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Jamie Simoben Date

Approval Sheet

Association between Antenatal Care (ANC), Breastfeeding, and Neonatal Mortality in Cameroon

By

Jamie Simoben

Master of Public Health

Applied Epidemiology

Amy Webb Girard, PhD

Committee Chair

Soh Florence Fru, MD

Committee Member

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By

Jamie Simoben

B.S., Rensselaer Polytechnic Institute, 2012

Thesis Committee Chair: Amy Webb Girard, PhD

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Abstract

Association between Antenatal Care (ANC), Breastfeeding, and Neonatal Mortality in Cameroon

By Jamie Simoben

Background: As of 2020, Cameroon has a neonatal mortality rate (NMR) of 28 per 1,000 live births. This study sought to determine if Antenatal Care (ANC) and initiating breastfeeding within an hour from birth (early initiation of breastfeeding, EIBF) influences the likelihood of neonatal mortality (NNM) in Cameroon.

Subjects and Method: This was a cross-sectional study using the 2018 Cameroon Demographic and Health Survey (DHS). Women aged 15-49 (n=13,527) provided information on all children they had given birth to (n=34,990), living or dead. Bivariate analysis, chi-square, and multivariate logistic regression models were used for analysis. Adjusted models analyzed three primary relationships: (1) ANC on NNM, (2) EIBF on NNM, and (3) ANC on EIBF.

Results: Adequate ANC coverage (aOR 1.16 (95%CI 0.64-2.10), p=0.195) and EIBF (aOR 0.55 (0.29-1.05), p=0.070) were not significantly associated with NNM, nor was adequate ANC coverage significantly associated with EIBF (aOR 1.05 (95%CI 0.89-1.25), p=0.543). Significant risk factors of NNM were adolescent mothers (OR 1.60 (95%CI 1.34-1.92), p=0.023), mothers with no education (OR 1.39(95%CI 1.05-1.85), p=0.014), poorer households (OR 1.26 (95%CI 0.96-1.66), p=0.027), being male(OR 1.23 (95%CI 1.08-1.41), p=0.002), and low birthweight (LBW) (OR 5.11 (95%CI 3.20-8.16), p<0.001). Factors that decreased the odds of EIBF were adolescent mothers (OR 0.87 (95%CI 0.73-1.03), p=0.020), mothers with no education (OR 0.81 (95%CI 0.64-1.002), p=0.002), a Muslim household (OR 0.74 (95%CI 0.50-1.09), p=0.006), being born at home (OR 0.75 (95%CI 0.61-0.91), p=0.005), born through Cesarean section(OR 0.36 (95%CI 0.25-0.49), p<0.001), or being male (OR 0.88 (95% CI0.78-1.00), p=0.041). Houses of the richest quintile(OR 1.65 (95%CI 1.31-2.07), p<0.001) or mothers with a higher education(OR 1.49 (95%CI 1.09-2.04), p=0.002) made children significantly more likely to experience EIBF.

Conclusion: Receiving adequate ANC and EIBF was not significantly associated with NNM. Receiving adequate ANC was not associated with EIBF. Maternal age, maternal education, household wealth index, sex of the child, and birthweight were significant risk factors of NNM. Maternal age, maternal education, household wealth index, religion, mode of delivery, and sex of the child were significant predictors of EIBF.

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Table of Contents

Chapter 1: Background Literature Review

I. Child Mortality and the Global Burden of Disease

a. Global Trends in Child Mortality

In 2020, the global mortality rate for children under five years old was estimated to be 37 per 1,000 live births [1]. The most vulnerable period for a child's survival is the neonatal period, the first 4 weeks of life. An estimated 44 to 47% of under five deaths are neonatal deaths with an estimated average global rate of 17 deaths per 1,000 live births in 2020, equating to 2.4 million children dying within their first month of life [2] in 2020, or 6,500 neonatal deaths each day [2]–[5]. Seventy-five percent of neonatal deaths occur within the first week of life [4], [6].

The causes of childhood deaths are often preventable or treatable, with the leading causes of death attributed to infectious diseases (including malaria, pneumonia, and diarrhea), premature birth and complications during delivery[1]. High child mortality rates can be an indicator of inequity and systemic challenges, as it is often a result of factors such as poor nutrition, poor maternal health, and poor maternal education. These often preventable deaths can be an indicator of a lack of access to quality health care services [7].

b. Global Efforts to Reduce Child Mortality (MDG/SDG)

In 2000, the United Nations (UN) established the Millennium Development Goals (MDG) which set out to combat poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women [8]. Among them, MDG4 set out to reduce the global under-five mortality rate by two-thirds between 1990 and 2015. While this goal was not met, significant progress was made in reducing the under-five

mortality rate by 49% between 1990 and 2015, and by 61% when comparing 1990 to 2020 (from 93 deaths/1000 live births in 1990 to 37 deaths/1000 live births in 2020) [1], [8].

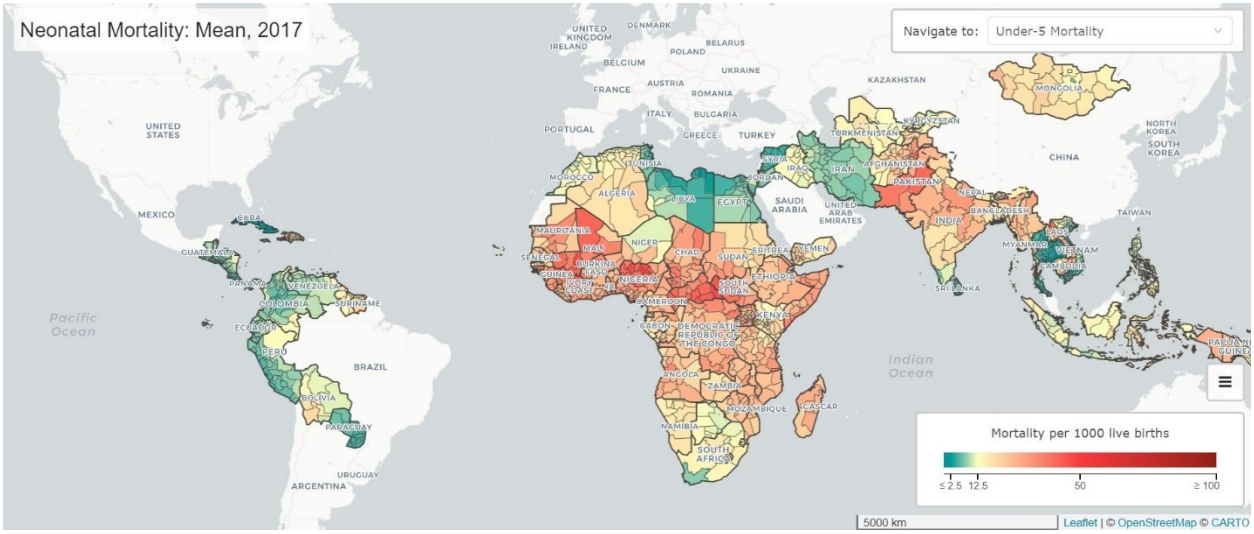
At the conclusion of the MDG in 2015, the UN established the Sustainable Development Goals (SDG). The SDG focuses on both under five mortality and, more specifically, neonatal mortality. SDG target 3.2 states: "By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births" [9]. The global neonatal mortality rate (NMR) saw a decrease of 54% from 1990 to 2020 (37 deaths/1000 live births to 17 deaths/1000 live births)[2].

c. Disparity in Child Mortality in LMIC

Despite the declining global rates, there is a stark disparity in NMR across regions and countries. Lower-income and middle-income countries (LMIC) account for about 99% of neonatal deaths, with the highest NMR observed in sub-Saharan Africa (27 deaths/1000 live births in 2020) [2], [3]. As of 2021, there are over 60 countries that need to increase their efforts to be able to meet the SDG target by 2030 and 51 countries that need to more than double their current rate of reduction of NMR [10]. Seventy-five percent of these countries are located in Sub-Saharan Africa. Meeting the SDG target for under five and neonatal mortality by 2030 would avert 8 million deaths of children under five compared to the current trend. If the current trends continue, over 43 million children under 5 will die between 2021 and 2030, half of whom will be

newborns and 59% (26 million) of these deaths will occur in Sub-Saharan Africa [10]. Countries with the highest NMR are shown in Figure 1.

Figure 1: Countries with Highest Neonatal Mortality Rates, 2017 [11]



d. Child Mortality in Cameroon

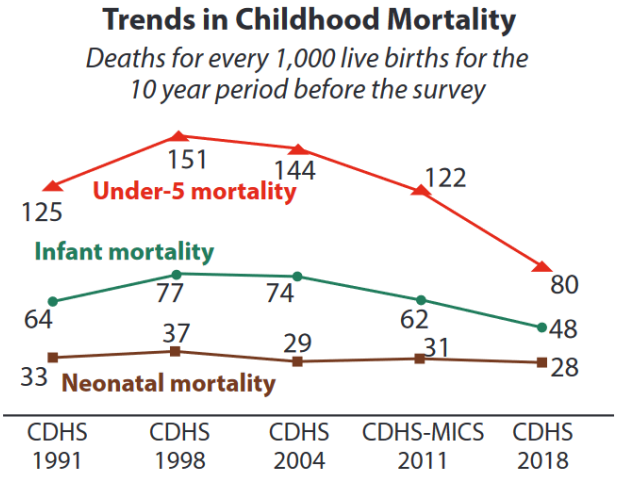
Cameroon's under-five mortality rate has decreased from an estimated 151 deaths/1000 live births in 1998 to 80 deaths/1000 live births in 2018 (

Figure 2) [12]. This improvement has been attributed to improvements in child health indicators such as malaria prevalence, anemia, child vaccination, antenatal care, postnatal care, place of birth, and childbirth assistance by skilled health workers [13]. The under-five mortality rates in Cameroon vary based on factors such as geographic region, maternal age, maternal education, household wealth, birth intervals, and birth order[12], [13].

Despite reduction in under five mortality and infant mortality since 1998, there has not been a significant change in the NMR in Cameroon (

Figure 2). Cameroon has an estimated NMR of 28 deaths per 1,000 live births as of 2018 [12].

Figure 2: Trends in Childhood Mortality, Cameroon Demographic and Health Survey (CDHS) 1991-2018 [12]



II. Neonatal Mortality in Cameroon

a. Clinical Causes of Neonatal Mortality

The most common causes of neonatal mortality in Cameroon have been consistently identified as birth asphyxia[4], [14]–[18], prematurity[4], [15]–[21], and neonatal sepsis[4], [15], [17], [17], [19], [20]. Table 1 summarizes the results of hospital-based studies of neonatal mortality in Cameroon which confirm these most common causes of death. These estimates from four studies spanning three regions of Cameroon are consistent with estimates for the top three neonatal diseases reported globally by the WHO: prematurity (29.0%), birth asphyxia (23.0%), and neonatal sepsis (25.0%)[4].

There was a notably lower proportion of neonatal deaths due to neonatal sepsis at BRH, a suburban hospital, compared to YGOPH and Bonassama District Hospital, both urban hospitals. This was hypothesized by Ndombo et al. to be due to a refresher training on hygienic care during childbirth and the

postnatal period that was recently provided to the obstetrical and neonatal staff at BRH.

Table 1: Summary of Leading Clinical Causes of NNM in Cameroon

Reference	Study Location	Sample Size	Study Type	In-hospital NMR	Cause of Death		
					Neonatal infections	Prematurity	Birth asphyxia
Mah et al, 2014 [15]	Yaounde Gynaeco-Obstetric and Pediatric Hospital (YGOPH), Yaounde, Center Region, Cameroon	5,828	Retrospective medical record review	10%	**37.85%**	31.56%	16%
Chiabi et al., 2014 [6]	YGOPH, Yaounde, Center Region, Cameroon	7,824	Retrospective case-control	9.83%	**60.20%**	42.60%	37.40%
Christiane et a., 2015 [4]	Bonassama District Hospital, Douala, Littoral Region, Cameroon	269	Cross-sectional	12.60%	32.30%	**41.10%**	26.40%
Ndombo et al, 2017 [16]	Bamenda Regional Hospital (BRH), Bamenda, North-West Region, Cameroon	332	Prospective cohort	15.70%	6%	**69%**	23%

Birth Asphyxia

Birth asphyxia is the failure to initiate and sustain default breathing at birth. Birth asphyxia affects about 3% of the 120 million neonates born in developing countries each year, with approximately 900,000 dying as a result. Birth asphyxia accounts for 23% of global neonatal deaths [22]. Most causes of birth asphyxia occur before or during labor. A prospective case-control study performed at YGOPH from May to September 2010 by Chiabi et al. found the incidence of birth asphyxia at YGOPH in this timeframe was 80.5 per 1000 live

births. Statistically significant risk factors of birth asphyxia were identified as single motherhood (p=0.039), antenatal visits occurring at a health center compared to YGOPH or other hospitals (p=0.01), malaria during pregnancy (p=0.015), pre-eclampsia/eclampsia (p=0.046), prolonged labor(p<0.001), and prolonged rupture of membranes (p=0.007). [22] Christiane et al. found that the odds ratio (OR) of birth asphyxia leading to neonatal mortality was 17.8 (95% CI 2.02-158.1, p=0.01)[4].

Prematurity

Prematurity or preterm birth refers to babies born before 37 weeks of gestation [23]. Globally, the WHO estimates that 15 million babies are born premature each year, yielding a global rate of preterm birth of 11% [24]. Of these 15 million premature neonates, approximately 1 million die due to complications of prematurity[23], [24]. Estimates of the incidence of preterm birth in Cameroon's capital of Yaoundé decreased from 26.5% in 2003 through 2011 (YGOPH)[25] to 14.8% in 2013 to 2017 (YGOPH, Yaoundé Central Hospital, and Centre Hospitalier d'Essos) [26]. The North West region's BRH had a preterm birth incidence rate of 18.5% from 2016 to 2019 [27]. Prematurity is a main cause of low birth weight (LBW), with preterm infants generally weighing between 500g to 2400 g [6], [28]. Prematurity may sometimes be associated with hypotrophy[28] or hypothermia [16]. With a shortened gestational age, preterm neonates may have structurally and functionally immature organs which make it difficult to adapt to life outside of the womb. Complications such as hypothermia[16], digestive intolerance, infections[20], bleeding, or pulmonary

surfactant deficiencies[19] contribute to the increased risk of neonatal mortality amongst premature neonates[15].

