MEKELLE UNIVERSITY

COLLEGE OF HEALTH SCIENCE

SCHOOL OF PUBLIC HEALTH

DEPARTMENT OF BIOSTATISTICS

ASSESSMENT OF PRETERM BIRTH AND PREDICTIVE FACTORS AT AYDER COMPREHENSIVE SPECIALIZED HOSPITAL, NORTHERN ETHIOPIA: AN ORDINAL LOGISTIC REGRESSION ANALYSIS: 2025

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THESIS SUBMITTED TO MEKELLE UNIVERSITY COLLEGE OF HEALTH SCIENCE SCHOOL OF PUBLIC HEALTH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTER OF SCIENCE IN BIOSTATISTICS AND HEALTH INFORMATICS

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MEKELLE UNIVERSITY COLLEGE OF HEALTH SCIENCE SCHOOL OF PUBLIC HEALTH DEPARTMENT OF BIOSTATISTICS PROPOSAL SUBMISSION FORM.

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Advisor's Approval Sheet

This is to certify that the research thesis entitled "Assessment of Preterm Birth and Predictive Factors at Ayder Comprehensive Specialized Hospital, Northern Ethiopia: An Ordinal Logistic Regression Analysis" is submitted in partial fulfillment of the requirement for specialty in **BIOSTATISTICS AND HEALTH INFORMATICS** to the postgraduate program of the school of public health department of biostatistics and has been carried out by Daniel Abate under my supervision. Therefore, the student had fulfilled the requirement and hence, by can submit the thesis to the department.

_____	_____	_____
Name of major advisor	signature	date
_____	_____	_____
Name of co-advisor	signature	date

Declaration

I hereby declare this thesis is my original work and has been not presented for a master's specialization in biostatistics and health informatics in any other university and all sources of material used for this thesis have dully acknowledged.

Name _____ Signature _____ date _____

This thesis had been submitted for examination with my approval as thesis advisor

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Assurance of Principal Investigator

I, the undersigned, agree to accept all responsibilities for the scientific and ethical conduct of the research proposal and for the provision of required progress reports as per the terms and conditions of the requirements of the department. I provided timely progress report to my advisers and seek the necessary advice and approval from my main adviser in the course of the proposal.

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Approval of the Graduate Program Co-ordinator

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List of Abbreviations and Acronyms

ACSH	Ayder Comprehensive Specialized Hospital
ANC	Antinatal Care
HBV	Hepatitis B virus
MPTL	Moderate Preterm Labor
NICU	Neonatal Intensive Care Unit
POM	Proportional Odd Model
PPOM	Partial Proportional Odd Model
SPTL	Severe Preterm Labor
VON	Vermont Oxford Network

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ABSTRACT

Background: Preterm birth is a major public health concern due to its important impact on infant mortality and morbidity. Previous studies conducted in Ethiopia have examined the prevalence and risk factors of preterm birth, using a binary outcome of preterm birth, without considering the severity of preterm birth.

Objective: -To assess Predictive Factors of Preterm Birth severity at Ayder Comprehensive Specialised Hospital, North Ethiopiafrom 2018 to 2020 .

Methods: A facility-based retrospective cross-sectional study was conducted among 2082 preterm and term neonates from February 2018 to May 2020 at Ayder Comprehensive Specialized Hospital. The minimum sample size was 538. All preterm and term neonates were included in this study. Ordinal logistic regression with partial proportional odd model(PPOM) was used to determine predictors of preterm. Parallel line assumption was tested using Brant test. Odd Ratio with 95% confidence interval was used to assess the strength of association between independent and dependent variables.

Result- The overall prevalence of preterm was found to be 36.7% (95%C. I:34.67, 38.86). Being having congenital malformation the odd very preterm versus (moderate preterm, late preterm and term) increased by OR= 2.295(95% C.I :1.566,3.363) times. Being having multiple gestation the odd very preterm versus (moderate preterm, late preterm and term) increased by OR= 2.319(95% C.I:1.526,3.524) times, Being having history of preterm birth the odd very preterm versus (moderate preterm, late preterm and term) increased by OR= 10.03(95% C.I:6.803,14.788). Being having hypertension the odd having higher preterm level increased by OR= 3.835(95% C.I:2.036,7.226). Being having ANC visit the odd of having higher preterm level decreased by 91.8% OR= 0.182(95% C.I:0.039,0.841).

Conclusions and Recommendations- In the PPOM, the variables congenital malformation, multiple gestation, history of preterm birth, hypertension, and malaria infection, had a positive significant association with the odd of preterm birth, whereas ANC visit had a negative significant effect. In order to decrease the probability of preterm birth, every mother should prevent chronic disease by changing life style. Health professional should provide health education, early screening of chronic disease and aware mothers to have appropriate ANC follow up during prenatal period.

Key word: - preterm birth, severity, NICU, Tigray, Ethiopia, ordinal

1. INTRODUCTION

1.1 Background

Preterm birth is defined as the delivery of a fetus before 37 completed weeks of gestation. It is classified into three subcategories: extremely preterm (<28 weeks), very preterm (28 to <32 weeks), and moderate to late preterm (32 to <37 weeks)(1). Preterm birth can also be categorized as either spontaneous or provider-initiated (induced). Spontaneous preterm birth occurs when labor begins naturally with intact or pre-labor rupture of membranes, leading to birth before 37 weeks of gestation (4,5)

Preterm birth is among the leading causes of neonatal death (1). Preterm infants face numerous challenges, as they are more vulnerable to serious complications such as respiratory distress syndrome, infections, and developmental delays.(2) For many families, the birth of a preterm baby brings uncertainty, fear, and emotional distress as they face the possibility of losing their newborn or dealing with long-term health issues. Despite the efforts to improve neonatal care worldwide, preterm births remain a major problem, especially in resource-limited settings, where access to critical care may be limited (3).

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In sub-Saharan Africa, preterm birth accounts for a substantial proportion of neonatal deaths, exacerbated by limited access to advanced neonatal care. The high burden of preterm birth in this region is further compounded by socio-economic disparities, inadequate maternal healthcare services, and insufficient neonatal intensive care units (NICUs), which significantly hinder efforts to improve neonatal survival rates (5).

In Ethiopia, the issue of preterm birth touches the lives of many families. With a population of over 110 million, Ethiopia faces its own set of challenges in managing preterm births. In rural areas, where access to healthcare can be limited, the risk of preterm birth and its complications is even higher. Despite ongoing improvements in healthcare services, much work remains to ensure that every newborn, particularly those born prematurely, receives the care they need to survive and

thrive) (6,7). Although national policies and interventions have been implemented to reduce neonatal mortality, a substantial gap remains in addressing the burden of preterm birth effectively. Comprehensive strategies, including improved maternal health services, early detection and management of risk factors, and expanded neonatal care infrastructure, are essential to mitigate the impact of preterm birth and improve newborn survival in Ethiopia(2).

1.2 Statement of the Problem:

Preterm birth remains a global public health challenge. The global prevalence of preterm birth is 10%, accounting for 15 million births, globally and approximately 50% of all perinatal deaths every year. More than 60% of preterm births occurred in Sub-Saharan Africa and 9.1 million (12.8%) in south Asia(3,8). In South Africa, more than 8 out of 100 babies are preterm. National and international organizations, including the WHO, emphasize the need to reduce preterm birth rates and improve outcomes for preterm infants through targeted healthcare interventions (9).

