INVESTIGATING THE DETERMINANTS OF NEONATAL SEPSIS IN LIBERIA

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A thesis submitted in partial fulfilment of the requirement for the degree of

Master of Science in Public Health

by Jamesetta Beh

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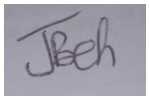
X 

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ABSTRACT

Background: N**e**onat**al** sepsis, a systemic inflammatory response syndrome from infection caused by bacteria, viruses, or fungi, continues to be one of the leading causes of hospitalization and deaths among neonates in Liberia. Severe infection accounts for about 28% of newborn mortality in Liberia which stands currently at 37 deaths per 1000 live births according to the LDHS 2019-2020 report and UNICEF reported 22% of all neonatal deaths in Liberia were as a result of sepsis in 2016.

Objective: The research aimed to explore the multitude of factors associated with neonatal sepsis in Liberia.

Study method: A review of relevant literature from across Sub-Saharan Africa was done with analysis being guided by a framework developed for the unique purpose of this study based on the child survival framework from Mosley and Chen and factors influencing neonatal mortality from Titaley et al.

Findings: Improper umbilical cord care at home, poor hygiene practices during home delivery and inadequate supply of infection prevention and control materials to health facilities were found to have contributed to neonatal sepsis in Liberia. Other major contributing factors included the late initiation of antenatal care by young mothers, complications of female genital mutilation during pregnancy and delivery and traditional childbirth practices while maternal age, parity, birth interval, political and economic factors played significant roles.

Conclusion and recommendation: Several factors related to infection prevention and control, were found to be associated with increased occurrences of neonatal sepsis and lower socio-economic status was associated with poor hygiene practices. Policies on chlorhexidine umbilical cord care and improved hand hygiene practices have been recommended.

Key words: “Neonatal sepsis”, “Liberia”, “umbilical cord care”, “cultural cord practices” Sub-Saharan Africa.

Word Count: 12,578

List of Abbreviations

ANC	Antenatal care
AOR	Adjusted odds ratio
BPHS	Basic package of health services
CL	Confidence Interval
COR	Crude odd ratio
EVD	Ebola Virus Disease
EPHS	Essential package of health services
EONS	Early onset neonatal sepsis
FGM	Female genital mutilation
GDP	Gross domestic product
IPC	Infection prevention and Control

JFK	John Fitzgerald Kennedy Hospital
LDHS	Liberia demographic health survey
LONS	Late onset neonatal sepsis
MOH	Ministry of health
NICU	Neonatal Intensive Care Unit
OR	Odd ratio
RMNCAH	Reproductive Maternal, Neonatal, Child, Adolescent, Health
WHO	World health organization

Glossary of Terms

Apgar score: is a quick test performed on a baby at 1 and 5 minutes after birth. The 1-minute score determines how well the baby tolerated the breathing process. The 5-minute score tells the health care provider how well the baby is doing outside the mother's womb(1).

Early onset neonatal sepsis: Sepsis occurring in preterm in the first three days of life, caused by bacterial pathogens transmitted vertically from mother to infant before or during delivery.(2)

Late onset neonatal sepsis: sepsis occurring after 72 hours in neonatal intensive care unit and 7 days of life in term infants. It usually occurs up to or less than 90 days or 120 days and may be caused by vertically or horizontally acquired pathogens.(2)

Female genital mutilation: involves the partial or total removal of the external female genitalia or other injuries to the female genital organs for non-medical reasons. (3)

Gestational age: gestational age is the common term used during pregnancy to describe how far along the pregnancy is. It is measured in weeks, from the first day of the woman's menstrual cycle to the current date. The normal pregnancy can range from 38 to 42 weeks. gestation is the period of time between conception and birth. During this time, the baby grows and develop inside the mother's womb.(4)

Neonatal sepsis: is a blood infection that occurs in an infant younger than 90days old, it can be caused by bacteria such as Escherichia coli, Listeria, and some strains of Group B streptococcal.