A cross-sectional review of hospital records at YGOPH from 2003 to 2011 identified significant risk factors of prematurity to be attending antenatal visits at a health center compared to at YGOPH (OR 6.19 (95% CI 1.15-33.22; p=0.033)) and urinary tract infection (UTI) (OR 39.04 (95% CI 17.19-88.62; p<0.001)) while factors that decreased the odds of prematurity were being a student mother (OR 0.44 (95% CI 0.20-0.98; p=0.047), being married (OR 0.40 (95% CI 0.19-0.84; p=0.016), and attending 4 or more antenatal care visits (OR 0.23 (95% CI 0.15-0.35; p<0.001) [25]. A retrospective case-control study conducted at BRH for neonates enrolled from January 2016 to December 2019 identified maternal primary and secondary education (adjusted OR (AOR) 2.86 (95% CI 1.12-8.49; p=0.034)), preterm rupture of membranes (AOR 2.74 (95% CI 1.13-6.61; p=0.025)), and attending less than 4 ANC visits (AOR 3.14 (95% CI 1.87-5.23; p<0.001)) as significant predictors of preterm birth [27]. Christiane et al. found that the odds ratio (OR) of prematurity leading to neonatal mortality was 21.3 (95% CI 1.4-304.2, p=0.02)[4].

Neonatal Sepsis

Neonatal sepsis is an infection in the bloodstream of newborns less than 28 days old [29]. Neonatal sepsis that occurs within the first 72 hours of life is generally caused by transmission of maternal genitourinary infection to the fetus or neonate. Bacteria may travel to the uterus and amniotic fluid or may transfer to the neonate during delivery. Neonatal sepsis that occurs after the first 72 hours

of life are generally caused by bacterial transmission from the surrounding environment after delivery. The risk of neonatal sepsis is increased for preterm births, prolonged rupture of membranes over 18 hours, maternal genitourinary infections (including Group B streptococcus (GBS)), and neonates who require invasive procedures such as intravascular catheter insertions or feeding tubes. [29] A systematic review and meta-analysis of studies conducted in developing countries, including Cameroon, found the pooled prevalence of neonatal sepsis in developing countries was 29.92% (95% CI 23.95-35.90) [3]. A prospective study conducted from November 2008 to May 2009 at YGOPH found that this facility had a neonatal sepsis incidence rate of 34.7%, with the most frequent risk factors identified as prematurity and prolonged rupture of membranes [20]. While Christiane et al. found a higher rate of neonatal sepsis at Bonassama District Hospital in Douala from May 2013 to April 2014 (79.1%), neonatal sepsis was not significantly associated with neonatal mortality (p=0.2)[4].

b. Risk Factors Associated with Neonatal Mortality

Low Birth Weight (LBW)

LBW is defined as a weight at birth of less than 2,500 g [30]. LBW is most common in developing countries, and the proportion of newborns with a LBW is an indicator of public health issues such as long-term maternal malnutrition, poor health, and poor health care during pregnancy. It can be caused by intrauterine growth restriction or prematurity and contributes to adverse health outcomes including neonatal mortality [30]. According to the WHO, newborns with a LBW have a 20 times higher risk of neonatal mortality than newborns of a normal weight [20]. Chiabi et al., Christiane et al., and Ndombo et al. observed

a significant association between LBW and neonatal mortality at YGOPH ($p<0.01$), Bonassama District Hospital in Douala ($p<0.05$), and BRH ($p<0.01$), respectively[4], [16], [20]. Chiabi et al.'s subsequent case-control study at YGOPH confirmed this association, with an OR of 1.62 (95% CI: 1.01-2.61, $p=0.045$)[6].

APGAR Score

Apgar stands for Appearance, Pulse, Grimace response, Activity, and Respiration. An Apgar score is on a scale of 1 to 10, with each of the five components scored from 0 to 2. Apgar scores are monitored at 1 minute and 5 minutes after birth to determine how well the baby tolerated birth and how well they are doing outside of the womb, respectively. Apgar scores were designed to identify newborns requiring respiratory support, but it alone should not be considered evidence of asphyxia. Low Apgar scores at the 1 minute test are not predictive of health outcomes, however a low Apgar score (<7) at 5 minutes is correlated with neonatal mortality. Apgar scores from 7-10 are normal, between 4-6 need re-evaluation and monitoring for five minutes, and <3 requires immediate attention. [31]

Low Apgar scores at the 5th minute was found to be a significant predictor of neonatal respiratory distress (NRD) at Douala General Hospital (aOR 5.19 (95% CI 3.59-7.50, $p<0.0001$)). In this study by Tochie et al., NRD was then associated with an increase in neonatal mortality (OR = 2.53 (95% CI = 1.69-3.80, $p < 0.01$)) [19]. Chiabi et al., Christiane et al., and Ndombo et al. observed a significant association between a low Apgar score and neonatal mortality at

YGOPH (OR 6.89 (95% CI 4.07-11.69, p <0.0001)), Bonassama District Hospital in Douala (p=0.03), and BRH (p<0.01), respectively [4], [6], [16].

Prolonged Membrane Rupture

Amniotic membranes are meant to protect the fetus and have antibacterial, antiviral, and anti-inflammatory properties. Prolonged rupture of membranes (PROM) occurs when membranes rupture over 12 hours before delivery. PROM is a risk factor for early-onset neonatal sepsis [32]. At YGOPH, Chiabi et al. found that PROM was associated with neonatal mortality through a prospective study conducted from 2008-2009 (n=218, p=0.04) and in a case-control study from 2003-2012 (n=850, OR 3.87 (95% CI: 2.36-6.34; P=<0.0001) [6], [20]. A similar association was found in a retrospective cohort study performed by Chelo et al. at Centre d'Animation Sociale et Sanitaire (CASS) from 2007 to 2008 (OR 4.69 (95%CI 0.95-23.09, p<0.05) [18].

Place of Birth

Birth occurring at home, at local health centers, and at hospitals have shown differences in health outcomes including neonatal mortality. Being born in a hospital has been found to be protective against neonatal mortality due to the increased access to medical resources and the ability to respond to medical issues or emergencies in a timely manner. Chiabi et al. found that being born at YGOPH was protective against neonatal mortality with an OR of 0.4409 (95%CI 0.26-0.76, p=0.003)[6]. Several studies considered the place of birth as a potential confounder when identifying risks of neonatal mortality [4], [6], [15], [16], [33]–[36].

Mode of Birth

The mode of birth refers to whether a baby was born vaginally or through cesarean section. Elective Cesarean delivery has been found to be associated with an increased risk of NRD (OR 3.61 (95% CI 2.01-4.08, p=0.004)) [19] as well as birth asphyxia (OR 2.03 (95% CI 0.45-6.6))[22] in Cameroon. These adverse respiratory outcomes are likely due to a loss of beneficial effects of manual, vaginal delivery such as a reduction in water in the lungs, increased catecholamine levels, secretion of surfactant into the alveoli, and pulmonary vasodilation [19]. Despite these outcomes, at YGOPH Cesarean delivery has been shown to be protective against neonatal mortality (OR 0.26 (95% CI 0.15-0.47, p<0.0001)). This may be because neonates born by Cesarean delivery are routinely observed in the neonatology department for at least two days, whereas those born vaginally are only admitted to neonatology if they have signs of disease. It may also be because this mode of delivery is primarily used when there are indications that the procedure is needed to save the baby's life [6]. The protective association between Cesarean delivery and neonatal mortality has been consistently reported in the literature [6], [37], [38].

Maternal Age

Adolescent and teen pregnancy has an increased risk of adverse fetal outcomes. Kongnyuy et al. conducted a cross-sectional study comparing adolescent pregnancies (≤19 years, n=268) with adult pregnancies (20-29 years, n=832) in 4 hospitals in Yaoundé (n=1100). This study found that there was a 2-fold increase in the likelihood of adverse fetal outcomes for adolescent mothers (OR 1.8 (95% CI 1.4–2.4)) and early neonatal death (OR 2.18 (95% CI 1.04–4.48))

[21]. A retrospective cohort study conducted by Ngowa et al. at YGOPH found no significant difference in neonatal mortality between adolescent pregnancies (<19 years, n=285) and adult pregnancies (age 20-25, n=1394) [39], however an earlier retrospective cohort study by Ngowa et al. at Yaoundé teaching hospitals found that women of advanced maternal age (>40 years, n=585) had an increased incidence of perinatal mortality (neonatal deaths or stillbirths; 3.5% vs 1.6%, RR=2.18, $p<0.05$) compared to women age 20-29 (n=1816) [40].

Sex of Baby

Neonatal mortality amongst male babies is frequently reported as higher than amongst female babies. In a study using national representative surveys from sub-Saharan Africa, including Cameroon, Garenne found that in all 44 surveys analyzed the neonatal mortality rate was higher for males than females, with 40 showing a significant difference. There was a corresponding higher prevalence of malnutrition amongst males compared to females ($p=2.7 \times 10^{-8}$), but no significant difference in health seeking behavior such as preventive medication (vaccination), curative medication, or breastfeeding practices. This indicates that the difference in neonatal mortality between males and females is due to biological factors. [41] Doku and Neupane found similar differences between male and female neonatal mortality rates using DHS data from 57 LMIC, with females showing a protective hazard ratio (HR) of 0.75 (95% CI 0.72–0.78, $p<0.001$) [34].

In Cameroon, neonatal deaths have been reported as 1.4 times higher for males than females in the East region [35] and 1.27 times higher at YGOPH for

newborns admitted between 2004-2010 (n=5,828)[15]. In Douala, Christiane et al. observed that male babies were predominant amongst neonatal deaths (52.9%), however the difference was not significant (p=0.9) [4]. In their case-control study at YGOPH from 2033-2012 (n=850), Chiabi et al. did not find a significant association between sex and neonatal mortality (OR 1.12 (95% CI 0.85 - 1.47, p= 0.2)) [6].

III. Antenatal Care (ANC)

ANC refers to the preventive health care that a woman receives during pregnancy from a skilled health-care professional. ANC provides services to mothers and unborn children that may prevent, detect, and treat risk factors early in pregnancy [6], [36], [42]. The goal of ANC is to ensure the best health conditions for mother and child [43]. ANC offers a platform to deliver interventions such as nutrition and breastfeeding counselling, immunizations, education on family planning and birth intervals, and preparation for birth and complication readiness [36], [42]. The components of ANC include prevention and management of diseases that occur during or because of pregnancy, health education, and health promotion [43]. ANC can reduce morbidity and mortality of mother and child by detecting and treating pregnancy-related conditions, both directly and indirectly [43].

a. WHO Recommendations on ANC

The WHO has published evidence-based guidelines for timing of and content to deliver during ANC visits. In 2002, the WHO released guidelines establishing the focused ANC, or FANC, model. The FANC model included recommendations that pregnant women attend at least 4 ANC visits, with the first occurring during the first trimester between 8-12 weeks, the second

occurring during the second trimester between 24-26 weeks, and the third and fourth occurring during the third trimester at week 32 and between weeks 36-38, respectively [43]. The FANC model was created to allow targeted implementation in low-resource settings, delivering key interventions in a limited number of visits. At the time of its introduction, clinical evidence suggested that maternal and neonatal outcomes were similar for women receiving FANC compared to women receiving standard ANC with more visits. However, later studies found that there was a statistically significant increase in perinatal mortality for women in LMIC who received FANC compared to standard ANC [44]. This prompted the WHO to reevaluate its guidelines on ANC.

Revised guidelines were published in 2016, whereby the recommended number of ANC visits increased from 4 to 8. These additional contacts are recommended in the second trimester at week 20 and during the third trimester, with recommended contacts at weeks 30, 34, 36, and 38. Additionally, the first contact is recommended at any time during the first trimester up to week 12. [43]

In addition to providing a suggested schedule for ANC visits, the WHO guidelines include recommended topics to cover during visits. This includes details on nutritional interventions, maternal and fetal assessments (including screening for anemia, asymptomatic bacteriuria, intimate partner violence (IPV), gestational diabetes mellitus, tobacco use, substance use, human immunodeficiency virus (HIV), syphilis, and tuberculosis (TB)), fetal

assessments (including daily fetal movement counts, fundal heigh measurements, and ultrasound scans), preventive measures (including when providing antibiotics is appropriate, preventative anthelminthic treatment, and tetanus toxoid vaccinations, malaria prevention, and HIV pre-exposure prophylaxis (PrEP)), interventions for common physiological symptoms (including nausea, vomiting, heartburn, leg cramps, back and pelvic pain, constipation, and varicose veins), and health systems interventions to improve the utilization and quality of ANC (including having women carry their own case notes, offering midwife-led continuity of care, group antenatal care, and community-based interventions for improving communication and support). [43]

b. Benefits of ANC

Studies conducted to quantify the benefits of ANC generally measure the timing of the initiation of care, the number of visits, or the interventions provided during visits. More frequently, researchers will combine these factors into measurements of the quality and adequacy of ANC. While the meaning of the terms quality and adequacy can be switched based on the author, the following definitions will be applied to allow a consistent review and summary of the current literature. Adequacy of ANC refers to a binary categorization of whether or not the WHO recommendations were met, namely if the pregnant woman attended at least four ANC visits, ANC was provided by a skilled health care worker, and if ANC was initiated in first trimester (<14 weeks gestational age). Quality of ANC seeks to quantify the content or interventions provided

during ANC visits compared to the recommended, evidence-based list of interventions. The Quality of ANC is a constructed index that varies by study; it may be presented as a percentage of the recommended interventions received or as a count of interventions received.