In Ethiopia, preterm birth is a key area of focus for reducing neonatal mortality and improving maternal health. The prevalence vary from 4% to 18%, with a significant portion of these births occurring in the northern regions(6). In Gondar University hospital, Northwest Ethiopia about one in seven adverse birth outcomes (14.3%) was found to be preterm birth and in Mettu Karl hospital, was 31.4%. (3,10). In Northern Ethiopia, particularly the Tigray region, maternal health challenges contribute to a high incidence of preterm births. Factors such as infections, short birth intervals, and low antenatal care utilization are significant contributors. The lack of skilled healthcare providers and essential equipment in many healthcare facilities further exacerbates the impact of preterm births in the region (11).

Preterm birth leads to neonatal morbidity and mortality, with preterm infants at increased risk of respiratory distress syndrome, infections, and perinatal asphyxia. The long-term effects of preterm birth include developmental delays and cognitive impairments. The burden of preterm birth extends beyond healthcare systems, affecting families and communities, particularly in regions with limited access to specialized neonatal care.(12).Preterm births have different causes and risks of mortality, morbidity, impaired growth, and non-communicable diseases. Thus, being born

preterm predisposes infants to higher risks of chronic diseases and mortality later in life. Specially, infants born before 32 weeks of gestation are at high risk of adverse health outcomes (3)

preterm birth occurs has grown in both developed and developing countries, over the last decade. Increased maternal age during pregnancy, infertility treatment and maternal health conditions, changes in obstetric practice (evidenced by an increase in induced deliveries and cesarean section, maternal infections, hypertensive disorders, and poor antenatal care are major contributor's preterm birth. The highest increase in preterm birth incidence was observed to be in the moderate preterm category (32–33 weeks' gestation), as well as the late preterm category (34–36 weeks' gestation) (9,13,14).

Existing studies on preterm birth in Ethiopia often group all preterm births together, without distinguishing between different severities of preterm birth and do not apply advanced statistical methods like **ordinal logistic regression**, which could reveal more announced relationships between risk factors and outcomes. This study aims to address the gap in understanding the factors contributing to the severity of preterm birth by categorizing preterm births into extremely preterm, very preterm, and moderate to late preterm and applying **ordinal logistic regression** will allow for a more detailed analysis, uncovering relationships between risk factors and preterm birth outcomes that are masked when all preterm births are treated as a single group.

1.3 Significance of the Study:

By conducting a study at this facility, the research can generate valuable insights to inform the development of targeted interventions and policies. The study will provide essential information to policymakers and healthcare planners by identifying the specific factors contributing to preterm birth severity. This, in turn, will allow for more efficient allocation of resources, ensuring that neonatal care services are adequately equipped to address the needs of the most vulnerable infants in Northern Ethiopia.

Furthermore, by identifying the specific risk factors for each category of preterm birth, healthcare providers at ACSH and other regional hospitals can develop more targeted interventions. very preterm infants who face the highest risks of morbidity and mortality could benefit from specialized care tailored to their unique needs, such as advanced respiratory support and infection prevention

The results of this study will add to the amount of information already available on preterm birth and the circumstances surrounding it in Ethiopia. The study team can offer important insights to direct the creation of evidence-based strategies and policies to prevent preterm birth and enhance mother and child health outcomes in Northern Ethiopia by identifying the major predicting factors and analyzing the consequences of premature birth.

2. LITERATURE REVIEW:

2.1 Overview of Preterm Birth and Outcomes

A retrospective case-control study was conducted among a record of 100 women with live preterm birth as cases and 400 women with live term delivery as controls at Mukalla MCH Hospital Yemen in 2018. Logistic regression analysis used. Factors that statistically significant association with premature birth were a family history of preterm birth, pre-eclampsia, Parity, premature rupture of membranes and abnormal amniotic fluid volume(15).

A systematic review and metanalysis study were conducted among 172,774 reproductive-aged women from recent Demographic and Health Surveys (DHSs) data of 36 SSA countries during 2006 to 2018. They used a multilevel logistic regression model to identify the associated factors of preterm birth in SSA. They considered a statistical significance at a p-value less than 0.05. From the result, 5.33% of respondents in SSA had delivered preterm baby. Being from eastern Africa, southern Africa, rural area, being educated, substance use, having multiple pregnancy, currently working history, having history of terminated pregnancy, and previous cesarean section delivery, primiparity, and short birth interval were associated with higher odds of preterm birth among reproductive aged women. However, having better wealth index, being married, wanted pregnancy, and having four or more antenatal care visit were associated with lower odds for a preterm birth among reproductive aged women(8)

A case control study was conducted among117 women with case group 72 had PTL (<37 gestational weeks and control group 45 had term birth (≥37 gestational weeks) in Egypt during 2009 to 2010.Ordinal logistic regression analysis used. The final multivariable ordinal model identified age <20 years old, abortion history, vaginal pH, and heavy growth of vaginal organisms as the significant predictors of SPTL and MPTL.(16)

A cross-sectional study conducted among 3243 case records of women in Zambia between 1st January 2018 to 30th September 2019. From the analysis the median age was 26 years (IQR, 22-33), of whom 399 (12.3%) delivered very preterm infant, 914 (28.18%) delivered moderate-term infants, 957 (29.51%) delivered late-term infants and 973 (30%) delivered term infants. Factors

that were significantly associated with severity of preterm birth preeclampsia, HIV/AIDS, ANC visit, sex of infant and maternal age (17).

A cross-sectional study conducted among 590 comprehensive maternal medical records, of deliveries that occurred at the facility between April 2020 and July 2021 in Uganda. The prevalence of preterm delivery among mothers who gave birth was 35.8%. The outcomes of logistic regression analysis revealed that maternal employment status had a statistically significant association with preterm birth having a baby with low birth weight and experiencing preeclampsia were also identified as significant predictors of preterm birth in the study (18).

A prospective cohort study was conducted among 687 pregnant women of mother and child birth cohort in Bahri Dar, Ethiopia during 2013 to 2017.The partial proportional odds model was employed to model severity levels of preterm birth. Because it allows the effect of predictor variables to vary across categories of the ordinal response variable of interest. Women with increased consumption of vegetable-rich foods showed a reduced risk of very to moderately preterm birth incidence (AOR = 0.73, Lower odds of very/moderately preterm birth compared to late preterm or term birth were observed for women following “nuts and rice foods” dietary pattern AOR = 0.25, high dietary consumption of starch foods dietary pattern AOR = 2.09 was associated with the most severe level of preterm birth outcome of very/moderately preterm birth. The partial proportional odds modeling allowed the description of the effect of maternal dietary patterns across the different severity levels of preterm birth(9).

A systematic review and meta-analysis study were conducted among a total of 30 studies articles that published from 2009-2020 in Ethiopia. The overall pooled prevalence of preterm birth in Ethiopia was 11.4% On pooled analysis, preterm birth was associated with pregnancy-induced hypertension, being HIV-positive, premature rupture of membrane, rural residence, the mother having a history of abortion, multiple pregnancies, and anemia during pregnancy.(19)

A hospital-based cross-sectional study was undertaken among 482 mother-newborn pairs in North West Amhara from February to April 2020. From the result the prevalence of preterm birth was 11.41%. In multivariable logistic regression model, maternal age < 20 years AOR = 7.8,

preeclampsia AOR = 5, premature rupture of mem- brane AOR = 3.9, chronic medical illness AOR = 4.6, and history of stillbirth AOR = 2.7 were significantly associated with preterm birth(20).