CHAPTER ONE: BACKGROUND

1.1 Country Context

Liberia is a Country located in West Africa surrounded by Sierra Leone to the northwest, to the north is the Republic of Guinea, Ivory Coast is to the east and the Atlantic Ocean lies at its south and southwest. It has a total area of 111,369km^2 with 96,320km^2 land and 15km^2 water.(5)The country is divided into five geographical regions and 15 counties with 93 health districts along with 839 health facilities. Grand Kru County has the smallest population of 57,913 people while Montserrado County has the highest population of 1.1million inhabitants.(5–7) Monrovia is its capital and the home of 25% of the urban population, while 52% live in other urban cities. There are 16 indigenous or ethnic groups that make up 95% of the population.(5,7)

They are: Gio (or Dan), Mano, Bassa, kpelle, Grebo, Krahn, Madingo, Kru, Mende, Vai, Gola, Fanti, Lorma, Dei, Belle, Americo-Liberians, or Congo people. The ethnic minority form 25% of the total population.

Also, 85.5% of Liberians are Christians of which 7.2% are Catholics. Muslims make up 12.2% of the religion of Liberia. The Population of Liberia is approximately 5.2 million of which one-third comprised of adolescents and youth (10-24). Liberia has a population density of 47.64/km^2 and an annual growth rate of 2.44%. The country ranks 122nd in the world in terms of population density. About 1.2 million women in Liberia are in the reproductive age of 15-49, with a life expectancy of 66.5 years while men have a life expectancy of 63.5 years.(7)(8)