A key aspect of the WHO's FANC model adopted by the Cameroon Ministry of Public Health is birth preparedness and complication readiness (BPCR). BPCR is a process of planning for a normal birth and preparing for what actions to take if there is an emergency. A goal of BPCR is for pregnant women and their families to avoid the delays in care seeking that can lead to maternal or neonatal mortality. Through BPCR, pregnant women and their families make active, advanced preparations and decisions such as identifying what health facility and skilled health care worker will attend their birth, saving money for costs associated with delivery, transportation, and emergencies, arranging transportation to the health facility, identifying blood donors, identifying a support person who will be present at the birth, and knowing how to identify danger signs [45]. A study conducted by Ijang et al. in the Bamenda Health District in the North West region of Cameroon found that the number of ANC visits was a significant predictor of birth preparedness (aOR 2.16 (95% CI 1.18-3.90)), with women who attended four or more ANC visits about twice as prepared as women who attended less than four visits [45]. In this study, women who demonstrated BPCR were more likely to show knowledge of the danger signs during pregnancy that indicate a need to seek immediate medical care (OR 1.95 (95% CI 1.12-3.38, p=0.018)) [45].

Halle-Ekane et al. studied the relationship between quality of ANC and pregnancy outcomes amongst 300 post-partum women in hospitals in the Fako Division of the Southwest Region of Cameroon from 2014-2015. Late initiation of ANC compared to initiation within the first trimester was associated with poorer pregnancy outcomes, including low APGAR score (p=0.006), induced labor (p=0.001), augmented labor (p=0.001), and difficult birth/dystocia (p=0.001). Attending less than the recommended four ANC visits showed an increased risk of preterm delivery (p=0.001), low APGAR score (p=0.001), stillbirth (p=0.001), and LBW (p=0.001). This study measured quality of care as having at least 70% of the recommended components of ANC related to preventive care, health promotion, curative care, or preparation of childbirth. Overall insufficient quality of ANC was associated with preterm birth (p=0.001), low APGAR (p=0.001), stillbirth (p=0.001), LBW (p=0.001), delivering post-term (p=0.044), labor induction (p=0.016), labor augmentation (p=0.001), and dystocia (p=0.035). [46]

Several studies have shown that adequate and quality ANC can reduce the risk of LBW[36], [47]. Using data from 193 DHS from 69 LMIC spanning from 1990 to 2013 (n=752,635), Kuhnt and Vollmer found that attending at least one ANC visit was associated with a 3.82% reduced probability of LBW (p=0.004), a 4.11% reduced probability of stunting (p=0.003), and 3.26% reduced probability of a child being underweight (p=0.002). Attending at least four ANC visits and seeing a skilled health care worker at least once reduced the probability of LBW, stunting, and being underweight by an additional 2.83%

(p=0.002), 1.41% (p=0.002) and 1.90% (p=0.002) points, respectively [36]. Through two-stage least squares (2SLS) regression with instrumental variables, Odette et al. constructed a predictive model using Cameroon DHS results from 2018. This model found that adequate ANC increased a child's birth weight by 882.84g. Considering quality of ANC as a 0 to 6 point scale, where one point is granted for each intervention provided during ANC (blood pressure, blood tests, urine tests, tetanus immunization, iron supplement, and antimalarial drug), increasing the quality of ANC by one point increased a child's birth weight by 147.79g. Receiving 75% of the recommended ANC interventions increased a child's birth weight from 120g to 180g. This model also found that the mother's education had a significant effect on birth weight, with an increase in years of schooling by 1 year associated with an increase in birth weight by 84 to 95g. The results from Odette et al. demonstrate that receiving adequate ANC has a greater effect on birth weight than receiving higher quality ANC [47].

At YGOPH, Chiabi et al. found that attending ANC visits at a primary health facility significantly increased the occurrence of birth asphyxia compared to attending ANC at YGOPH or other hospitals (OR3.81 (95% CI 1.8-7.7, p=0.01)). This may be due to the lack of skilled health workers available at health centers and the fact that referrals from local health centers to hospitals such as YGOPH are only made if there are complications. In this study, there was no significant association between the number of ANC visits and birth asphyxia (p=0.61) [22].A chart review performed at Douala General

Hospital for 703 newborns admitted between 2011 and 2013 found that attending at least four ANC visits reduced the odds of neonatal respiratory distress (NRD) (aOR 0.39 (95% CI 0.16-0.98, p=0.045)). In this study, NRD was associated with an increase in neonatal mortality (OR = 2.53 (95% CI = 1.69-3.80, p < 0.01))[19].

c. ANC and Neonatal Mortality

Several studies have found that attending ANC visits reduces the risk of neonatal mortality. In the study previously described by Kuhnt and Vollmer using DHS data from 69 LMIC countries, it was found that attending at least one ANC visit was associated with a 1.04% reduced probability of neonatal mortality (p=0.001). Attending at least four ANC visits and having seen a skilled health care provider at least once reduced the probability of neonatal mortality by an additional 0.56% (p=0.001) and 0.42% (p=0.001), respectively [36]. In a similar study conducted by Doku and Neupane, DHS data from 57 LMIC (n=464,728) was used to determine the relationship between ANC and neonatal mortality using survival analysis. This study found that women who had adequate ANC had a 55% lower risk of neonatal mortality (HR 0.45 (95% CI 0.42-0.48)). ANC was associated with lower neonatal mortality in all regions studied except the Middle East and Northern Africa. In Cameroon, after adjusting for maternal age, area of residence, BMI, wealth quintile, previous children, sex of the child, and maternal education, the adjusted hazard ratio (aHR) for neonatal mortality among those who met at least one ANC recommendation was 0.65 (95% CI 0.36-1.14) [34]. A systematic review and

meta-analysis used random effects modelling to analyze 18 studies (n= 94,118) that measured the association between attending ANC visits and neonatal mortality. In this study, Wondemagegn et al. found that the risk of neonatal mortality was reduced by 34% for newborns whose mothers attended ANC (pooled effect size 0.66 (95% CI 0.54-0.80)). The effect of ANC visits on neonatal mortality in Cameroon was measured to have an effect size of 0.39 (95% CI 0.24-0.65)[5].

Facility-based studies conducted in Cameroon have sought to confirm the associations between ANC and neonatal mortality reported above. In a prospective cohort study on neonates admitted to Bamenda Regional Hospital from November 2015 to February 2016 (n=332), bivariate analysis found that attending less than four (0-3) ANC visits was associated with neonatal hospital mortality compared to attending at least four visits (OR 3.08 (95% CI 1.68-5.64, $p<0.01$)) [16]. In a retrospective case-control study of newborns admitted to YGOPH from March 2003-December 2012 (n=850), the association between attending at least four ANC visits and neonatal mortality was not significant (OR 1.31 (95% CI 0.87-1.97, p=0.1). Chiabi et al. took these results to mean that it is not the number of visits that influences pregnancy and neonatal outcomes, but rather the quality of the visits. However, this study did not include data to measure quality of ANC [6].

d. ANC in Cameroon

Since the WHO's introduction of the FANC model in 2002, there has been an improvement in the use of ANC in Cameroon. Based on data from the

Cameroon DHS from 1991 to 2018, the percentage of pregnant women who met the WHO's recommendations for ANC have increased, as shown in Table 2. From 1991 to 2018, attending at least four ANC visits increased from 49% to 65%, initiating ANC within the first trimester increased from 33% to 41%, and having a skilled health care professional present during ANC visits increased from 4% to 7.2%[13], [47]. Despite these improvements, Cameroon is still far from meeting the WHO recommendations on adequate ANC.

Table 2: Measures of Adequacy of ANC in Cameroon from 1991 to 2018 from Cameroon DHS [13], [47]

	1991	1998	2004	2011	2018
Four or more ANC visits (%)	49	52.4	60	62	65
Initiating ANC during the first trimester (%)	33	-	35	34	41
Skilled health care provider (%)	4	4.2	5	7.6	7.2

e. Patterns of ANC usage in Cameroon

A study conducted by Saad-Haddad et al. using DHS data from 2011 further analyzed the patterns of ANC usage in Cameroon. This study found that women who attend at least four ANC visits usually saw a skilled health care provider at least once and received more evidence-based interventions compared to women who attended less than four ANC visits [44]. Disparities were identified in access to ANC based on household wealth and women's education. Attending at least four ANC visits was more likely for women who received a secondary education (OR 1.56 (95% CI 1.13-2.16, p=0.007) or higher (OR 3.89 (95%CI 1.85-8.16, p<0.001) compared to no education, for women in a richer (OR 1.60 (95% CI 1.13-2.26, p=0.008) or richest (OR 1.84 (95% CI 1.24-2.73, p=0.002) wealth quintile compared to the poorest [44], and for adults age 20-34

(OR 1.57 (95% CI 1.24-1.97, p<0.001) and 35-49 (OR 1.46 (95% CI 1.06-2.01, p=0.021) compared to adolescents age 20 or younger. Attending at least four ANC visits were less likely for those who attended the first ANC visit in the second (OR 0.24 (95% CI 0.20-0.28, p <0.001)) or third (OR 0.03 (95% CI 0.02-0.04, p<0.001)) trimester compared to the first trimester and for women who had a preceding birth interval of less than 2 years (OR 0.64 (95% CI 0.47-0.86, p=0.004)), 2-3 years (OR 0.72 (95%CI 0.55-0.95, p=0.022)), or more than 3 years (OR 0.76 (95% CI 0.59-0.98, p=0.032)) compared to no previous births. [44]

In 2012, the Verbal/Social Autopsy (VASA) study was conducted in the East region of Cameroon in the health districts of Doume, Nguelemndouka, and Abong-Mbang. The aim of this study was to determine the biological causes as well as social determinants of child mortality in these health districts using questionnaires administered to households who had experienced a newborn death. Of the 164 neonatal deaths identified in the VASA study, 24% did not attend any ANC visit. While 79% of women attended at least one ANC visit, only 32% of these women received quality care in that they received all of the recommended components of ANC visits. The gaps in quality care varied based on ANC component; of the 125 women who attended at least one ANC visit, 10% did not have their blood pressure measured, 20% did not have a urine sample collected, 22% did not have a blood sample taken, 44% did not receive nutrition counseling, and 54% did not receive counseling about pregnancy danger signs. Of the 164 mothers interviewed who had experienced a neonatal

death, only 37% had attended the recommended minimum of four ANC visits. This study highlights the importance of both the adequacy and quality of ANC. The VASA questionnaires identified the main barriers to health services during pregnancy as well as for labor and delivery complications or newborn fatal illnesses were expenses for transportation, expenses for health care, and distance. [35]

A survey of pregnant woman enrolled in ANC at Saint Elizabeth General Hospital in Shisong in the North West Region of Cameroon between October and November 2016 sought to identify factors that contributed to late initiation of ANC. Of the 602 pregnant women in the study, 75% initiated ANC after 14 weeks of pregnancy. Factors that were significantly associated with late initiation of ANC were maternal age (age 30-44 compared to age 15-29; $p = 0.001$), maternal level of education at primary level or lower (compared to secondary or higher; $p = 0.002$), marital status of single ($p = 0.016$), religion (Christian compared to Muslim; $p = 0.034$), parity (4-8 previous births compared to 0-3; $p = 0.001$), not having a source of income ($p=0.001$), cost of services not being affordable ($p = 0.010$), distance to health facility over 5 km ($p = 0.021$) and dissatisfaction with previous ANC ($p = 0.014$)[48].

f. Attitudes Towards ANC in Cameroon

In a cross-sectional study at government health centers in Buea in the Southwest region of Cameroon, Edie et al. surveyed pregnant women attending ANC (n=385) to determine their perception and knowledge of ANC as well as their satisfaction in services received. Most women (99%) perceived ANC to

be important for both mother and child. The perception of timing of the first ANC visit varied based on previous pregnancies; women who had attended ANC for previous pregnancies believed it was beneficial to start ANC early, whereas first-time mothers or those who had not previously attended ANC did not see this value and did not begin ANC until the third trimester. Similarly, first time mothers, younger, and single women were less likely to know the recommended number of ANC visits compared to older women who had previous pregnancies. Overall, the satisfaction with ANC services provided was high (96.4%), with some areas of dissatisfaction identified as having poor seating facilities, amenities, having few health education talks, and poor nursing skills. Women with higher education levels (high school and university) (χ^2=8.7, p=0.01) and women pregnant for the first time (χ2 = 4.2, p=0.04) had significantly lower satisfaction. This may have been because these women were more interested in more in depth information regarding complications that can arise during pregnancy, or feeling that a focus on post-natal issues such as newborn care and breastfeeding were not as pertinent as receiving more immediate information about labor. [49]

At Nkwen Baptist Health Center in Bamenda in the North West region, focus group surveys were conducted with 18 pregnant women who had initiated ANC after their first trimester of pregnancy as well as with 3 key informant midwives. This study found that reasons for late ANC initiation included perceiving pregnancy as a normal health condition (don't need to attend ANC unless something is wrong), seeing ANC as a curative rather than preventive

service, seeing early ANC as a waste of time or money because the baby isn't big enough to meaningfully monitor, misconception or misinformation regarding when ANC should ideally begin, and fear of announcing pregnancy (fear of perceived enemies who could harm them, shame about being pregnant, attending ANC early can be perceived as boastful, or fear negative reactions from parents, especially for young, unmarried women). Perceived barriers to care included the system for booking ANC visits was unfriendly to users, there were long wait times, staff was rude, it was too expensive (delaying the initiation of care would either give more time to raise money or reduce the overall cost by reducing the amount of visits they would attend), and the distance to the health facility was too great. [50]

g. Adoption of Revised 2016 WHO Guidelines for ANC

Despite the data suggesting that the FANC model led to an increase in perinatal mortality[44], there has been conflicting opinion published in the literature regarding Cameroon's decision to adopt the 2016 ANC model including the recommended 8 visits. Cameroon DHS data from 2018 showed that only 8.9% of women attended at least 8 ANC visits, but those that did had a higher chance of receiving all recommended ANC services (aOR 1.41 (95% CI 1.00-1.99)) [51]. While most authors acknowledge the benefits of increasing ANC visits, only 35% of pregnant women attended less than 4 ANC visits as of 2018 [12]. Increasing the target to 8 visits may therefore not seem realistic. The barriers to attending ANC will be compounded when increasing the number of visits, and the disparities seen in access to care will continue to widen. A survey conducted

by Tumasang et al. in Bamenda Health District found that while there was not a significant difference in women's preferences between 4 or 8 ANC visits, the willingness to pay for the additional visits did not meet the actual costs to meet the new recommendations. The average willingness to pay for 4 extra ANC visits was 2,209 FCFA, whereas the cost for these visits would be 10,390 FCFA [52].