A facility-based cross-sectional study was conducted among 1785 neonates admitted to the neonatal intensive care unit in Ayder Comprehensive Specialized Hospital from June 1, 2018 to May 30, 2019. Data was collected retrospectively and logistic regression analysis was used. Respiratory distress syndrome AOR=12.56, perinatal asphyxia AOR= 19.64, congenital anomaly AOR=2.42, early neonatal sepsis (AOR= 3.68), late onset sepsis AOR= 8.9, gestational age, 34–36+6 weeks AOR =0.09, 3741+6 weeks AOR= 0.025, >42 weeks AOR= 0.039, parity AOR=0.64 and hospital stay AOR= 0.09 were significantly associated with neonatal mortality(21)

Preterm birth remains a significant public health challenge in Ethiopia, with a high burden and a range of adverse neonatal outcomes. Understanding the predictive factors and severity of preterm birth outcomes is crucial for developing targeted interventions and improving maternal and child health outcomes in the region. The proposed study at the Ayder Comprehensive Specialized Hospital in Northern Ethiopia, using ordinal logistic regression analysis, will contribute to the existing knowledge base and inform the development of evidence-based policies and programs to address this important public health issue.

2.3 Conceptual Framework:

The conceptual framework consists of three main components: 1) Maternal Factors, 2) Fetal Factors, and 3) Environmental and Social Determinants. These factors are hypothesized to influence the severity of preterm birth outcomes, which can be categorized into an ordinal scale (late, moderate, and very preterm birth).

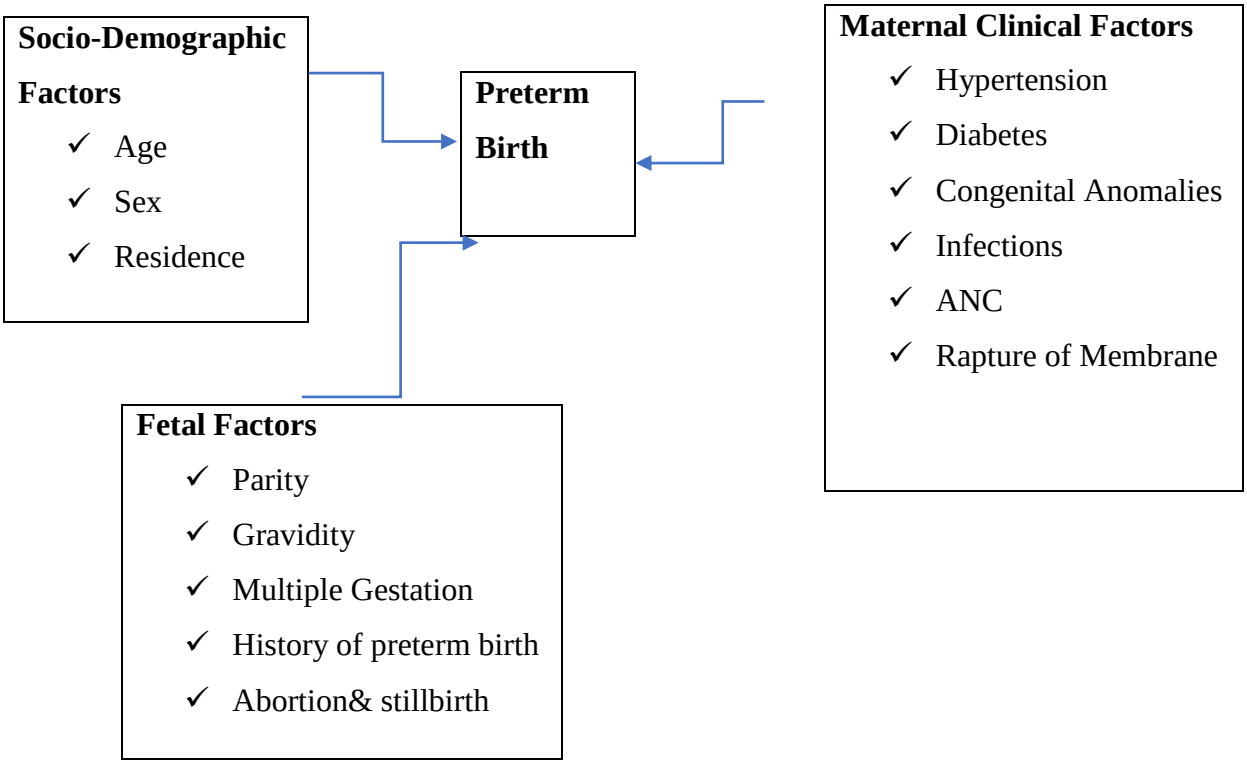

Figure 1: conceptual frame work of predictors of preterm birth Developed after reviewing different related literatures (8,15–19,21)

3. OBJECTIVES

3.1 General Objective:

- ✓ The overall objective of this study was to asses preterm birth severity and its predictors at Ayder Comprehensive Specialized Hospital, Northern Ethiopia from 2018 to 2020.

3.2 Specific Objectives:

1. To determine the magnitude of preterm birth (late, moderate, very preterm) among delivered neonates.
2. To determine factors associated with the severity of preterm birth

4.METHODS and MATERIALS

4.1 Study Area

The study was conducted at the Ayder Comprehensive Specialized Hospital, a tertiary-level referral hospital located in Mekelle, the capital city of the Tigray region in Northern Ethiopia Ayder Comprehensive Specialized Hospital had been rendering its referral and non-referral services since 2008 to population of 8 million in its catchment areas of the Tigray, Afar, and South-eastern parts of the Amhara region. The hospital has around 500 inpatient beds in four major departments and other specialty units. Currently, Ayder Comprehensive Specialized Hospital is also used as a teaching hospital for the College of Health Sciences, Mekelle University**.** Given the hospital's role in managing high-risk pregnancies and preterm birth s, it presents an opportune setting to investigate the predictive factors of preterm birth.

4.2 Study design and Period

A facility based retrospective cross-sectional study design was employed from February 2018 to May 2020.

4.3 Population

4.3.1 Target Population

All preterm births admitted to Neonatal Intensive Care Units (NICU) at ACSH.

4.3.2 Study population

Preterm births admitted to NICU of ACSH during study period.

4.4 Eligibility criteria

4.4.1 Inclusion Criteria:

All preterm birth delivered and registered in the Vermont Oxford University Global Neonatal Network (VON) Database Registry at the ACSH during the study period were included in the study.

Term birth neonates for reference purpose were included. In order to compare the odd of pre-term birth among different independent variable as compared to term birth.

4.4.2 Exclusion Criteria:

All preterm neonates born from mothers with incomplete medical records(when the data had <5% incompleteness the medical card were excluded).
All preterm neonates born from mothers who delivered at other healthcare facilities and were referred to the ACSH.

4.5 Study Variables

4.5.2 Dependent Variable:

Severity of preterm birth (ordinal variable): categorized based on gestational age at birth (term birth (37-41 weeks), late preterm: 34-36 weeks, moderate:32-33 weeks, very preterm: up to 32 weeks)

4.5.1 Independent Variables:

- **Sociodemographic and economic factors** (residence, educational status, sex of the newborn, marital status)
- **maternal medical conditions** (hypertension, infections, parity, gravidity)
- **Fetal factors**: multiple gestations, fetal congenital anomalies, RH Status, Previous Still birth.