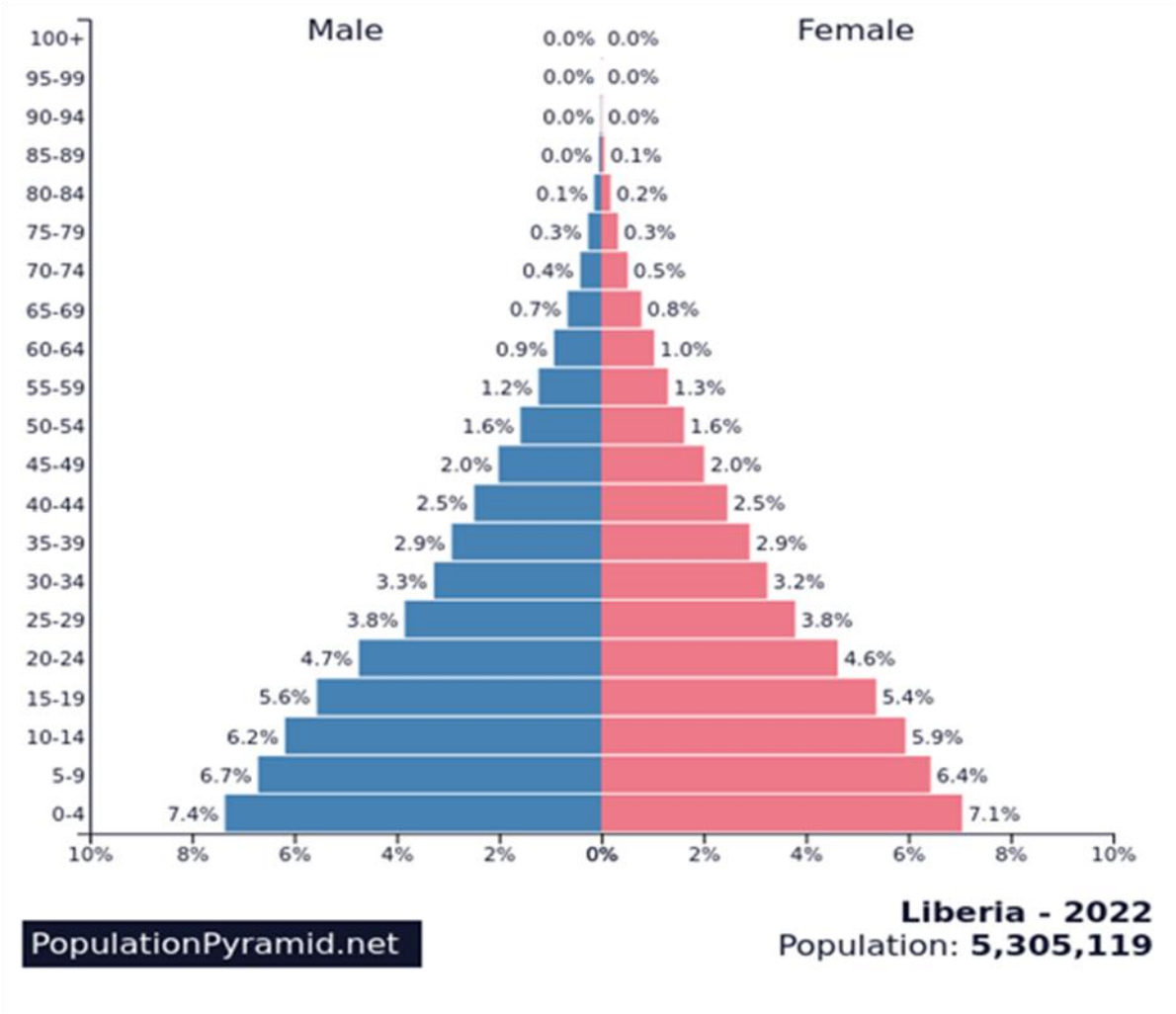

Figure 1 Population pyramid of Liberia (5)

1.2 Socio-economic Background

Liberia is amongst the world's poorest countries with over 2.2 million of its citizens reportedly not being able to afford basic food in 2016. This includes about 58% of the population living below the poverty line of 1.25 United States dollars per day while 48% is considered to be in extreme poverty.(11) These conditions were made even worse with the increased incidence of adolescent and teen pregnancies, intimate partner violence and school closure, along with multiple health events including the COVID-19 pandemic. Despite being among the poorest countries, Liberia is rich in iron ore, gold, diamond, fertile soil, fishery, and forestry. Liberia's Gross Domestic Products (GDP) is projected to have increased by 4.9% in 2022/2023 following the initial dip due to the Ebola at 2.5% in 2016 and 2.6% in 2021.The GDP is expected to regain its pre-COVID-19 status by 2023, and the economy growth is anticipated to be directed by the mining sector and external demand, while structural reforms are to increase mining, agriculture, and construction activities.(8,9)

1.3 Healthcare System and Financing

The 14 years of civil war in Liberia, which lasted from 1989 to 2003, debilitated the health system and resulted in shortages of the health workforce and infrastructure. Although significant progress has been made in the post war rebuilding process with the introduction and implementation of several health policies and programs including the Basic Package of Health Services (BPHS) and the Essential Package of Health Services (EPHS) that have seen the promotion of health care delivery at all levels, many people within the rural regions still do not have access to health care services because of the distance to the nearest health facility. (6)

The utilization of healthcare services has continuously declined due to outbreaks of infectious diseases, the Ebola Virus Disease (EVD) outbreak between 2014 and 2016 and the Covid-19 pandemic in 2020. Both of these outbreaks along with many smaller outbreaks of endemic diseases like cholera, Yellow fever and Lassa fever, have repeatedly interrupted health services, reduced essential health workforce with high mortality amongst an already limited number of healthcare professionals, with decreased utilization of maternal and child health services.(10) The impact of the COVID-19 pandemic has further worsened the already strained and

devastating healthcare sector resulting into even more uneven distribution of resources, inadequate amount of health infrastructures, poor supply chain management with regular essential drugs stock-outs, and poor health management information system. These events have caused a steep rise in the incidence and prevalence of communicable, non-communicable and neglected tropical diseases with serious negative effects on the health of the population.(10–12)

The financial allocation to the health sector in Liberia remains inadequate for the provision of basic and essential health services to the entire population, a condition even made worse by the high level of corruption, poor accountability, and lack of transparency.(6) In the 2019/2020 fiscal year budget, the government allocated just 16.1% of the total national budget which included external donor support to the health sector. Most of the funding are usually externally sourced with multinational donor funding accounting for 59.2% of the Total Health Expenditure (THE) of 219 million USD that same year. Although many of the public facilities are said to be free, out-of-pocket expenses on healthcare account for 54.4% while health insurance covers only 6.9% of cost.(13) The most paramount barriers to accessing health care include cost accounting for 47% and distance to health facility, accounting for 40%.(10)