IV. Breastfeeding

a. WHO Recommendations on Breastfeeding

The WHO and the United Nations International Children's Emergency Fund (UNICEF) recommend initiating breastfeeding within one hour of birth (early initiation of breastfeeding (EIBF)), exclusively breastfeeding for the first 6 months of life (meaning that no other foods or liquids are provided, including water), and introducing safe complementary foods at 6 months while continuing to breastfeed up to 2 years of age or beyond[53]. Exclusive breastfeeding for 6 months provides protection against gastrointestinal infections in both developing and developed countries. EIBF has been shown to protect newborns from infection and reduce neonatal mortality[33], [54]–[56]. The risk of death from diarrheal diseases and other infections increases for infants that are partially breastfed or not breastfed at all[56].

From 2015-2020, the global estimate of infants aged 0-6 months who were exclusively breastfed was 44%. The WHO estimates that over 820,000 children under the age of five could be saved each year if all children aged 0-23 months were optimally breastfed. [56]

b. Breastfeeding and Neonatal Mortality

Hypothermia and hypoglycemia are causes of neonatal death that may be affected by breastfeeding practices. Newborns have low amounts of body fat, especially for those born with LBW. This leads to babies losing more heat per unit body weight than adults. Body heat production is dependent on metabolizing fat, which makes having an early and sufficient breast milk supply beneficial to both producing heat and growth. Suckling and being close to the mother are beneficial in reducing the risk of hypothermia. More frequent suckling typically accompanies breastfeeding compared to bottle feeding, which contributes to breastfeeding being better able to prevent hypothermia. Randomized controlled trials have shown that newborns that keep skin to skin contact with their mothers immediately after birth have significantly higher skin temperature and blood glucose levels compared to babies that were separated from their mothers. Skin to skin care has been found to be more effective in helping babies reach normal temperatures than incubator care (90% of low-risk babies reaching normal temperature vs. 60% of babies in the incubator group reaching normal temperature)[57]. Skin to skin contact for at least 1 hour immediately after birth can reduce the risk of neonatal mortality by 22% [33].

Colostrum is the first milk that is produced at the start of breastfeeding. It is a concentrated, yellow liquid that has a high nutrient and protein content[58]. It provides protection against infection and helps support the newborn's immune system through transfer of white blood cells and antibodies[59]. Colostrum leads to intestinal colonization by saprophytic bacteria, reduction of intestinal colonization by potentially harmful Gram negative bacteria, and the ability to produce bioactive immune factors needed by the newborn, all of which contributes to the protective effect of EIBF [33]. Colostrum can also

help prevent jaundice and is rich in Vitamin A and minerals such as magnesium, copper, and zinc[59]. Initiation of breastfeeding within 1 hour of birth is important for babies to receive the benefits of colostrum as soon as possible. Delayed initiation of breastfeeding increases the odds of neonatal mortality due to infection [33].

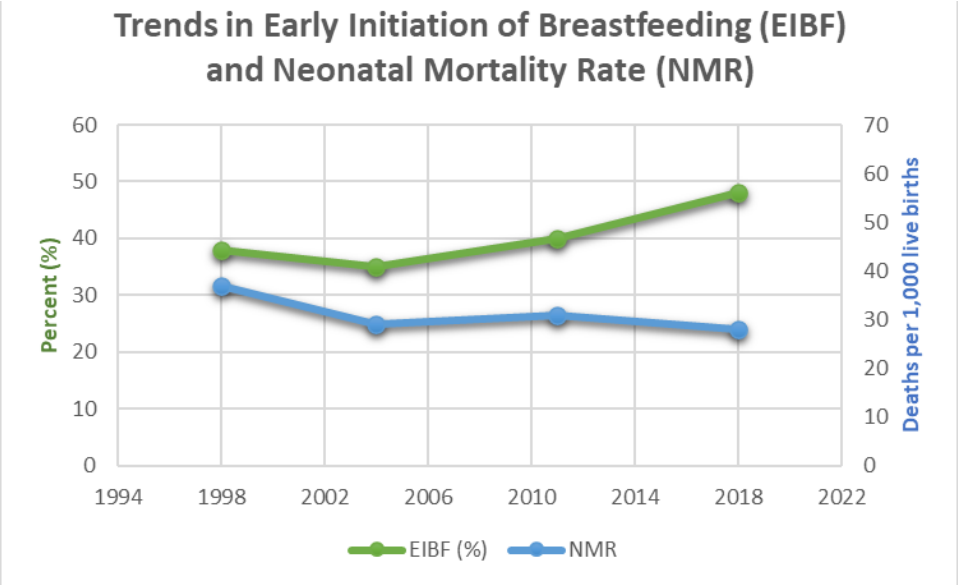
There are limited studies in the literature which have analyzed the relationship between breastfeeding and neonatal mortality in Cameroon. Boccolini et al. conducted a cross-sectional study using DHS data from 67 countries, including Cameroon. This analysis found that EIBF was protective against neonatal mortality (Spearman's Rho = −0.245, p = 0.046) and that this correlation was stronger for countries with greater than 29 neonatal deaths per 1000 births (Spearman's Rho = −0.327, p = 0.048) [33]. Countries in the lowest tertile of breastfeeding had a 24% higher rate of neonatal mortality (Rate Ratio 1.24 (95% CI 1.07-1.44, p<0.05))[33].

c. Barriers to Breastfeeding in Cameroon

Ninety-two percent of children in Cameroon are ever breastfed, with 48% being breastfed in the first hour of life and 40% exclusively breastfed for the first 6 months[12]. The proportion of mothers who breastfeed varies by region, from 69.9% in the Southwest and Littoral regions to 90% in the North West region[60]. Trends in EIBF and NNM from 1998 to 2018, as measured by the Cameroon DHS, are summarized in Figure 3 [12], [61], [62]. As the neonatal mortality rate in Cameroon has been decreasing steadily since 1998, the percentage of children who experience EIBF has been increasing. Amongst infants born at YGOPH weighing at least 2000g from December 2018 to May 2019 (n=250), the rate of EIBF was 38.8% and 66.6% of mothers intended to exclusively breastfeed for 6 months[28], [54], [63], [64]. Of the 153 newborns with delayed initiation of breastfeeding,

94% were in good health immediately after birth; 24.8% were hospitalized within one week, of which 55.2% were due to sepsis and 15.7% were due to metabolic disorders[54]. Sixty-three percent of the 24.8% hospitalized neonates experienced delayed initiation of breastfeeding. The mortality rate from these neonates with delayed initiation of breastfeeding was 7.9% compared to 4.5% for those with EIBF, which may suggest that they had weaker immunological protection and were more likely to develop illness that could be fatal. Infants experiencing neonatal sepsis were significantly more likely to have had delayed initiation of breastfeeding (OR 10.9 (95% CI 1.3-90.5, p=0.009))[54]. Factors associated with a delay in breastfeeding were primary education level, Cesarian delivery, HIV infection, prematurity, LBW, and neonatal infection at birth [63]. Similarly, higher rates of inadequate breastfeeding were seen amongst those with Cesarian delivery (92.3%), preterm neonates (85.7%), LBW (83.3%), and neonatal sepsis (92.9%) [65].

Figure 3: Trends in EIBF and NMR, Cameroon DHS Surveys



Surveys conducted at YGOPH Yaoundé in the Center Region (n=153) [66], Cameroon Baptist Convention Health Board (CBCHB) Primary Health Centers in Ndu in

the North West Region (n=320) [60], and Bafoussam Regional Hospital in the West Region (n=195) [67] sought to understand the barriers to breastfeeding and the primary reasons that mothers did not practice EIBF or exclusive breastfeeding, as summarized below.

EIBF

Reasons for delaying initiation of breastfeeding greater than 1 hour after birth from each survey are summarized in Table 3. Cesarean delivery is a known determinant for delayed initiation of breastfeeding, in large part due to hormone variations that lead to reducing galactorrhea and the desire to breastfeed immediately after delivery [66]. The survey conducted at YGOPH also found that some women did not know that they should have initiated breastfeeding within 1 hour even after Cesarean delivery[66]. The belief that colostrum is “bad” or spoiled due to its yellow color has led to local traditions or family pressure to avoid breastfeeding until more mature milk is available[60], [66]. There is similarly a belief that colostrum is inadequate for the baby, and other food or drink must be given to help the baby gain weight. The 59 women with delayed initiation of breastfeeding at BRH had given pap, a porridge made from corn, before breastfeeding[67]. Having no milk production was a commonly reported reason for not breastfeeding within the first hour after delivery, and this may be compounded by the misinformation that colostrum is not good for or adequate for the baby and is therefore not counted as milk production. Health care provider recommendations against EIBF and lack of awareness or knowledge of the expectation to begin breastfeeding within 1 hour after delivery highlight that there are improvements that can be made in the education regarding breastfeeding provided during ANC and to health care providers.

Table 3: Summary of Survey Results for Reasons for Delayed Initiation of Breastfeeding

Reason for Delayed Initiation of Breastfeeding	Nguefack et al. YGOPH Center Region n=153 [66]	Chiabi et al. BRH West Region n=59 [67]	Kakute et al. CBCHB North West Region n=320 [60]
Cesarean delivery	22.0%	10.2%	--
Belief that colostrum inadequate or bad for the baby	16.0%	--	52.2%
Lack of awareness/ knowledge	20.4%	--	--
No milk production	9.2%	74.6%	*
Sick newborn	7.6%	8.5%	--
Health care provider recommendation	3.6%	3.4%	--
Sick mother	8.0%	--	--
Baby was sleeping	5.2%	--	--
Tradition	--	1.68%	*

* Reason reported, percentage of respondents indicating this reason not quantified

Exclusive Breastfeeding

Despite health care provider recommendations, exclusive breastfeeding is not commonly practiced. At BRH, only 29 (20%) survey participants practiced exclusive breastfeeding for 6 months[67]. All 320 women at CBCHB health facilities reported mixed feeding before 6 months[60]. Pap is a common food given to infants; 84.7% of the women surveyed at CBCHB health centers reported giving pap to infants before 6 months of age and 30.3% of women surveyed at BRH reported giving pap to newborns before breastmilk. Similarly, water was introduced before 6 months for 93% of infants at CBCHB and before breastmilk for 14.3% of newborns at BRH. Reasons for not exclusively breastfeeding are summarized in Table 4.

Tradition and pressure from family and community members are a key reason for not exclusively breastfeeding. Mixed feeding has been practiced for generations, and changes to this practice are introduced by Western culture, which is also seen as responsible

for diseases that were not present in the past. Going against this tradition can lead to conflict within families and mothers fear repercussions[60]. There is similarly belief that breastmilk alone is not enough for babies to be satisfied or to gain weight, and that food such as pap or other solid food is necessary [60], [67].

Mothers who must return to work or who are expected to perform farm work reported mixed feeding because they could not be with the baby the whole day to breastfeed them. Similarly, housewives without help from family for performing daily work, such as cooking and fetching water, reported difficulties in being able to exclusively breastfeed. At BRH, Chiabi et al. found that the mean duration of exclusive breastfeeding was 5 months and was significantly associated with parity and the profession of the mother ($p<0.05$). The age of weaning was lower for multiparous women compared to primiparous, and lower for students and housewives compared to civil servants. There was no significant difference between weaning before 6 months and maternal age, matrimonial status, or level of education ($p>0.05$) [67].

Table 4: Summary of Survey Results for Reasons for Not Exclusively Breastfeeding for 6 Months

Reason for Not Exclusively Breastfeeding	Chiabi et al. BRH West Region n=51 [67]	Kakute et al. CBCHB North West Region n=320 [60]
Family and community pressure	--	42.5%
Belief that baby not satisfied with breastfeeding alone / Insufficient milk supply	52.9%	20.0%
Mother tired from work in field/home	--	8.4%
No help from family with daily work	--	7.2%
Twins – inadequate supply	--	2.2%

Mother ill	--	1.6%
Breastfeeding difficulties	--	1.3%
Child eating a lot of solids	31.38%	--

V. Research Gap

The relationship between ANC and neonatal mortality in Cameroon has been studied through pooled analyses of several LMIC countries[34], [36] and through facility-based studies conducted at primarily urban hospitals in Cameroon[4], [6], [16], [19].

The facility-based studies were subject to selection bias, in that newborns included in the study were either born at or were later enrolled in the hospital where the study was conducted. These neonates or their mothers may have been considered high risk prior to birth or suffered from illness after birth, leading to their presence at the hospital, whereas babies born outside of these hospitals who did not face health complications would not be captured in the study population. This could lead to the reported hospital neonatal mortality rates and adverse outcome rates being higher than that of the general population. There has not been an analysis of nationally representative data in Cameroon.

There is an inherent bias in the study of the association between breastfeeding practices and neonatal mortality as neonates that experience health complications may face additional barriers to breastfeeding compared to healthier children. Neonates with health complications may require immediate medical attention, preventing immediate initiation of breastfeeding and increasing the likelihood of needing to supplement with other sources of nutrition. Most published literature regarding Cameroon have studied the FANC WHO recommendations of 4 ANC visits rather than the revised recommendations in 2016 of 8 ANC visits. More research is needed to understand if there are differences in NMR amongst

those receiving adequate ANC by FANC standards compared to the revised 2016 standards.

Several facility-based studies have been conducted to identify the adherence to WHO recommendations for EIBF and exclusive breastfeeding[28], [54], [60], [63], [64], [66], [67], however the only studies that looked at the association between breastfeeding and neonatal mortality in Cameroon were pooled analyses conducted on over 60 LMIC [33].