4.6 Sample Size Determination and Data Sources

The study utilized data from the Vermont Oxford Network (VON) Global Neonatal Database Registry, a comprehensive international database that collects standardized information on high-risk neonates, including preterm and low birth weight infants. This database includes 2082 participating neonatal intensive care units (NICUs), providing a robust and representative sample for analysis.

Sample size was calculated using single population proportion formula by using Epi Info 7.2 software. Input values like prevalence and proportions were taken from a systematic review and

meta-analysis conducted in Ethiopia taking, 13.2%) (22),assuming a 95% confidence level with 3% desired precision. The minimum sample size with 10% contingency for none response rate was 538. The calculation procedure and the sample size were as follows:

$$n = \frac{\left(Z_{1-\alpha/2}\right)^2 * P(1-P)}{d^2}$$

Where n = the required sample size, Z = is the standard normal deviate, usually set at 1.96 which corresponds to the 95% confidence level , P = 13.2%. d^2 = margin of error which is taken as 3% (0.03)

$$\boldsymbol{n = \frac{\left(Z_{1-\alpha/2}\right)^2 * P(1-P)}{d^2}}$$

$$\boldsymbol{n = \frac{(1.96)^2 * 0.126(1-0.126)}{0.03^2}}$$

$$\boldsymbol{n = \frac{(3.8416) * 0.132 * 0.868}{0.0009}}$$

n =489

The minimum sample size required for this study after adding Considering 10% contingency non-response rate of 49was:

n = 49 + 489=538

4.7 Sampling technique/procedure

The minimum sample size for this study was 538. All preterm and term births that were 2082 with complete data were included to this study. The records with full information of the variables entirely counted from Ayder Comprehensive Specialized Hospital during the selected follow-up period. It is planned to include all the study population from 2018-2020.

4.8 Data collection procedure

Secondary Data extracted from the VON database which were already collected. The data extraction sheet was used to asses collected data included expected variables that involve in this study variables unless excluded from the study.

4.9 Operational Definition and Measurement

Preterm is defined as babies born alive before 37 weeks of pregnancy are completed. There are sub-categories of preterm birth, based on gestational age are(23):

Very preterm – Any alive neonate birth up to 32 weeks)

Moderate preterm - Alive neonate birth from 32 to 33 weeks.

late preterm (34 to 36 weeks).

Term neonates -newly born neonates after 37 weeks of gestation up to 42 weeks and considered as normal for reference (23)**.**

4.10 Data Processing management and Analysis

The extracted data imported to STATA 17 for further data management and analysis. Both descriptive and inferential statistics was employed after the data cleaned and coded Categorical variables described using frequency and percentage. Continuous variables described using an appropriate combination of measure of central tendency and measure of dispersion.

Model Building Strategies

Variable selection Methods

Factors that affect the severity or level of preterm birth identified using an ordinal logistic regression analysis. Candidate variables for multivariable analysis selected using bivariate analysis and Wald test with $p < 0.25$ used as selection criterion to get many variables to the multivariable analysis. In the multivariable ordinal logistic regression, the default enter method of variable selection was used. It had an advantage of many variables included to the model and also prevented over fitness of model that happened in stepwise variable selection

Assumptions of Ordinal Logistic Regression

The following are the main assumptions of ordinal logistic

- ✓ The dependent variable is ordinal.
- ✓ The odds are proportional (proportional odd, or parallel lines assumption): This means that each independent variable has an identical effect at each cumulative split of the ordinal dependent variable.
- ✓ The parallel line assumption implies that, there is one regression equation for each category except the last category.
- ✓ One or more of the explanatory variables are either continuous, categorical or ordinal.
- ✓ No multi-collinearity

Additionally, the variance inflation factor (VIF) used to assess multicollinearity among the predictor variables and VIF > 10 was removed from the model, combine variables or create interaction. So, this Provides a clear statistical test for the proportional odds assumption and Helps to ensure the validity of ordinal logistic regression results.

Test of Interaction

From the bivariate analysis that candidate from multivariable ordinal logistic regression analysis tested for interaction effect by conducting correlation and variable with Pearson correlation value > 0.75 were tested for interaction effect. But in this analysis, there was no interaction effect**.**

Ordinal Logistic Regression Model

In the context of ordinal logistic regression, ordinal means order of the categories. The ordinal logistic regression is, therefore, a regression technique used when the dependent variable is measured at the ordinal level, given one or more explanatory variables, which could be ordinal, continuous or categorical. Therefore, when the outcome variable is polychotomous and ordinal in nature, the best choice model often used to preserve information about the ordering of the categories of the dependent variable is the ordinal logistic regression model(24). It is mostly considered as a generalization of the binomial logistic regression model. In ordinal logistic

regression, instead of modelling the probability of an individual event, as we do in logistic regression, we are considering the probability of that event and all others above it in the ordinal ranking(25). We are concerned with cumulative probabilities rather than probabilities for discrete categories.

Hence the model;

$$logit\big(P(Y_i \leq j)\big) = \beta_j = 0 + \beta_{j=1}x_1 = 1 + \cdots + \beta_p x_p \; for \; j = 1,..j-1 \; (24)$$

With p predictors and P cumulative probability is called the ordinal logistic regression model. This model uses cumulative probabilities up to a threshold, thereby making the whole range of ordinal categories binary at that threshold. For instance, considering the level of the dependent variable used in the ordinal regression analysis let the response *be* Y = 1, … , j with a natural ordering. Also, let P0, P1 …, Pj−1 be the associated probabilities. The cumulative probability of a response less than and equal to *j* is given as: + $\beta_{2j}x_{j+} \ldots \beta_{pj}x_{pj}$

$$P(Y \leq j) = \frac{exp^{\alpha_j + \beta_j x_{j+}} \beta_j x_j + \beta_{2j} x_{j+} \ldots \beta_{pj} x_{pj}}{1 + exp^{\alpha_j + \beta_j x_j + \beta_{2j} x_{j+} \cdots \beta_{pj} x_{pj}}} \quad (24)$$

Final Ordinal Logistic Sub-models

Data analysis was done in two stages to identify the potential determinates for levels of preterm birth. Firstly, the proportional odds model (POM) was fitted, considering preterm's ordinal nature. parallel line assumption which states that the lines of the independent variables across the category of the outcome variable was parallel or the odd ratios was the same except for sampling variability. It assessed using. Appropriateness of ordinal logistic regression evaluated using Brant Test of Parallel line assumption and the model was assumed appropriate if the p-value for the test > 0.05 indicating that the proportional odds assumption holds. After analysis, we observed that the test for POM assumption, done using a user-written command "brant" test, showed that the overall model assumption and failed the model assumption as its p-value was significant (P-value<0.05.

Partial Proportional Odd Model

In the second analysis, before making a final decision, we used a suitable alternative model, the partial proportional ordinal model (PPOM). The main advantage of PPOM is that it relaxes the parallel lines assumption for explanatory variables across the outcome variable levels. In that regard, it is more accurate than the proportional ordinal regression model, and it has better parsimonious than the multinomial regression model. To fit the PPOM to the data, use a user-written command "*gologit2"* with a relaxed parallel regression assumption(17). According to R Williams, the general model of PPOM is written as equation one below:

$$P(Y \leq j) = \frac{exp^{\alpha_j + \beta_j x_j + \beta_j x_j + \beta_{2j} x_{j+} \ldots \beta_{pj} x_{pj}}}{1 + exp^{\alpha_j + \beta_j x_j + \beta_{2j} x_{j+} \ldots \beta_{pj} x_{pj}}}$$

The response variable, severity of preterm birth, is going to be treated as ordinal under the assumption that the levels of preterm birth have a natural ordering (Very, Moderate and late preterm). Results of ordinal logistic regression reported in terms of odds ratio with its 95% confidence interval and p-value.

