018. "Anaemia in Pregnancy: Prevalence, Risk Factors, and Adverse Perinatal Outcomes in Northern Tanzania." *Anemia* 2018. doi: 10.1155/2018/1846280.

Survey, Health, and Key Indicators Report. 2022.

Tamirat, Koku Sisay, Malede Mequanent Sisay, Getayeneh Antehunegn Tesema, and Zemenu

Tadesse Tessema. 2021. "Determinants of Adverse Birth Outcome in Sub-Saharan Africa : Analysis of Recent Demographic and Health Surveys." 1–10.

Tibambuya, B. A., Ganle, J. K., & Ibrahim, M. (2019). Anaemia at antenatal care initiation and associated factors among pregnant women in West Gonja District, Ghana: a cross-sectional study. *The Pan African Medical Journal*, *33*.

Toro, Francesca Di, Mattheus Gjoka, Giovanni Di Lorenzo, Davide De Santo, Francesco De Seta, Gianpaolo Maso, Francesco Maria Risso, Federico Romano, Uri Wiesenfeld, Roberto Levi-d Ancona, Luca Ronfani, and Giuseppe Ricci. 2021. "Impact of COVID-19 on Maternal and Neonatal Outcomes : A Systematic Review and Meta-Analysis." *Clinical Microbiology and Infection* 27(1):36–46. doi: 10.1016/j.cmi.2020.10.007.

Tunkyi, K., and J. Moodley. 2016. "Prevalence of Anaemia in Pregnancy in a Regional Health Facility in South Africa." *South African Medical Journal* 106(1):101–4. doi: 10.7196/SAMJ.2016.v106i1.9860.

Ullah, A., Sohaib, M., Saeed, F., & Iqbal, S. (2019). Prevalence of anaemia and associated risk factors among pregnant women in Lahore, Pakistan. *Women & health*, *59*(6), 660-671.

UNICEF. Direct and indirect effects of the COVID-19 pandemic and response in South Asia. 2021

United Nations (2016). Sustainable Development Goals.

Uta, M., Neamtu, R., Bernad, E., Mocanu, A. G., Gluhovschi, A., Popescu, A., ... & Craina, M. (2022). The Influence of Nutritional Supplementation for Iron Deficiency Anaemia on Pregnancies Associated with SARS-CoV-2 Infection. *Nutrients*, *14*(4), 836.

Wang, P. H., Lee, W. L., Yang, S. T., Tsui, K. H., Chang, C. C., & Lee, F. K. (2021). The impact of COVID-19 in pregnancy: Part I. Clinical presentations and untoward outcomes of pregnant women with COVID-19. *Journal of the Chinese Medical Association, 84*(9), 813-820.

Wemakor, A. (2019). Prevalence and determinants of anaemia in pregnant women receiving antenatal care at a tertiary referral hospital in Northern Ghana. *BMC pregnancy and childbirth*, *19*(1), 1-11. Wang, Peng-hui, Wen-ling Lee, Szu-ting Yang, Kuan-hao Tsui, Cheng-chang Chang, and Fa-kung Lee. 2021. "The Impact of COVID-19 in Pregnancy : Part I . Clinical Presentations and Untoward Outcomes of Pregnant Women with COVID-19." 813–20. doi: 10.1097/JCMA.0000000000000595>813.

Whitelaw, N., Bhattacharya, S., McLernon, D., & Black, M. (2014). Internet information on birth options after caesarean compared to the RCOG patient information leaflet; a web survey. *BMC pregnancy and childbirth*, *14*(1), 1-13.

WHO. (2011). *Intermittent iron and folic acid supplementation in menstruating women*. Geneva: World Health Organization.

Woldegebriel, Ataklti Gebretsadik, Gebremedhin Gebregziabiher Gebrehiwot, Abraham Aregay Desta, Kiros Fenta Ajemu, Asfawosen Aregay Berhe, Tewolde Wubayehu Woldearegay, and Nega Mamo Bezabih. 2020. "Determinants of Anaemia in Pregnancy : Findings from the Ethiopian Health and Demographic Survey." 2020.

World Health Organization (2015). *The Global Prevalence of Anaemia in 2011*. World Health Organization; Geneva, Switzerland.

World Health Organization (2018). *Recommendations on Antenatal Care for a Positive Pregnancy*

Experience : Summary Highlights and Key Messages from the World Health Organization's 2016 Global Recommendations for Routine Antenatal Care." 10(January):1–10. doi: 10.1186/1742-4755-10-19.5.

World Health Organization. Anaemia in Women and Children: WHO Global Anaemia Estimates, 2021 Edition; World Health Organization: Geneva, Switzerland, 2021; Available online: https://www.who.int/data/gho/data/themes/topics/anaemia_in_women_and_children.

Wouters, H. J., van der Klauw, M. M., de Witte, T., Stauder, R., Swinkels, D. W., Wolffenbuttel, B. H., & Huls, G. (2019). Association of anaemia with health-related quality of life and survival: a large population-based cohort study. *Haematologica*, *104*(3), 468.

Wu, P., Hao, X., Lau, E. H., Wong, J. Y., Leung, K. S., Wu, J. T., ... & Leung, G. M. (2020). Real-time tentative assessment of the epidemiological characteristics of novel coronavirus infections in Wuhan, China, as at 22 January 2020. *Eurosurveillance*, *25*(3), 2000044.

Zhang, Qi, Xiao Min Lu, Min Zhang, Chen Ying Yang, Si Yuan Lv, and Shi Fen Li. 2021. "Adverse Effects of Iron Deficiency Anemia on Pregnancy Outcome and Offspring Development and Intervention of Three Iron Supplements." *Scientific Reports* 1–11. doi: 10.1038/s41598-020-79971-y.

Zhao, S. Y., Jing, W. Z., Liu, J., & Liu, M. (2018). Prevalence of anaemia during pregnancy in China, 2012-2016: a Meta-analysis. *Zhonghua yu Fang yi xue za zhi [Chinese Journal of Preventive Medicine]*, *52*(9), 951-957.

Zuin, M., Rigatelli, G., Quadretti, L., Fogato, L., Zuliani, G., & Roncon, L. (2021). Prognostic Role of Anaemia in COVID-19 Patients: A Meta-Analysis. *Infectious disease reports*, *13*(4), 930-

937.