There is a need to understand the relationship between ANC, early initiation of breastfeeding, and neonatal mortality in Cameroon using a nationally representative dataset.

VI. Significance

Cameroon is not on track to meet the SDG 3.2 of ending preventable deaths of children by 2030. Understanding the association of Antenatal Care (ANC) and early initiation of breastfeeding (EIBF) with neonatal mortality in Cameroon to inform targeted interventions to drive towards meeting the SDG 3.2 of reducing the neonatal mortality rate to at least as low as 12 deaths/1,000 live births by 2030.

Chapter 2: Journal Article

Student Contribution

Student contribution includes secondary data analysis, writing, and data interpretation, figure/table development. The manuscript is intended for submission to the Journal of Maternal and Child Health (JMCH) (max 6,000 words, 8 tables/figures).

I. Abstract

Background: As of 2020, Cameroon has a neonatal mortality rate (NMR) of 28 per 1,000 live births. This study sought to determine if Antenatal Care (ANC) and initiating breastfeeding within an hour from birth (early initiation of breastfeeding, EIBF) influence the likelihood of neonatal mortality (NNM) in Cameroon.

Subjects and Method: This was a cross-sectional study using the 2018 Cameroon Demographic and Health Survey (DHS). Women aged 15-49 provided information on their children (n=34,990), living or dead. Bivariate analysis using Chi-Square and unadjusted odds ratios (OR) studied relationships with dependend variables NNM and EIBF. Adjusted odds ratios (aOR) were obtained through multivariate logistic regression for three primary relationships: ANC on NNM, EIBF on NNM, and ANC on EIBF.

Results: Adequate ANC coverage (aOR 1.16 (95%CI 0.64-2.10), p=0.195) and EIBF (aOR 0.55 (0.29-1.05), p=0.070) were not associated with NNM, nor was adequate ANC coverage associated with EIBF (aOR 1.05 (95%CI 0.89-1.25), p=0.543). Significant risk factors of NNM included adolescent mothers (OR 1.60 (95%CI 1.34-1.92), p=0.023), mothers with no education (OR 1.39(95%CI 1.05-1.85), p=0.014), poorer households (OR 1.26 (95%CI 0.96-1.66), p=0.027), being male(OR 1.23 (95%CI 1.08-1.41), p=0.002), and low birthweight (LBW) (OR 5.11 (95%CI 3.20-8.16), p<0.001). Factors decreasing the odds of EIBF included adolescent mothers (OR 0.87 (95%CI 0.73-1.03), p=0.020), mothers with no education (OR 0.81 (95%CI 0.64-1.002), p=0.002), being born at home (OR 0.75 (95%CI 0.61-0.91), p=0.005), born through Cesarean section(OR 0.36 (95%CI 0.25-0.49), p<0.001), or being male (OR 0.88 (95% CI0.78-1.00), p=0.041).

Conclusion: Receiving adequate ANC and EIBF was not significantly associated with NNM. Receiving adequate ANC was not associated with EIBF. Maternal age and education, household wealth index, child's sex, and birthweight were significant risk factors of NNM. Maternal age and education, household wealth index, religion, mode of delivery, and child's sex were significant predictors of EIBF.

II. Background

The most vulnerable period for a child's survival is the neonatal period, the first 4 weeks of life. In 2020, the global neonatal mortality rate (NMR) was estimated to be 17 deaths per 1,000 live births, equating to 2.4 million children dying within their first month of life [2] in 2020, or 6,500 neonatal deaths each day [2]–[5]. In 2015, the United Nations (UN) established the Sustainable Development Goals (SDG), including SDG target 3.2 which states: "By 2030, end preventable deaths of newborns… with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births" [9]. The global NMR decreased 54% from 1990 to 2020 (37 deaths/1000 live births to 17 deaths/1000 live births)[2]. Cameroon has an estimated NMR of 28 deaths per 1,000 live births as of 2018 [12].

Antenatal Care (ANC) refers to the preventive health care that a woman receives during pregnancy from a skilled health-care professional. ANC provides services to mothers and unborn children that may prevent, detect, and treat risk factors early in pregnancy [6], [36], [42]. ANC can reduce morbidity and mortality of mother and child by detecting and treating pregnancy-related conditions, both directly and indirectly [43]. In 2002, The World Health Organization (WHO) released guidelines establishing the focused ANC, or FANC, model which included recommendations that pregnant women attend at least 4 ANC visits, with the first occurring during the first trimester between 8-12 weeks and the visits being attended by a skilled health provider [43]. In 2016, the WHO revised their guidelines to increase the number of ANC visits from 4 to 8. [43]

The WHO and the United Nations International Children's Emergency Fund (UNICEF) recommend initiating breastfeeding within one hour of birth (early initiation of breastfeeding (EIBF)). [53]. EIBF has been shown to protect newborns from infection and reduce neonatal

mortality[33], [54]–[56]. Colostrum, the first milk that is produced at the start of breastfeeding, provides protection against infection and helps support the newborn's immune system through transfer of white blood cells and antibodies[59]. Delayed initiation of breastfeeding increases the odds of neonatal mortality due to infection [33]. The WHO estimates that over 820,000 children under the age of five could be saved each year if all children aged 0-23 months were optimally breastfed. [56]

The relationship between ANC and neonatal mortality in Cameroon has been studied previously as part of pooled analyses of several low- and middle- income countries (LMIC) [34], [36]; however, Cameroon specific estimates were not generated. This relationship has also been examined in facility-based studies conducted at primarily urban hospitals in Cameroon[4], [6], [16], [19]. The facility-based studies were subject to selection bias, in that newborns included in the study were either born at or were later enrolled in the hospital where the study was conducted. These neonates or their mothers may have been considered high risk prior to birth or suffered from illness after birth, leading to their presence at the hospital, whereas babies born outside of these hospitals who did not face health complications would not be captured in the study population. To date, the relationship between ANC and NNM have not been analyzed in Cameroon using nationally representative data.

Several facility-based studies in Cameroon have quantified prevalence of EIBF and exclusive breastfeeding[28], [54], [60], [63], [64], [66], [67], however the only studies that looked at the association between breastfeeding and neonatal mortality in Cameroon were pooled analyses conducted on over 60 LMIC [33].

There is a need to understand the relationship between ANC, EIBF, and NNM in Cameroon using a nationally representative dataset. Cameroon is not on track to meet the SDG

3.2 of ending preventable deaths of children by 2030. Understanding the factors which have been shown to reduce the likelihood of NNM will inform targeted intervention strategies to drive towards meeting SDG 3.2 of reducing the neonatal mortality rate to at least as low as 12 deaths/1,000 live births by 2030. This analysis seeks to determine if ANC and EIBF affect the likelihood of NNM in Cameroon, as well as if receiving ANC affects EIBF.

III. Subjects and Methods

1. Study Design, Population, and Sample

This was a cross-sectional study using the nationally representative 2018 Cameroon Demographic Health Survey (DHS). The DHS uses a stratified two-stage cluster design where households are the sampling unit. The sample is generally representative at the national, residence (urban-rural), and regional level. Women aged 15-49 (n=13,527) were surveyed from the sampled households and provided information on all children they have given birth to (n=34,990), living or dead. Maternity and Reproduction questionnaires collect details related to ANC coverage, pregnancy, and delivery for children born within the previous 5 years (n=10,061).

2. Study Instruments

Data used in this cross-sectional study were collected using the DHS Household Questionnaire and Woman's Questionnaire. DHS processes raw data and provides recode data files which are presented in a standardized format that can be compared across countries. The Birth's Recode file (CMBR71FL) was used for analysis, which provides one record for every child that was ever born to the surveyed women. This dataset includes the full birth history of all interviewed women, information on pregnancy and postnatal

care, and, for children born within the previous 5 years, details on child immunization, health, and nutrition, was used for analysis.

3. Study Variables

The dependent variable was neonatal mortality (NNM), defined as a child which died within the first 28 days of life. The independent variables were number of ANC visits (categorized into <4 visits (0-3), 4-7 visits, and 8 or more visits), the adequacy of ANC care (where "adequate" indicates the WHO FANC guidelines of attending at least 4 ANC visits, beginning ANC visits during the first trimester, and having ANC visits attended by a skilled health worker were met), and early initiation of breastfeeding (EIBF; defined by the WHO and UNICEF as the child being breastfed ≤1 hour from birth). A separate analysis was conducted with EIBF as the dependent variable and number of ANC visits and adequacy of ANC care as the independent variables.

A review of current literature identified additional covariates. Sex of the child, household wealth index, and low birth weight (LBW, <2500 g) were tested for potential effect modification as these covariates have been shown to be associated with the independent variables (ANC and EIBF) and dependent variable (NNM). In addition to these variables, potential confounders that were tested included maternal factors (age at the time of the child's birth, education, marital status, religion, duration iron supplementation taken during pregnancy), household factors (region), and child factors (place of delivery, mode of delivery).

4. Data analysis

Data analysis was performed using univariate analysis, bivariate analysis with unadjusted odds ratio (OR) and chi-square, and multivariate logistic regression with adjusted odds

ratios (aOR). A significance level of $\alpha=0.05$ was used. Three primary relationships were explored using multivariate logistic regression models: (1) ANC on NNM, (2) EIBF on NNM, and (3) ANC on EIBF. Adjusted models controlled for maternal education and any other covariate that was observed to be a significant confounder, as defined by causing a 10% or higher difference in the crude OR versus aOR. Sex, wealth index, and LBW were tested for effect modification. Results were stratified if the interaction term for these potential effect modifiers was statistically significant ($p<0.05$). Subjects that had missing values for any of the primary variables or covariates were excluded from analysis.

The data analysis for this paper was generated using SAS software, Version 9.4. Copyright © 2016 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA. The proc surveyfreq, proc surveymeans, and proc surveylogistic procedures were used to account for complex survey design and the effect of stratification, clustering, and unequal sample weights.

IV. Results

1. Sample Characteristics

Demographic information of the study sample is presented in **Error! Reference source not found.**. Data are provided for the overall demographic breakdown of the participants of the 2018 DHS as well as for the subset of participants for which there was a complete data for the outcome and exposures of interest used to construct multivariate models. The rate of NNM decreased from 3.19% in the full survey population to 1.51% amongst the sample subset with complete data. The proportion of children whose mothers received adequate ANC coverage increased from 37% in the full survey population to 48.08% in the sample

subset with complete data. The sample subset with complete data was skewed towards higher maternal education, household wealth index, and home or health center births compared to the full survey population (See **Error! Reference source not found.**).

Of the 4,403 children with a complete dataset for analysis, about half were male (52.6%) and about 6% were born with LBW. The average maternal age was 26.6 years, with three-quarters married or living with a partner. There was a significant difference in the age distribution of mothers who had received adequate ANC Coverage compared to those who received inadequate ANC coverage, with more adolescent mothers in the latter group ($p=0.002$). The group of mothers who had adequate ANC coverage had a higher proportion aged 20-29 years compared to adolescents ($p=0.002$) and were more educated ($p<0.001$) than mothers who did not receive adequate ANC coverage. While the proportion of mothers who were Catholic or Muslim were comparable in the adequate and inadequate ANC groups, the adequate ANC group had more Protest and other Christians and less Other religions (including traditional religions) than the inadequate ANC group ($p<0.001$). The adequate ANC group had a higher proportion of Richer and Richest households compared to the inadequate ANC group ($p<0.001$).

2. Bivariate Analysis

Results of a bivariate analysis using Chi-Square to identify the determinants of NNM and EIBF are summarized in Table 2- 2 and Table 2- 3. Maternal age, maternal education, wealth index, sex of the child, and LBW were significantly associated with NNM. Maternal age, maternal education, religion, wealth index, place of birth, mode of birth, and sex of the child were significantly associated with EIBF.

3. Multivariate Analysis

a. Adequate ANC → NNM

A multivariate logistic regression model was used to assess the relationship between adequate ANC coverage and NNM (See Table 2- 4). The model adjusted for maternal education level and the following confounding variables: mother's marital status, mode of delivery, birth order number, LBW, and the number of days iron supplements were taken during pregnancy. There was no statistically significant difference in the odds of NNM amongst children whose mothers received adequate ANC coverage and those who did not (aOR 1.16 (95% CI 0.64-2.10), p=0.497). However, infants delivered by Cesarean section had more than double the odds of NNM compared to those delivered vaginally (aOR 2.48 (95% CI 1.09-5.63), p=0.030), and children born LBW had >4 times the odds of NNM compared to their normal weight counterparts (aOR 4.73 (95% CI 2.31-9.68), p=0.005). Higher birth order also demonstrated higher odds of NNM, whereby every increase in birth order number increased odds of NNM by 19% (aOR 1.19 (95% CI 1.06-1.35), p=0.005).

b. EIBF → NNM

The multivariate logistic regression model of the effect of EIBF on NNM, adjusted for maternal education and birth order number, is found in Table 2- 5. While the direction of

the adjusted odds ratio indicated that children who experienced EIBF were less likely to experience NNM, these results were not statistically significant (aOR 0.55 (95% CI 0.29-1.05), p=0.070).

c. *Adequate ANC → EIBF*

The final multivariate logistic regression model considered was the effect of adequate ANC coverage on EIBF (See Table 2- 6). This model adjusted for maternal education, mode of delivery, and LBW. There was significant interaction between adequate ANC coverage, sex of the child (p=0.011), and wealth index (p=0.011).

Adequate ANC coverage was not significantly associated with EIBF in unstratified analysis (aOR 1.05 (0.89-1.25), p=0.543). In stratified analysis, though not statistically significant, female infants receiving adequate ANC had higher odds of EIBF (aOR 1.25 (95% CI 0.99-1.59), p=0.065) while male infants receiving adequate ANC had lower odds of EIBF (aOR 0.91 (95% CI 0.74-1.11), p=0.345). When stratified by wealth index (Table 2- 7), adequate ANC was associated with reduced odds of EIBF for poorer or poorest households (aOR 0.80 (95% CI 0.57-1.12), p=0.189) but greater odds of EIBF for middle income households (aOR 1.25 (95% CI 0.88-1.77), p=0.218); The relationship among the richer or richest households appeared null (aOR 1.05 (95% CI 0.83-1.32), p=0.682).