The results of the study presented and disseminated for all responsible individuals and institutions to ensure that the study is conducted formally and to be used by health planners as an input for intervention and further study. Eventually, the thesis final work will be published in journal article that will be accessed by others.

Model fitness and Diagnosis

Model fitness was assessed using LR test of chi-square of the null model with the full model. A significant LR test or P- value < 0.05 indicated the full model was best fitted than the null model. AIC and BIC also used to assess model fitness with small AIC and BIC was the best fitted.

4.11 Data quality control

To assure the quality of data, the following measures are undertaken. Standard data collection instrument by VON database registry was used. Data were checked by neonatologist and VON statistician expert every time during data sending to the center for the completeness of filled checklist and whether recorded information makes sense to ensure the quality of the data collected. Any missing or inconsistent data was identified and for continuous variable use mean imputation and for categorical variable use mode imputation to replace the missing data .

4.12 Ethical Considerations

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of the Ayder Comprehensive Specialized Hospital and the College of Health Sciences at Mekelle University. Informed consent was waived due to the retrospective nature of the study, and patient confidentiality was strictly maintained throughout the research process. MU-IRB2479/2025

4.13 Dissemination of Study Findings

The findings of this thesis will be disseminated to Department of biostatistics, School of public health, college of health science, Mekelle University. Finally, it will be sent for publication to journals.

5.RESULT

Descriptive Statistics

Based on the result data out of 2082 newly delivered neonates, 765 (36.7%) were preterm birth with 187(8.98%) very preterm, 207(9.94%) moderate preterm, 371(17.82%) late preterm and the rest 1317 were term neonates. The overall prevalence of preterm birth was 36.7 with (95% C.I: 34.67, 38.86). The sex of the neonate was 60.4% were male and the rest 39.6 % were female. Out of the total neonates 14.8% had congenital anomalies,61.7% of women had more than 4 ANC visit and 9.9% women had multiple gestation. Regarding history of previous preterm 17% of women had history of preterm and 1.8% of women had hypertension. In terms of gravidity 37.5% were primigravida and the rest 62.5 were multigravida. Regarding the parity 36.2% were primipara and 57.8% were multipara and 6% were grand multipara.

Table 1 Socio-demographic factors among delivered neonates in ACSH 2018-2020.

Variables	**Categories**	**Frequency**	**Percent (%)**
Sex			
	Female	824	39.6
	Male	1258	60.4

Table 2:This table indicated Fatal factors related to severity of preterm birth among delivered neonates in ACSH 2018-2020

Variables	**Categories**	**Frequency**	**Percent (%)**
Multiple Gestation			
	No	1876	90.1
	Yes	206	9.9
		2082	100
Stillbirth &Abortion			
	No	1850	88.7
	Yes	232	11.3
Parity		2082	100
	Primipara	753	36.2
	Multipara	1204	57.8
	Grand Multipara	125	6
		2082	100
Gravidity		2082	100
	Primigravida	781	37.5
	Multigravida	1301	62.5
		2082	100
History of Preterm Labor			
	No	1727	83
	Yes	355	17
		2082	100

Table 3: This table represented Maternal Clinical Factors related to severity of preterm birth among delivered neonates in ACSH 2018-2020

Variables	**Categories**	**Frequency**	**Percent (%)**
Congenital Malformation			
	No	1774	85.2
	Yes	308	14.8
Syphilis		2082	100
	No	1929	92.7
	Unknown	144	6.9
	Yes	9	1.4
ANC		2082	100
	1 To 3	751	36.1
	Visits		
	None	24	1.2
	Unknown	20	1
	>= 4 Visits	1287	61.7
HIV/AIDS		2082	100
	No	2002	96.2
	Unknown	43	2.1
	Yes	37	1.7
HBV		2082	100
	No	1904	91.5
	Unknown	152	7.3
	Yes	26	1.2
Malaria		2082	100
	No	1959	94.1

	Unknown	117	5.6
	Yes	6	0.2
Hypertension		2082	100
	No	2045	98.2
	Yes	37	1.8
		2082	100
Chorioamnionitis			
	No	2072	99.5
	Yes	10	0.5
		2082	100
Rh-Negatives			
	No	1830	87.9
	Unknown	172	8.3
	Yes	80	3.8
		2082	100
Antibiotic Labor			
	No	2016	96.8
	Yes	66	3.2
		2082	100
Antenatal Corticosteroids			
	No	1971	94.7
	Yes	111	5.3
		2082	

The pie chart below indicated the severity of preterm birth among the newly delivered neonates. Among those the largest percent was term neonates with 63.26% next late preterm with 17.82%, moderate preterm with 9.942% and very preterm with 8.982%.

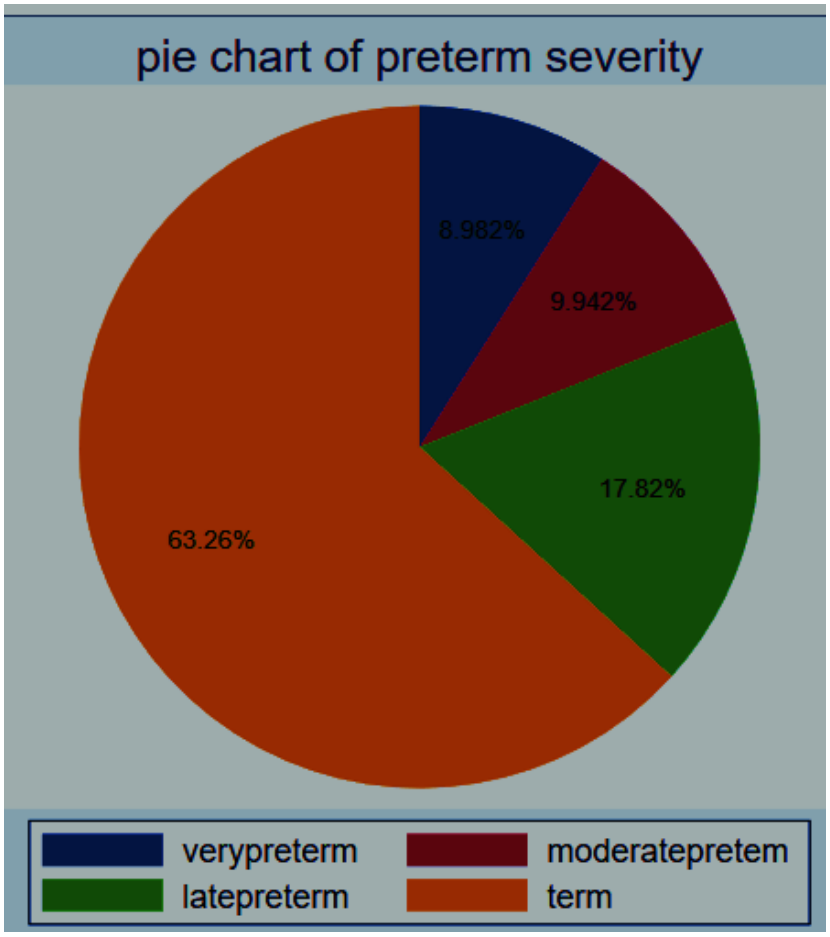

Figure 2:This pie chart indicated severity of preterm birth among newly delivered neonates in ACSH from 2018-2020.