V. Discussions

Receiving adequate ANC coverage and EIBF was not significantly associated with NNM in this nationally representative sample of mothers and infants from Cameroon after adjusting for sociodemographic and other influential covariates. When analyzed individually, the components of adequate ANC coverage (number of ANC visits (modeled either numerically or categorically), timing of the first ANC visit, and attendance of ANC by a skilled healthcare

worker) were similarly not associated with NNM (**Error! Reference source not found.**). T hese findings are inconsistent with previously published literature, in which both large-scale pooled analysis of DHS data from several LMIC countries (including Cameroon) and facility-based studies conducted in Cameroonian hospitals found the risk of NNM was reduced by attending at least one ANC visit[5], [34], [36], at least 4 ANC visits[16], [34], [36], starting ANC in the first trimester[34], or having a skilled health provider present during an ANC visit[36].

This study likely found no significant associations between ANC or EIBF and NNM due to the low neonatal mortality rate (NMR) of the study sample. 13,527 women surveyed during the 2018 Cameroon DHS provided information on 34,990 children with a reported NMR of 3.19% (N=1,116) However, of those experiencing NMR, only 4,403 children had complete data regarding ANC. Among those children with complete ANC data, the NMR was much lower at 1.51% (N=66.58) suggesting significant reporting bias. For comparison, the facility-based studies of NNM conducted in Yaoundé, Douala, and Bamenda had in-hospital NMR ranging from 9.83% to 15.70% [4], [6], [15], [16]. This reduced sample size, particularly among those experiencing the outcome of interest, led to wide confidence intervals such that even when the direction of the odds ratios was as expected and the effect size large, the results were not statistically significant. While the DHS collects a basic birth history of all children born to the interviewed mother and if have died, subsequent details of the child and pregnancy (including information on ANC and breastfeeding) are only collected for children born within the last five years. The DHS survey methodology will therefore inherently reduce the sample size of children with a complete data set to only the most recently born children.

Several studies have reported that the introduction of the WHO FANC model led to an increase in perinatal mortality (defined as death between 28 weeks gestation and 7 days after birth) [44]. As a result, the WHO revised their ANC guidelines in 2016, increasing the number of recommended ANC visits from 4 to 8. There has been conflicting opinions published in the literature regarding Cameroon's decision to adopt the 2016 WHO ANC guidelines. In 2018, only 8.9% of women attended at least 8 ANC visits with infants born in the previous 5 years, but those that did had a higher chance of receiving all recommended ANC services [51]. While most authors acknowledge the benefits of increasing ANC visits, 35% of pregnant women in Cameroon attended less than 4 ANC visits [12]; increasing the target to 8 visits may therefore not be realistic. Our study finds that children whose mothers attended at least 4 visits (4-7) and those who attended at least 8 visits (8+) had similarly null odds of NNM, (OR 0.99 (95% CI 0.63-1.54), p=0.961; OR 1.00 (95% CI 0.42-2.35), p=0.996, respectively; Table 2- 2). These relationships as well as their lack of statistical significance are likely due to the disproportionate sample distribution amongst the number of ANC visit categories in the total DHS survey sample (n=6546, Less than 4 visits 34.49%, at least 4 visits 57.79%, at least 8 visits 7.73%) compared to in the final dataset used for analysis (n=4,403, Less than 4 visits 19.98%, at least 4 visits 72.60%, at least 8 visits 11.42%). While the sample sizes for at least 4 visits and at least 8 visits remained relatively stable (3783.00 vs 3074.00 and 505.84 vs 483.57, respectively), there was a large decrease in the sample size of those attending less than 4 visits (2258.00 vs 845.90).

Several studies in the literature have suggested or observed that the quality of ANC coverage, defined as the amount of services received out of the recommended list of services, has equal to or more of an effect on pregnancy outcomes such as NNM compared to the number

of ANC visits attended [6], [36], [46]. Information on the specific services provided during ANC visits is not captured through the DHS, which is a limitation of this study as only adequacy of ANC coverage could be studied.

Low birthweight was a significant confounder in all multivariate logistic regression models studied, being associated with both the exposure (ANC) and the outcome (NNM). Prematurity is a main cause of LBW, with preterm infants generally weighing between 500g to 2400 g [6], [28]. Prematurity is also one of the top three most common clinical causes of neonatal mortality in Cameroon [4], [15]–[21]. Gestational age at the time of birth was not captured on the DHS, therefore LBW may be a proxy for prematurity. Previously published studies conducted in Cameroon hospitals have found that attending 4 or more antenatal care visits decreases the likelihood of prematurity[25], [27], and that prematurity can have up to a 20-fold increase in the risk of NNM.[4]. Several facility based studies in Cameroon observed a significant association between LBW and NNM [4], [6], [16], [20]. Given the relationship between LBW/prematurity and ANC visits as well as LBW/prematurity and NNM, it was expected that LBW would be a significant mediator.

Previously published studies found being born in a hospital was protective against neonatal mortality due to the increased access to medical resources and the ability to respond to medical issues or emergencies in a timely manner[6]. Several studies considered the place of birth as a potential confounder when identifying risks of neonatal mortality [4], [6], [15], [16], [33]–[36]. In our study, place of birth was not associated with NNM in univariate analyses and could not be included in adjusted models as a confounder because its inclusion did not allow for model convergence. This is likely due to the significant reduction in sample size for children born at

home in the complete analytical dataset (n=186) compared to the DHS survey as a whole (n=3331).

While delivery by Cesarean section did not have a significant association with NNM on its own, it was a significant confounder in the relationship between adequate ANC coverage and NNM, showing a 2.5-fold increase in the risk of NNM in the adjusted models compared to children born through vaginal delivery (p=0.030). It was not specified in the DHS data whether procedures were medically indicated or elective. The estimated prevalence of Cesarean delivery in Cameroon ranges from 3.5% to 9.9%, with the most common reasons reported as cephalopelvic disproportion, a previous Cesarean delivery, and fetal distress[13], [68]. Cesarean delivery has been shown to increase the risk of neonatal respiratory distress and birth asphyxia, both key risk factors of NNM [19]. This is likely due to a loss of the beneficial effects of manual, vaginal delivery such as a reduction in water in the lungs, increased catecholamine levels, secretion of surfactant into the alveoli, and pulmonary vasodilation. Infants requiring Cesarean delivery due to medical emergencies such as fetal distress, dystocia, and antepartum hemorrhage face additional risk of asphyxia. Since the resources for identifying these risk factors and performing Cesarean sections are limited in Cameroon, there can be a significant time delay between the onset of the child's distress and delivery by Cesarean section [68]. Despite these outcomes, the protective association between Cesarean delivery and neonatal mortality has been consistently reported in the literature [6], [37], [38]. While children requiring Cesarean delivery may have had risk factors identified prior to birth whereby the mode of delivery was chosen as an intervention to increase their likelihood of survival, once born, these children receive longer observation and follow-up within a hospital or health facility, allowing for more rapid response to indications of illness or distress. Attending

adequate ANC provides the opportunity for monitoring the child throughout pregnancy, so the need for Cesarean section if there was risk to the child would be more likely to be identified compared to children whose mothers were not attending ANC visits.

Male babies had a higher risk of NNM compared to female babies, which is consistent with previous studies conducted in Cameroon and globally[15], [34], [35], [41]. This is believed to be primarily due to biological or genetic factors as there has not been a difference observed in health seeking behaviors for male versus female children[41]. Male babies have been observed to have a higher risk of prematurity, growth restrictions within the womb, respiratory morbidities, and suppressed immune systems from high levels of testosterone, leading to infection[69], [70]. Our study found male babies were less likely to have EIBF, and sex of the child was a significant effect modifier of the relationship between adequate ANC and EIBF.

While hypothesized that attending ANC visits would improve the rates of EIBF by providing an opportunity for education on the importance of starting breastfeeding within the first hour of life, this study did not find a significant association between adequate ANC and EIBF. Sex of the child and wealth index were significant effect modifiers between adequate ANC and EIBF. When stratified by each of these variables, the effect size of the adjusted odds ratios was large but not statistically significant. This is likely due to the relatively small sample sizes in each stratum. Children born through Cesarean section were significantly less likely to have initiated breastfeeding within 1 hour, which is consistent with published literature [63], [65]. After delivery, mothers and children typically require time for recovery or additional medical attention that prevent immediate initiation of breastfeeding.

Key limitations of this study were the relatively small sample sizes after excluding those with incomplete data. The sociodemographic characteristics of the sample with complete data

did not follow the same pattern as that of the full survey, indicating that our study sample may no longer be nationally representative. Information available for this study were limited to what was included on the DHS, which excluded factors such as quality of ANC, gestational age, and the cause of death. There was the potential for recall bias as the information provided related to ANC, delivery, and EIBF were based on recall from all children born within the past five years. Due to security concerns, some zones of the Southwest region were not able to be visited while collecting data for the 2018 Cameroon DHS. Data from the Southwest are not representative of the region, and instead represent only urban areas within that region.

In conclusion, this study found that neither receiving adequate ANC nor EIBF were statistically significantly associated with NNM. Further, receipt of adequate ANC was not associated with EIBF. While the Cameroon DHS is a nationally representative dataset, sampling strategies and the questions included aren't intended to capture NNM specifically. The rate of NNM was significantly smaller in the study population compared to the rate in Cameroon as a whole. Children with adolescent mothers, mothers that did not receive an education, households in the poorer quintile, with a LBW, and who were male were significantly more likely to experience NNM. Children with adolescent mothers, mothers that did not receive an education, households that were Muslim, who were born through Cesarean section or who were male were less likely to experience EIBF, whereas those from households in the richest quintile or with mothers who received higher education were more likely to experience EIBF. These findings are consistent with previously understood risk factors and highlight the importance of providing resources to support maternal education and household economic strengthening.

VI. Tables and Figures

Table 2- 1. Demographic characteristics of Cameroon DHS 2018 and Analytical Sample used for Analysis*

Variables	Category	Total Survey Response Sample		Children Born in Previous 5 Years		Complete Analytical Sample Used for Multivariate Models						p-value
						Total		Adequate ANC Coverage		Inadequate ANC Coverage		
		N	%	N	%	N	%	N	%	N	%	
Maternal Factors												
Maternal Age	<20 years	8796	26.84%	1816	18.91%	683.2	16.1%	280	13.6%	403.17	18.5%	0.002
	20 to 35 years	21632	66.02%	6654	69.29%	2966	70.1%	1490	72.6%	1476.00	67.7%	
	35+ years	2338	7.14%	1133	11.80%	584.6	13.8%	282	13.7%	302.58	13.9%	
Highest educational level	No education	11332	32.39%	2773	27.56%	498.5	11.3%	154.5	7.3%	344.02	15.0%	<0.001
	Primary	11879	33.95%	3171	31.52%	1303	30%	522.7	24.7%	780.75	34.1%	
	Secondary	10539	30.12%	3571	35.49%	2212	50%	1162	54.9%	1049	45.9%	
	Higher	1240	3.54%	546.81	5.43%	389.9	8.9%	277.4	13.1%	112.45	4.9%	
Marital Status	Single	6155	17.59%	1663	16.53%	1045	23.7%	518.6	24.5%	526.69	23.0%	0.313
	Married or living with partner	28834	82.41%	8399	83.48%	3358	76.3%	1598	75.5%	1760	77.0%	
Religion	Catholic	12059	34.46%	3487	34.66%	1882	42.7%	1040	49.1%	841.49	36.8%	<0.001
	Protestant and Other Christian	10798	30.86%	3222	32.02%	1522	34.6%	725	34.2%	797.05	34.9%	
	Muslim	10565	30.19%	2958	29.40%	895.9	20.3%	305.3	14.4%	590.62	25.8%	
	Other	1568	4.48%	393.95	3.92%	103.7	2.4%	46.1	2.2%	57.56	2.5%	
Household												
Wealth index combined	Poorest	8004	22.88%	2264	22.50%	350.1	8.0%	101.9	4.8%	248.22	10.9%	<0.001
	Poorer	8036	22.97%	2285	22.71%	795.3	18.1%	291.2	13.8%	504.05	22.0%	
	Middle	7205	20.59%	2025	20.13%	980.6	22.3%	384.6	18.2%	595.99	26.1%	
	Richer	6430	18.38%	1935	19.23%	1193	27.1%	625.8	29.6%	567.12	24.8%	
	Richest	5315	15.19%	1553	15.44%	1084	24.6%	713.1	33.7%	371.34	16.2%	
Child/Birth												
Place of Birth	Home	3331	33.11%	3331	33.11%	186.0	4.2%	77.6	3.7%	108.44	4.7%	<0.001
	Hospital	3121	31.02%	3121	31.02%	2091	47.5%	1151	54.4%	939.79	41.1%	
	Health Center	3609	35.87%	3609	35.87%	2126	48.3%	887.6	41.9%	1238	54.2%	
Sex of child	Male	17918	51.21%	5179	51.48%	2317	52.6%	1094	51.7%	1223	53.5%	0.318
	Female	17072	48.79%	4882	48.52%	2086	47.4%	1022	48.3%	1064	46.5%	
Low Birth weight (<2500g)	Yes	470.54	7.23%	470.54	7.23%	289.3	6.6%	129.3	6.1%	159.96	7.0%	0.327
	No	6034	92.76%	6034	92.76%	4114	93.4%	1987	93.9%	2127	93.0%	

*Data presented as weighted estimates adjusted for sample weights

Table 2- 2. Determinants of Neonatal Mortality (an analysis by Chi Square)

Variables	Neonatal Mortality				OR	95% CI		p
	No		Yes					
	N	%	N	%		Lower limit	Upper limit	
Breastfeeding								
EIBF								
Yes	3661	99.32%	24.67	0.67%	0.54	0.28	1.04	0.059
No	2238	98.76%	27.79	1.23%				
Antenatal Care								
Number of ANC visits								
Less than 4 visits (0-3)	2213	98.01%	44.90	1.99%	--	--	--	--
At least 4 visits, less than 8 (4-7)	3709	98.04%	74.24	1.96%	0.99	0.63	1.54	0.961
At least 8 visits (8+)	495.82	98.02%	10.01	1.98%	1.00	0.42	2.35	0.996
Adequate ANC								
Yes	2365	97.65%	57.02	2.35%	1.35	0.86	2.13	0.187
No	4052	98.25%	72.12	1.75%				
Maternal Factors								
Maternal Age Category								
<20 years	8421	95.74%	374.98	4.26%	1.60	1.34	1.92	0.023
20 to 35 years	21047	97.30%	585.29	2.71%	--	--	--	--
35+ years	2244	95.98%	94.50	4.04%	1.52	1.13	2.03	0.245
Highest educational level								
No education	10879	96.00%	453.05	4.00%	1.39	1.05	1.85	0.014
Primary	11534	97.10%	344.60	2.90%	--	--	--	--
Secondary	10257	97.32%	282.50	2.68%	0.92	0.74	1.15	0.087
Higher	1204	97.10%	35.67	2.88%	0.99	0.63	1.55	0.676
Marital Status								
Single	5940	96.51%	215.63	3.50%	1.13	0.90	1.42	0.307
Married or living with partner	27934	96.88%	900.19	3.12%				
Religion								
Catholic	11683	96.88%	375.07	3.11%	1.15	0.71	1.86	0.915
Protestant and Other Christian	10471	96.97%	326.91	3.03%	1.12	0.70	1.79	0.835
Muslim	10194	96.49%	371.12	3.51%	1.30	0.78	2.18	0.240
Other	1526	97.32%	42.73	2.72%	--	--	--	--
Iron Supplements During Pregnancy								
Yes	5129	98.05%	102.08	1.95%	0.94	0.58	1.54	0.805
No	1329	97.94%	28.13	2.07%				
Household								
Wealth index combined								
Poorest	7705	96.26%	298.48	3.73%	1.13	0.87	1.46	0.324
Poorer	7767	96.65%	269.12	3.35%	1.26	0.96	1.66	0.027
Middle	6990	97.02%	214.75	2.98%	--	--	--	--
Richer	6225	96.81%	205.28	3.19%	1.07	0.82	1.40	0.736
Richest	5187	97.59%	128.20	2.41%	0.81	0.59	1.09	0.025
Child/Birth								
Place of Birth								
Home	3233	97.06%	98.63	2.96%	0.93	0.62	1.39	0.623
Hospital	3021	96.80%	99.47	3.19%	--	--	--	--
Health Center	3526	97.70%	82.85	2.30%	0.71	0.50	1.03	0.083
Mode of Delivery								
Cesarean Section	341.47	95.78%	15.06	4.22%	1.56	0.86	2.85	0.141
Vaginal	9419	97.25%	265.89	2.75%				
Sex of child								
Male	17290	96.50%	627.60	3.50%	1.23	1.08	1.41	0.002
Female	16584	97.14%	488.22	2.86%				
Low Birth weight (<2500g)								
Yes	433.04	92.03%	37.50	7.97%	5.11	3.20	8.16	<0.001
No	5934	98.34%	100.55	1.67%				

Table 2- 3. Determinants of Early Initiation of Breastfeeding (an analysis by Chi Square)

Variables	EIBF				OR	95% CI		p
	No		Yes			Lower limit	Upper limit	
	N	%	N	%				
Antenatal Care								
Number of ANC visits								
Less than 4 visits (0-3)	792.07	39.06%	1236	60.95%	--	--	--	--
At least 4 visits, less than 8 (4-7)	1288	37.74%	2125	62.26%	1.06	0.91	1.23	0.512
At least 8 visits (8+)	175.30	38.84%	275.99	61.16%	1.01	0.76	1.33	0.881
Adequate ANC								
Yes	809.78	37.51%	1349	62.48%	1.05	0.92	1.21	0.468
No	1445	38.71%	2288	61.29%				
Maternal Factors								
Maternal Age Category								
<20 years	410.50	41.06%	589.21	58.94%	0.87	0.73	1.03	0.020
20 to 35 years	1466	37.64%	2429	62.36%	--	--	--	--
35+ years	283.87	35.22%	522.08	64.78%	1.11	0.90	1.37	0.073
Highest educational level								
No education	665.73	42.46%	901.83	57.51%	0.81	0.64	1.02	0.002
Primary	667.52	37.44%	1116	62.59%	--	--	--	--
Secondary	832.14	36.97%	1419	63.04%	1.02	0.86	1.21	0.622
Higher	100.21	28.70%	248.93	71.30%	1.49	1.09	2.04	0.002
Marital Status								
Single	437.75	38.81%	690.53	61.22%	0.96	0.82	1.13	0.635
Married or living with partner	1828	37.90%	2995	62.10%				
Religion								
Catholic	760.08	36.02%	1350	63.98%	1.01	0.69	1.47	0.326
Protestant and Other Christian	694.13	35.97%	1236	64.04%	1.01	0.70	1.45	0.246
Muslim	727.11	43.36%	950.27	56.66%	0.74	0.50	1.09	0.006
Other	84.28	36.13%	149.00	63.87%	--	--	--	--
Iron Supplements During Pregnancy								
Yes	1813.00	38.50%	2896	61.50%	0.92	0.76	1.11	0.360
No	445.18	36.43%	776.94	63.58%				
Household								
Wealth index combined								
Poorest	512.84	41.03%	737.10	58.97%	1.05	0.83	1.33	0.085
Poorer	514.72	39.20%	798.61	60.82%	1.14	0.91	1.42	0.409
Middle	504.92	42.25%	689.72	57.72%	--	--	--	--
Richer	424.42	35.67%	765.49	64.33%	1.32	1.05	1.66	0.296
Richest	308.70	30.75%	694.81	69.20%	1.65	1.31	2.07	<0.001
Child/Birth								
Place of Birth								
Home	783.84	42.10%	1078	57.89%	0.75	0.61	0.91	0.005
Hospital	683.84	35.23%	1257	64.76%	--	--	--	--
Health Center	797.91	37.13%	1351	62.87%	0.92	0.78	1.09	0.401
Mode of Delivery								
Cesarean Section	150.89	62.60%	90.14	37.40%	0.35	0.25	0.49	<0.001
Vaginal	2110	37.04%	3586	62.96%				
Sex of child								
Male	1225	39.47%	1879	60.53%	0.88	0.78	1.00	0.041
Female	1041	36.56%	1807	63.47%				
Low Birth weight (<2500g)								
Yes	88.87	34.85%	166.15	65.15%	1.07	0.78	1.48	0.670
No	1370	36.43%	2390	63.55%				

Table 2- 4. Multiple Logistic Regression – Adequate ANC Coverage and NNM

Independent Variables	aOR	95% CI		p
		Lower limit	Upper limit	
Adequate ANC Coverage	1.16	0.64	2.10	0.195
Highest educational level				
No education	0.79	0.24	2.64	0.69
Primary	--	--	--	--
Secondary	0.91	0.48	1.73	0.87
Higher	1.14	0.40	3.20	0.65
Marital Status				
Single	1.72	0.92	3.23	0.092
Married or living with partner	--	--	--	--
Mode of Delivery				
Cesarean Section	2.48	1.09	5.63	0.030
Vaginal	--	--	--	--
Birth order number	1.19	1.06	1.35	0.005
Low Birth weight (<2500g)	4.73	2.31	9.68	0.005
Duration Iron Supplements Taken (Days)	1.00	1.00	1.00	0.439
		N observation = 3809		
		-2 log likelihood = 577.525		
		Nagelkerke R^2 = 0.0661		

Table 2- 5. Multiple Logistic Regression – EIBF and NNM

Independent Variables	aOR	95% CI		p
		Lower limit	Upper limit	
EIBF	0.55	0.29	1.05	0.070
Birth order number	1.17	1.04	1.30	0.007
Highest educational level				
No education	0.82	0.41	1.65	0.90
Primary	--	--	--	--
Secondary	0.61	0.27	1.40	0.27
Higher	1.04	0.27	3.98	0.67
		N observation = 5787		
		-2 log likelihood = 582.983		
		Nagelkerke R^2 = 0.0313		

Table 2- 6. Multiple Logistic Regression –Adequate ANC Coverage and EIBF, Stratified by Sex

Independent Variables	aOR	95% CI		p	Sex of Child							
					Male				Female			
					aOR	95% CI		p	aOR	95% CI		p
		Lower limit	Upper limit			Lower limit	Upper limit			Lower limit	Upper limit	
Adequate ANC	1.05	0.89	1.25	0.543	0.91	0.74	1.11	0.345	1.25	0.99	1.59	0.065
Highest educational level												
No education	0.96	0.68	1.36	0.199	1.09	0.69	1.71	0.892	0.84	0.52	1.35	0.063
Primary	--	--	--	--	--	--	--	--	--	--	--	--
Secondary	1.02	0.83	1.26	0.216	0.98	0.71	1.34	0.238	1.09	0.84	1.41	0.560
Higher	1.64	1.17	2.29	0.002	1.44	0.91	2.28	0.106	1.94	1.19	3.16	0.003
Mode of Delivery												
Cesarean Section	0.29	0.20	0.41	<.0001	0.29	0.17	0.47	<.0001	0.30	0.18	0.49	<.0001
Vaginal	--	--	--	--	--	--	--	--	--	--	--	--
Low Birth weight (<2500g)	1.14	0.83	1.58	0.417	1.30	0.77	2.18	0.328	1.02	0.67	1.56	0.932
	N observation = 3943				N observation = 2072				N observation = 1881			
	-2 log likelihood = 5099.781				-2 log likelihood = 2681.017				-2 log likelihood = 2405.760			
	Nagelkerke R^2 = 0.0309				Nagelkerke R^2 = 0.0367				Nagelkerke R^2 = 0.0329			

Table 2- 7. Multiple Logistic Regression – Adequate ANC Coverage and EIBF - Stratified by Wealth Index

Independent Variables	Wealth Index											
	Poorer or Poorest				Middle				Richer or Richest			
	aOR	95% CI		p	aOR	95% CI		p	aOR	95% CI		p
		Lower limit	Upper limit			Lower limit	Upper limit			Lower limit	Upper limit	
Adequate ANC	0.80	0.57	1.12	0.189	1.25	0.88	1.77	0.218	1.05	0.83	1.32	0.682
Highest educational level												
No education	0.94	0.55	1.63	0.745	0.88	0.50	1.53	0.695	0.99	0.57	1.72	0.519
Primary	--	--	--	--	--	--	--	--	--	--	--	--
Secondary	0.88	0.58	1.32	0.487	0.86	0.62	1.19	0.555	1.09	0.79	1.49	0.723
Higher	1.36	0.25	7.39	0.658	1.19	0.29	4.93	0.710	1.51	0.99	2.30	0.037
Mode of Delivery												
Cesarean Section	0.12	0.05	0.30	<.0001	0.32	0.14	0.70	0.005	0.31	0.20	0.48	<.0001
Vaginal	--	--	--	--	--	--	--	--	--	--	--	--
Low Birth weight (<2500g)	1.85	0.81	4.22	0.145	1.20	0.77	1.89	0.426	0.88	0.53	1.47	0.622
	N observation = 1057				N observation = 875				N observation = 2021			
	-2 log likelihood = 1362.868				-2 log likelihood = 1173.827				-2 log likelihood = 2530.138			
	Nagelkerke R^2 = 0.0480				Nagelkerke R^2 = 0.0231				Nagelkerke R^2 = 0.0355			

Chapter 3: Future Directions/Public Health Implications

Future Directions

While the primary exposures did not have a significant association with NNM in this study, the benefits of ANC and EIBF have been widely observed in the literature. The lack of significance in the studied associations is most likely due to the lack of statistical power, as the sample size that had a complete analytical dataset with all variables of interest was significantly smaller than the total sample size available in the DHS dataset. While the DHS is a powerful tool for obtaining nationally representative information regarding demographic and health indicators, it was not the strongest tool for this research question. The data provided offered a wider look across Cameroon than previously conducted studies which were conducted by individual hospitals in urban or suburban areas, but its sampling strategies are not specifically intended to find pregnant women or recent mothers and are not intended to seek out families who experienced a neonatal death. The level of detail covered by the DHS questions provides an overview of the usage of ANC or breastfeeding but did not get to the level of detail often collected in a study designed specifically for these topics. Since information collected regarding children are based on all children born in the past five years, the data collected is dependent on the memory of the women interviewed and it would not be appropriate to ask more detailed questions that are unlikely to be recalled with accuracy (such as what specific services were provided during ANC for each pregnancy, gestational age, etc.).

To be more likely to achieve statistical significance when studying ANC, EIBF, and NNM, future studies should focus on collecting data during and after pregnancy from a network of data sources, including a variety of health facility types (hospital, health centers, etc.) and locations (urban, suburban, and rural). This can help combine the strengths of the existing facility-based studies (targeted to population of interest, can collect information directly from

health records rather than recall, outcome of interest observed at a higher rate) and the DHS (wider dataset that is more representative of the country as a whole).

Public Health Implications

This study found that children with adolescent mothers, mothers that did not receive an education, or households in the poorer quintile were at an increased risk of NNM. Being from a poorer household limits the ability for a mother to seek medical care for themselves during pregnancy, including seeking medical care and receiving proper nutrition, which put them and their child at a higher risk. These mothers often have to continue working during their pregnancy, even if their work is physically demanding, which can put further strain on their health. Adolescent mothers and mothers who did not receive an education are likely to fall into these same risks, as adolescents are less likely to be financially stable, and women that did not receive an education likely did not because their family could not afford to send them to school. Similarly, children with adolescent mothers or mothers that did not receive an education are less likely to have early initiation of breastfeeding, possibly due to a lack of awareness or education on the benefits of EIBF that they would otherwise receive from health visits or school. Programs focused on providing resources to poorer households, including household economic strengthening programs and health education (youth sexual and reproductive health as well as health information for already pregnant adolescents and women) will offer a targeted approach aimed at a population most at risk of experiencing NNM and least likely to initiate breastfeeding early.