The bar graph below indicates the largest 85.207% of those neonates had no congenital malformation and the rest 14.793% had congenital malformation.

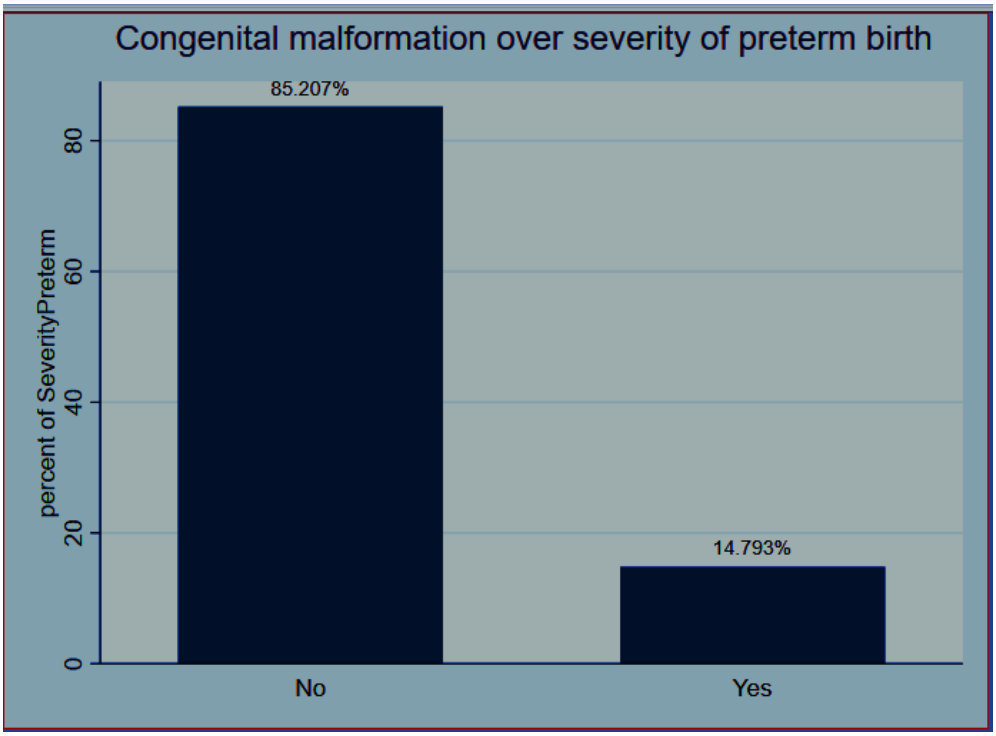

Figure 3:This bar graph indicates the percentage of congenital anomality among preterm birth in ACSH Tigray, Ethiopia from 2018-2020

As the bar graph below indicated the largest percent of mothers or 82.945% who give birth had no history of previous preterm birth and the remained 17.051% had history of preterm birth.

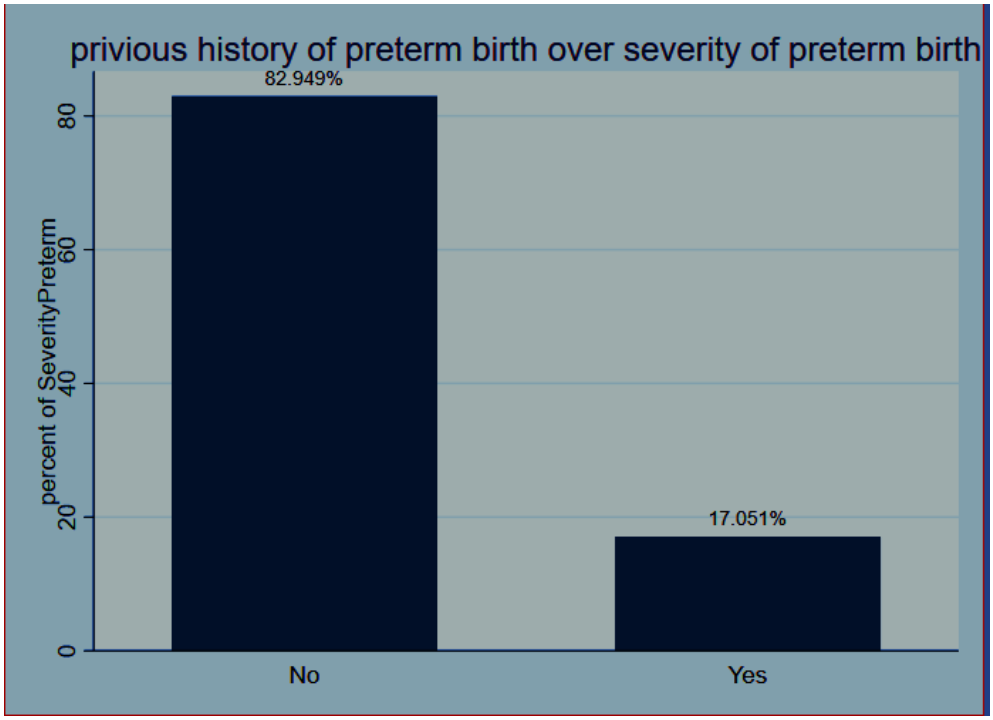

Figure 4:This bar graph indicated the percentage of history of preterm birth among mothers give preterm birth in ACSH, Tigray, Ethiopia from 2018-2020

Univariable Ordinal Logistic Model

In the univariable analysis congenital malformation, multiple gestation, sex, antenatal corticosteroid, antibiotic during labor, Rh- negative, history of preterm birth, hypertension, malaria, HBV and ANC visit were candidate for multivariable analysis with P-value <0.25.

Multivariable Ordinal Logistic Model

In the multivariable analyses of ordinal logistic model congenital malformation, multiple gestation, previous history of preterm birth, hypertension, malaria and ANC visit were statistically significant associated with severity of preterm birth for newly delivered neonates at the 5% level of significance.

Model Comparison in Ordinal Logistic Regression

The first model was POM fitted to asses parallel line assumption of ordinal logistic regression and the assumption violated as we had seen from the result below from the overall P-value of

chi-square was <0.001 as we seen from the result below. So if the P-value was less than 0.05 the parallel line assumption was violated.

Table 4: indicates parallel line assumption test of ordinal logistic regression on severity of preterm birth among delivered neonates in ACSH 2018-2020

Brant test of parallel regression Assumption			
	chi2	**p>chi2**	**df**
All	146.42	<0.001	32
2.Malformation	1.18	0.554	2
2.Multiple_Gestation	31.43	<0.001	2
2.Sex	3.76	0.153	2
Antenatal Corticosteroids	0.01	0.996	2
3.Antibiotic_Labor	0.49	0.783	2
2.RH_Negative	9.72	0.008	2
3.RH_Negative	2.12	0.346	2
3.Preterm_Labor	35.86	<0.001	2
3.Hypertension	3.91	0.142	2
2.Malaria	2.7	0.259	2
3.Malaria	2.47	0.292	2
2.HBV	7.37	0.025	2
3.HBV	6.29	0.043	2
1.ANC	4.79	0.091	2
3.ANC	11.6	0.003	2
4.ANC	5.05	0.08	2

The second model was PPOM and fitted to analysis for variables violated parallel line assumption. So that the best model was PPOM because of flexibility of parallel line assumption.