Appendix

Supplemental Data Tables

Table S- 1. Additional demographic characteristics of Cameroon DHS 2018 and Analytical Sample*

Variables	Category	Total Survey Response Sample		Children Born in Previous 5 Years		Complete Analytical Sample Used for Multivariate Models						p-value
						Total		Adequate ANC Coverage		Inadequate ANC Coverage		
		N	%	N	%	N	%	N	%	N	%	
Outcome												
Neonatal Mortality	Yes	1116	3.19%	280.95	2.79%	66.58	1.5%	37.1	1.8%	29.52	1.3%	0.245
	No	33874	96.81%	9780	97.21%	4337	98.5%	2080	98.3%	2257	98.7%	
Breastfeeding												
EIBF	Yes	3686	61.94%	3686	61.94%	2509	63.5%	1203	63.9%	1306	63.1%	0.665
	No	2266	38.08%	2266	38.08%	1444	36.5%	679.6	36.1%	764.72	36.9%	
Antenatal Care												
First ANC visit during first trimester	Yes	2702	46.93%	2702	46.93%	2265	52.5%	2117	100.0%	148.21	6.7%	N/A
	No	3056	53.07%	3056	53.07%	2049	47.5%	0	0.0%	2049	93.3%	
Number of ANC visits, categorical	Less than 4 visits (0-3)	2258	34.49%	2258	34.49%	845.90	20.0%	0	0.0%	845.90	38.8%	N/A
	At least 4 visits, less than 8 (4-7)	3783	57.79%	3783	57.79%	3074	72.6%	1724	84.0%	1350	61.9%	
	At least 8 visits (8+)	505.84	7.73%	505.84	7.73%	483.57	11.4%	392.7	19.1%	90.87	4.2%	
At least 4 ANC visits	Yes	4289	65.52%	4289	65.52%	3557	80.8%	2117	100.0%	1441	63.0%	N/A
	No	2258	34.49%	2258	34.49%	845.90	19.2%	0	0.0%	845.90	37.0%	
At least 8 ANC visits	Yes	505.84	7.73%	505.84	7.73%	483.57	11.0%	392.7	18.5%	90.87	4.0%	<0.001
	No	6041	92.29%	6041	92.29%	3920	89.0%	1724	81.4%	2196	96.0%	
ANC attended by skilled healthcare worker	Yes	5756	87.04%	5756	87.04%	4313	98.0%	2117	100.0%	2196	96.0%	N/A
	No	856.55	12.95%	856.55	12.95%	90.64	2.1%	0	0.0%	90.64	4.0%	
Adequate ANC (4 visits + skilled health worker)	Yes	2422	37.00%	2422	37.00%	2117	48.1%	2117	100.0%	0	0.0%	<0.001
	No	4124	63.00%	4124	63.00%	2287	55.5%	0	0.0%	2287	100.0%	
Adequate ANC (8 visits + skilled health worker)	Yes	411.41	6.28%	411.41	6.28%	392.70	8.9%	392.7	18.5%	0	0.0%	N/A

	No	6135	93.72%	6135	93.72%	4011	91.1%	1724	81.4%	2287	100.0%	
Maternal Factors												
Iron Supplements During Pregnancy	Yes	5231	79.40%	5231	79.40%	4062	92.5%	2017	95.5%	2045	89.7%	<0.001
	No	1357	20.60%	1357	20.60%	330.3	7.5%	95.9	4.5%	234.34	10.3%	
Household												
Region	Far North	1762	5.04%	1927	19.15%	456.6	10.4%	170.3	8.0%	286.22	12.5%	<0.001
	North	3464	9.90%	1580	15.70%	337.4	7.7%	79.6	3.8%	257.84	11.3%	
	Adamawa	3070	8.77%	462.43	4.60%	133.3	3.0%	60.3	2.8%	72.98	3.2%	
	North West	2288	6.54%	588.64	5.85%	338.6	7.7%	136.5	6.4%	202.05	8.8%	
	South West	6872	19.64%	135.46	1.35%	96	2.2%	44.3	2.1%	51.61	2.3%	
	West	1181	3.38%	1065	10.59%	632.4	14.4%	284.7	13.5%	347.62	15.2%	
	East	5604	16.02%	712.46	7.08%	263.6	6.0%	125.6	5.9%	137.94	6.0%	
	Center (without Yaoundé)	2138	6.11%	1107	11.00%	539.8	12.3%	252.4	11.9%	287.37	12.6%	
	Littoral (without Douala)	3837	10.97%	325.27	3.23%	213.3	4.8%	95.1	4.5%	118.21	5.2%	
	South	1560	4.46%	465.46	4.63%	244.1	5.5%	116.4	5.5%	127.69	5.6%	
	Yaoundé	454.05	1.30%	861.61	8.56%	545.8	12.4%	356.6	16.8%	189.22	8.3%	
	Douala	2759	7.89%	832.09	8.27%	602.7	13.7%	394.7	18.6%	207.99	9.1%	
Child/Birth												
Mode of Delivery	Cesarean Section	356.54	3.55%	356.54	3.55%	262.8	6.0%	173.6	8.2%	89.15	3.9%	<0.001
	Vaginal	9685	96.44%	9685	96.44%	4141	94.0%	1943	91.8%	2198	96.1%	

*Data presented as weighted estimates adjusted for sample weights

Table S- 2. Additional demographic characteristics of Cameroon DHS 2018 and Analytical Sample used for Analysis* (continuous data)

Variables	Total Survey Response Sample		Complete Analytical Sample Used for Multivariate Models						p-value
			Total		Adequate ANC Coverage		Inadequate ANC Coverage		
	Mean	SE of Mean	Mean	SE of Mean	Mean	SE of Mean	Mean	SE of Mean	
Antenatal Care									
Timing of 1st antenatal check (months)	3.77	0.03	3.58	0.03	2.60	0.02	4.53	0.03	<.0001
Maternal Factors									
Maternal Age (years)	24.26	0.06	26.60	0.13	26.94	0.16	26.28	0.19	0.01
Duration Iron Supplements Taken (days)	120.95	1.91	131.65	2.05	152.81	2.95	111.20	2.20	<.0001
Child/Birth									
Birth order number	3.15	0.03	3.30	0.04	3.05	0.06	3.52	0.06	<.0001
Birthweight (kg)	3424.37	16.54	3428.14	15.04	3439.49	21.24	3417.63	17.76	0.38

*Data presented as weighted estimates adjusted for sample weights

Table S- 3. Additional Variables - Determinants of Neonatal Mortality (an analysis by Chi Square)

Variables	Neonatal Mortality				Unadjusted OR	95% CI		p-value
	No		Yes			Lower limit	Upper limit	
	N	%	N	%				
Antenatal Care								
First ANC visit during first trimester								
Yes	2638.00	97.63%	64.31	2.38%	1.41	0.89	2.25	0.142
No	3004.00	98.30%	51.80	1.70%				
At least 4 ANC visits								
Yes	4205.00	98.04%	84.25	1.96%	0.99	0.63	1.55	0.956
No	2213.00	98.01%	44.90	1.99%				
At least 8 ANC visits								
Yes	495.82	98.02%	10.01	1.98%	1.00	0.47	2.17	0.992
No	5921.00	98.01%	119.13	1.97%				
ANC attended by skilled healthcare worker								
Yes	5640.00	97.98%	116.11	2.02%	1.17	0.66	2.07	0.597
No	841.69	98.27%	14.85	1.73%				
Adequate ANC (8 visits + skilled health worker+first trimester)								
Yes	402.42	97.81%	8.99	2.19%	1.12	0.49	2.56	0.790
No	6015.00	98.04%	120.15	1.96%				
Household								
Region								
Far North	6640.00	96.62%	232.24	3.38%	1.34	0.85	2.11	0.336
North	5355.00	95.56%	249.28	4.45%	1.78	1.22	2.61	0.001
Adamawa	1699.00	96.42%	63.49	3.60%	1.43	0.95	2.16	0.116
North West	2085.00	97.52%	52.75	2.47%	0.97	0.60	1.55	0.398
South West	439.74	96.85%	14.30	3.15%	1.25	0.65	2.39	0.732
West	3723.00	97.03%	113.99	2.97%	1.17	0.81	1.70	0.779
East	2203.00	96.28%	85.50	3.74%	1.49	0.99	2.22	0.060
Center (without Yaoundé)	3375.00	97.43%	88.21	2.55%	--	--	--	--
Littoral (without Douala)	1166.00	98.73%	14.58	1.23%	0.48	0.28	0.83	<0.001
South	1513.00	96.99%	46.63	2.99%	1.18	0.81	1.72	0.752
Yaoundé	2677.00	97.03%	81.68	2.96%	1.17	0.75	1.81	0.850
Douala	2996.00	97.59%	73.17	2.38%	0.93	0.59	1.48	0.281

Table S- 4. Additional Variables - Determinants of Early Initiation of Breastfeeding (an analysis by Chi Square)

Variables	EIBF				Unadjusted OR	95% CI		p-value
	No		Yes			Lower limit	Upper limit	
	N	%	N	%				
Antenatal Care								
First ANC visit during first trimester								
Yes	886.77	36.87%	1518.00	63.12%	1.14	0.99	1.32	0.072
No	1116.00	39.94%	1678.00	60.06%				
At least 4 ANC visits								
Yes	1463.00	37.86%	2401.00	62.14%	1.05	0.90	1.22	0.512
No	792.07	39.06%	1236.00	60.95%				
At least 8 ANC visits								
Yes	175.30	38.84%	275.99	61.16%	0.97	0.76	1.25	0.837
No	2080.00	38.23%	3361.00	61.77%				
ANC attended by skilled healthcare worker								
Yes	2003.00	38.53%	3195.00	61.47%	0.85	0.68	1.07	0.160
No	262.44	34.84%	490.77	65.16%				
Adequate ANC (8 visits + skilled health worker+first trimester)								
Yes	142.06	38.96%	222.54	61.04%	0.97	0.73	1.29	0.830
No	2113.00	38.22%	3415.00	61.78%				
Household								
Region								
Far North	470.63	43.10%	621.33	56.90%	1.11	0.78	1.58	0.037
North	374.48	42.70%	502.54	57.30%	1.13	0.84	1.52	0.012
Adamawa	110.74	38.92%	173.77	61.08%	1.32	0.94	1.85	0.366
North West	149.24	37.05%	253.56	62.95%	1.43	1.05	1.94	0.719
South West	34.88	34.84%	65.24	65.16%	1.57	0.87	2.83	0.835
West	261.95	46.80%	297.74	53.20%	0.96	0.69	1.33	0.001
East	93.80	22.10%	330.61	77.90%	2.96	1.93	4.56	<0.001
Center (without Yaoundé)	290.63	45.68%	345.63	54.32%	--	--	--	--
Littoral (without Douala)	64.79	30.72%	146.14	69.28%	1.90	1.37	2.62	0.054
South	110.50	39.74%	167.57	60.26%	1.28	0.90	1.80	0.257
Yaoundé	166.69	31.86%	356.51	68.14%	1.80	1.27	2.56	0.182
Douala	137.26	24.41%	425.07	75.59%	2.60	1.64	4.14	0.005

Table S- 5. Operational Definitions of Variables Including Variable Names from DHS record file (CMBR71FL)

NNM was defined as a child which died within the first 28 days of life. This is a binary variable constructed from DHS variables B5 (binary indicator for "Child is alive") and B6 ("Age at death").

EIBF was defined as the child being breastfed ≤1 hour from birth. EIBF was constructed from M34 (Time after the birth at which the respondent first breastfed the child).

Number of ANC visits (M14) was a continuous variable with the reported number of ANC visits the mother attended while pregnant.

Number of ANC visits (ANCcat) was categorized into <4 visits (0-3), 4-7 visits, and 8 or more visits. These categories were chosen based on the WHO FANC recommendation of attending at least 4 ANC visits and the updated 2016 WHO recommendation of attending at least 8 ANC visits.

Adequate ANC Coverage (ANCadq4) was defined as attending at least 4 ANC visits (M14), beginning ANC visits during the first trimester (from M13 "Timing of 1st antenatal check (months)"), and having ANC visits attended by a skilled health worker (from M2A ("doctor"), M2B ("nurse/Midwife"), M2C ("auxiliary midwife"), M2H("community/village health worker")).

Maternal age at time of child's birth (matagecat) was calculated from B3 ("Century month code for the date of birth of the child") and V011 ("Century month code of date of birth of respondent"), then categorized into <20 (adolescence), 20 to 35 years, and 35+ years (advanced maternal age).

Maternal education (matedu) was taken from V106 ("Highest education level" - No education, Primary, Secondary, or Higher).

Mother's marital status (maritalstatus) was constructed from V501 ("Current marital status"), where never in union, widowed, divorced, and no longer living together/separated were considered "Single" and married or living with partner was combined to "Married or living with partner".

Religion was constructed from V130, with collapsed categories of "Catholic," "Protestant or Other Christian," "Muslim," and "Other."

Wealth index quantiles (wealthindex) were taken from V190 ("Poorest," "Poorer," "Middle," "Richer," "Richest"). Collapsed wealth index categories (**wealthindexcol**) were used for stratification ("Poorer or Poorest," "Middle," "Richer or Richest").

Region was taken from V024 ("Region") and represents the 10 geopolitical regions of Cameroon.

Place of Delivery (placeofbirth) indicates if the child was delivered at a hospital, a health center, or at home/other location. It was constructed from M15 ("Place of delivery").

Low Birth Weight (LBW) was defined as having a birth weight <2500 g, as indicated by M19 ("Birthweight (kg)").

Mode of Delivery (csection) indicates if the child was delivered vaginally or through a Cesarean Section, as indicated in M17 ("Delivery by caesarean section").

Sex is the biological sex of the child (from B4 "Sex of child").

Iron Supplements During Pregnancy indicates if the mother was given or bought iron tablets or syrup during pregnancy, taken from M45. **Duration Iron Supplements Taken (Days)** is the number of days iron tablets or syrup was taken (from M46). These variables serve as proxies for anemia, since data on maternal anemia was only collected on a subset of surveyed women.

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