Interpretation of Multivariable Partial Proportional Odd Model

In the final regression model, we conducted a PPOM comprising of three equations. In the first equation, very preterm, moderate and late preterm were compared to term. In the second equation, a combination of the very preterm and moderate preterm were compared to a combined late preterm and term group. In the third equation, very preterm were compared to a combined group of moderate preterm, late preterm and term as we seen from the table below.

The LR test of chi-square was significant with P-value <0.001 indicated the full model was the best fitted as compared to null model.

In the analysis, significant variables interpreted using OR and 95% C.I including P- value. Congenital malformation was statistically significant with OR = 2.295(1.566, 3.363), P-value <0.001, meaning that being having congenital malformation, the odd of very preterm versus(moderate preterm , late preterm and term) increased by 2.295 times , very preterm and moderate preterm versus(late preterm and term) increased by 3.934 times and very preterm ,moderate preterm and late preterm versus(term) increased by 2.535 times as compared to no having congenital malformation keeping others constant.

Multiple gestation had a statistically significant association with odd of severity preterm birth with an OR =2.319(1.526, 3.524), P-value <0.001. This indicates being having multiple gestation the odd of very preterm versus (moderate preterm, late preterm and term) increased by 2.319, very preterm and moderate preterm versus(late preterm and term) increased by 2.899 times and very preterm ,moderate preterm and late preterm versus(term) increased by 7.265 times as compared to no having multiple gestation keeping others constant.

Previous history of preterm birth had a statistically significant association with odd of severity preterm birth with an OR =10.03(6.803, 14.788), P-value<0.001. This means that having Previous history of preterm birth, the odd of very preterm versus(moderate preterm, late preterm and term) increased by 10.03 times, very preterm and moderate preterm versus(late preterm and term) increased by 12.863 times and very preterm, moderate preterm and late preterm versus(term) increased by 121.284 times as compared to no having Previous history of preterm birth keeping others constant.

Table 5:Multivariable PPOM analysis of factors associated with severity of preterm birth among delivered neonates in ACSH from 2018-2020.

	Comparison								
	Very preterm vs. (moderate preterm, late preterm & term			Very preterm & moderate preterm vs. (late preterm & term)			Very preterm, moderate & late preterm vs. (term)		
Variables	**OR1**	**CI**	**P-value**	**OR2**	**CI**	**P-value**	**OR3**	**CI**	**P-value**
Malformation									
Yes	2.295	1.566,3.363	<0.001	3.934	2.882,5.368	<0.001	2.535	1.899,3.384	<0.001
Ref=No									
Multiple gestation									
Yes	2.319	1.526,3.524	<0.001	2.899	2.01,4.182	<0.001	7.265	4.8,10.997	<0.001
Ref=No									
Preterm labor									
Yes	10.03	6.803,14.788	<0.001	12.863	9.33,17.733	<0.001	121.284	58.637,250.864	<0.001
Ref=No									
Malaria									
Yes	0.868	0.156,4. 819	0.871	0.868	0.156,4.819	0.871	0.868	0.156,4.819	0.871
Unknown	4.28	2.067,8. 862	<0.001	4.28	2.067,8.862	<0.001	4.28	2.067,8.862	<0.001
Ref=No	862				2			2	
Hypertension									
Yes	3.835	2.036,7. 226	<0.001	3.835	2.036,7.226	<0.001	3.835	2.036,7.226	<0.001
Ref=No									
ANC									
1-3 visits	0.827	0.353,1. 935	0.661	0.827	0.353,1.935	0.661	0.827	0.353,1.935	0.661
>=4 visits	0.59	0.253,1. 376	0.222	0.59	0.253,1.376	0.222	0.59	0.253,1.376	0.222
Unknown	0.182	0.039,0. 841	0.029	0.182	0.039,0.841	0.029	0.182	0.039,0.841	0.029
Ref=No									
Constant	0.036	0.015,0. 088	<0.001	0.091	0.038,0.216	<0.001	0.306	0.130,0.720	<0.001

Hypertension had statistically significant association with odd of severity of preterm birth with OR=3.835(2.036, 7.226), P-value <0.001. Being Hypertension women the odd of having higher

preterm level increased by 3.835 times as compared to no hypertension women keeping others constant.

Malaria infection had statistically significant association with odd of severity of preterm birth OR =4.28(2.067, 8.862), P-value <0.001. This means that being unknown malaria infection status, the odd of having higher preterm level increased by 4.28 times as compared to no having malaria infection women keeping others constant. ANC visit had a significant association with odd of severity of preterm birth with OR= 0.182(0.039, 0.841), P-value =0.029. This indicated the odd of having higher preterm level decreased by 91.8% as compared to no having ANC visit keeping others constant.

Multicollinearity assessment

```
. vif, uncentered

    Variable |      VIF      1/VIF
-------------+----------------------
2.malforma~n |     1.22    0.817708
2.multiple~n |     1.18    0.848614
       2.sex |     2.52    0.396849
3.antenata~s |     1.48    0.674294
3.antibiot~r |     1.08    0.929245
 RH_negative |
           2 |     2.35    0.425119
           3 |     1.06    0.947247
3.preterm_~r |     1.82    0.549493
3.hyperten~n |     1.04    0.957913
     malaria |
           2 |     3.58    0.279154
           3 |     1.03    0.968781
         hbv |
           2 |     3.32    0.301556
           3 |     1.03    0.974984
         ANC |
           1 |     1.96    0.508986
           3 |     1.05    0.949485
           4 |     2.46    0.407020
-------------+----------------------
    Mean VIF |     1.76
```

Model Fit Assessment

```
Generalized Ordered Logit Estimates                   Number of obs =    2,082
                                                      LR chi2(24)   = 1097.50
                                                      Prob > chi2   =  0.0000
```

Model	N	ll(null)	ll(model)	df	AIC	BIC
.	2,082	-2171.578	-1622.828	27	3299.656	3451.966

6.DISCUSSION

The main objective of the study was to assess severity of preterm birth and associated factors among newly delivered neonates in Ayde Comprehensive Specialized Hospital during 2018 to 2020.

The prevalence of preterm birth was 36.7%. When compared to a study conducted in Zambia the prevalence in this study were smaller than Zambia. This could be due to difference in sample size as the sample size in Zambia were large and could be due to difference in providing service for mothers in that area (17). The significant factors associated with the odd of severity preterm birth were congenital malformation, multiple gestation, history of previous preterm, hypertension, malaria infection and ANC visit. This study agreed with a study conducted in Zambia(17).

Congenital malformation was statistically significant with OR = 2.295 meaning that being having congenital malformation, the odd of very preterm versus(moderate preterm , late preterm and term) increased by 2.295 times , very preterm and moderate preterm versus(late preterm and term) increased by 3.934 times and very preterm ,moderate preterm and late preterm versus(term) increased by 2.535 times as compared to no having congenital malformation keeping others constant. This study was in line with a study conducted in Tigray, Ayder referral hospital (21). This might be due to congenital malformation like short cervix increased the odd of preterm birth.

Multiple gestation had a statistically significant association with odd of severity preterm birth with an OR =2.319. This indicates being having multiple gestation the odd of very preterm versus (moderate preterm, late preterm and term) increased by 2.319, very preterm and moderate preterm versus(late preterm and term) increased by 2.899 times and very preterm ,moderate preterm and late preterm versus(term) increased by 7.265 times as compared to no having multiple gestation keeping others constant. This study was agreed with a study conducted in SSA and Ethiopia(8,19).This could be multiple gestation leads to excessive uterine expansion

Previous history of preterm birth had a statistically significant association with odd of severity preterm birth with an OR =10.03. This means that having Previous history of preterm birth, the odd of very preterm versus(moderate preterm, late preterm and term) increased by 10.03 times, very preterm and moderate preterm versus(late preterm and term) increased by 12.863 times and

very preterm ,moderate preterm and late preterm versus(term) increased by 121.284 times as compared to no having Previous history of preterm birth keeping others constant. This study agreed upon a study conducted in Yemen(15). This could be due to genetic susceptibility that this was not limited to that mother but also her sisters daughter and siblings.

Hypertension had statistically significant association with odd of severity of preterm birth with OR=3.835. Being Hypertension women the odd of having higher preterm level increased by 3.835 times as compared to no hypertension women keeping others constant. This study was in line with a study conducted in North West Amhara, Ethiopia, Zambia, yemen, Uganda(15,17–20). This might be hypertension leads to vascular damage to the placenta and then inducing the oxytocin receptors which results in preterm birth.

Malaria infection had statistically significant association with odd of severity of preterm birth OR =4.28. This means that being unknown malaria infection status, the odd of having higher preterm level increased by 4.28 times as compared to no having malaria infection women keeping others constant. This study agreed with a study conducted in Ethiopia (19). This could be due to placental malarial from the mother red blood cells with malaria parasite leads to anemia.

ANC visit had a significant association with odd of severity of preterm birth with OR= 0.182. This indicated the odd of having higher preterm level decreased by 91.8% as compared to no having ANC visit keeping others constant. This study was in line with a study conducted in SSA and Zambia(8,17).This might be due to mothers who had ANC visit the factors that leads to preterm birth could controlled early than mothers who did not had ANC visit.

7. STRENGTH AND LIMITATION OF THE STUDY

Strength

The main strength of the study was applying like advanced statistical analysis like Partial Proportional Odd model. The other strength was collecting of complete information for all related variables in categorical form and continuous form in order to appropriately explain the outcome variables.

Limitations

The main challenge of the study was limited literatures on the model that leads to difficult to discuss and compared the finding of this study especially in the study area and in Ethiopia.

8.CONCLUSION

The overall prevalence of preterm birth was 36.7%. The study assessed the severity of preterm birth and associated factors among newly delivered neonates in Ayder Comprehensive Specialized Hospital from 2018 to 2020 G.C. The POM and PPOM compared and the PPOM was best fitted because of flexible parallel line assumption.

In the PPOM, the variables congenital malformation, multiple gestation, history of preterm birth, hypertension and malaria infection, had a positive significant association with odd of preterm birth. The variables ANC visit had significant protective effect on the odd of preterm birth at the 5% level of significance. The variables had strong significant effect on the level of preterm birth compared to term birth.

9. RECOMMENDATIONS

Factors like hypertension and malaria infection increase the odd of preterm birth. In order to decrease the probability of preterm birth, every mother should prevent chronic disease by changing life style and malaria infection by using bed nets. Health professional should provide health education, early screening of chronic disease and initiation of early management and aware mothers to have appropriate ANC follow up during prenatal period. Health institutions should provide bed nets and ANC center early as possible. Health bureau should allocate resources to health institution to provide necessary maternal service to decrease preterm birth.

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12. ANNEXES

Annex 1: Data extraction format

#	Question	Response	Remark
1	Age of the neonate during admission	_____ days	
2	Age of the mother	_____Years	
3	Delivery place	1 Institution 2 Home	
4	Mode of delivery	1 Assisted Vaginal 2 Cesarean Section 3 Spontaneous Vaginal	
5	Gravidity		
6	Number of live births		
7	Number of still births		
8	HIV	1 No 2 Unknown 3 Yes	
9	HBV	1 No 2 Unknown 3 Yes	
10	Syphilis	1 No 2 Unknown 3 Yes	
11	Malaria	1 No 2 Unknown 3 Yes	
12	Hypertension	1 No 2 Unknown 3 Yes	
13	Chorioamnionitis	1 No 2 Unknown 3 Yes	
14	RH negative	1 No 2 Unknown 3 Yes	
15	Gestational age	_____ weeks	
16	Birth weight	_____ grams	
17	Head circumference	_____ cm	
18	Sex	1 Female 2 Male	
19	Antibiotic in birth	1 No 2 Unknown 3 Yes	
20	Antenatal corticosteroids	1 No 2 Unknown	

		3 Yes	
21	Multiple gestation	1 No 2 Yes	
22	Bag-mask ventilation during birth	1 No 2 Unknown 3 Yes	
23	Dried immediately after birth	1 No 2 Unknown 3 Yes	
24	Placed skin-to-skin at birth	1 No 2 Unknown 3 Yes	
25	Received delayed cord clamping	1 No 2 Unknown 3 Yes	
26	Breastfeeding initiated within one hour of delivery	1 No 2 Unknown 3 Yes	
27	Temperature measure within one hour of ICU admission	1 No 2 Unknown 3 Yes	If 1 or 2, Jump to Q.29
28	Temperature value during admission	____ ^{0}C	
29	Respiratory distress	1 No 2 Yes	
30	Meconium aspiration	1 No 2 Yes	
31	Birth trauma	1 No 2 Yes	
32	Perinatal asphyxia	1 No 2 Yes	
33	Neonatal seizure	1 No 2 Yes	
34	Intraventricular hemorrhage	1 No 2 Yes	
35	Suspected sepsis	1 No 2 Yes	
36	Proven sepsis	1 No 2 Yes	
37	Hyperbilirubinemia	1 No 2 Yes	
38	Congenital malformation	1 No 2 Yes	
39	Vitamin K	1 No 2 Unknown 3 Yes	
40	Kangaroo mother care	1 No 2 Yes	

41	Blood transfusion	1 No 2 Yes	
42	Exchange transfusion	1 No 2 Yes	
43	Phototherapy	1 No 2 Yes	
44	IV/IM antibiotics	1 No 2 Yes	
45	Oxygen	1 No 2 Yes	
46	Nasal CPAP	1 No 2 Yes	
47	Mechanical ventilation	1 No 2 Yes	
48	Surgery	1 No 2 Yes	
49	Anticonvulsants	1 No 2 Yes	
50	Outcome	1 Died 2 Discharged alive	
51	Cause of death	_____	If Q50 is answered "Died"
52	Duration of hospital stay	_____ days	

Annex 2; Assurance of Principal Investigator

The undersigned agrees to accept responsibility for the scientific ethical and technical Conduct of the research project and for provision of required progress reports as Per terms and conditions of the Research Publications Office in effect at the time of Grant is forwarded as the result of this application.

Name of the student _____

Date _____ Signature _____

Approval of the primary Advisor

Name of the primary advisor _____

Signature _____ Date_____

Approval of Graduate Program Coordinator

Name of coordinator _____

Signature _____ Date _____