CHAPTER TWO: PROBLEM STATEMENT, JUSTIFICATION, AND OBJECTIVES

2.1 Problem Statement

Neonatal Sepsis is defined as a systemic inflammatory response syndrome of a neonate due to a suspected or proven infection caused by bacteria, virus, or fungus.(14) Sepsis is a notable cause of neonatal mortality and long-term morbidity.(15) There are 1.3 million annual cases of neonatal sepsis worldwide, which is approximately 937 cases per 100,000 live births, with about 203,000 deaths globally. Low middle income countries, especially in Africa, have the highest incidence.(16) Neonatal sepsis is one of the major causes of morbidity and mortality among neonates in developing countries accounting for 30-50% of total neonatal deaths each year.(17) The high mortality caused by neonatal sepsis is due to delay in diagnosis and treatment.(18) Neonatal sepsis can be divided into two phases, early onset neonatal sepsis (EONS) and late onset neonatal sepsis (LONS). Early onset neonatal sepsis is acquired by vertical transmission from mother to baby and is caused by group B streptococcus while late onset neonatal sepsis is associated with nosocomial, or hospital based acquired infections.(19) Globally, between 4% - 56% of all causes of death of hospital born babies in the neonatal period is due to hospital acquired infections with three-fourth of this amount occurring in Sub-Saharan Africa.(20) Sepsis of the newborn is one of the leading causes of hospitalization and death among neonates in Liberia.(21) According to UNICEF, neonatal sepsis caused 22% of neonatal deaths in 2016 in Liberia.(22) And in 2017, Liberia had an increase in neonatal death by 5.92% due to neonatal sepsis and other infectious conditions, from 0.06% in 2016 to 0.36% in 2017.(23)

Studies have shown that low birth weight, preterm birth of less than 37 weeks of gestation, premature rupture of membrane (PROM), the sex of the newborn, and intrapartum related complications including perinatal asphyxia, low socio-economic status, poor hygiene, malnutrition, and overcrowdings, are factors associated with an increased risk of neonatal sepsis. (24) Maternal risk factors such as, maternal parity, cesarean section, repeated vaginal examination, and neonatal risk factors including neonatal age, sex, APGAR score less than 7 and resuscitation at birth were revealed as highly associated with newborn infections.(25) In low middle in-come countries, harmful traditional umbilical cord practices are amongst some of the contributing factors to neonatal sepsis with the application of herbal and other substances that are non-medical to the umbilical cord of neonates at home with the intention of drying, healing, or

stopping the cord from bleeding. These practices are common within many African cultures with variations from country to country, a factor with significant contribution to the high level of neonatal sepsis in Sub-Saharan Africa.(26)

As a way of addressing neonatal sepsis, the government of Liberia through the Ministry of Health adopted a Policy in 2013 for the application of chlorhexidine on the stump of the umbilical cord for all newborn babies after delivery. Without adequate local sourcing and funding for such ambitious and expensive policy to be implemented, competing priorities such as outbreaks and other issues saw most facilities without the needed supplies of chlorhexidine, inadequate training, communication and education resulted into misapplication resulting into harmful effects for newborns.(27) In addition, the Ministry of Health of Liberia, in collaboration with Maternal and Child Advocacy (MCAI) and Partners has trained some nurses and midwives to provide advanced neonatal care and set up Neonatal Intensive Care Units (NICU) in five rural hospitals in Liberia(28)

These policies and programs still seem inadequate in addressing this issue, as the problem is made even more complicated by anecdotal newborn deaths that occur outside health facilities which are not captured by reporting. With the limited number of research and available data on neonatal sepsis in Liberia including both neonatal sepsis at health facilities and those occurring during home birth, in addition to the lack of research on the social determinants of neonatal sepsis in Liberia, the current study seeks to focus on providing most of such information.

Table 1: Cases of Neonatal sepsis per County for public health facilities from an unpublished source (MOH)

County	2020		2021	
	Newborn with Sepsis	**Newborn Sepsis Treated with injectable antibiotics**	**Newborn with Sepsis**	**Newborn Sepsis Treated with injectable antibiotics**

Bomi	65	24	4	8
Bong	241	238	379	398
Gbarpolu	78	50	36	46
Grand Bassa	38	14	52	33
Grand Cape Mount	52	24	98	52
Grand Gedeh	392	331	352	317
Grand Kru	26	25	39	46
Lofa	246	155	166	179
Margibi	232	204	165	117
Maryland	65	75	103	62
Montserrado	629	390	837	420

Nimba	162	151	296	298
River Gee	47	19	13	12
Rivercess	61	22	42	55
Sinoe	58	55	31	16
Total	**2392**	**1777**	**2613**	**2059**

The above table shows cases of newborn sepsis recorded by an unpublished source from the MOH. From the data, there was an increased in cases in 2021, even though more babies were treated and recovered while some died. However, there is no information available on the numbers of babies who died and those who survived. These cases are presented here to show that only public health facilities data are captured which does not include all health facilities in the country leading to under reporting of cases that need to be considered.

2.2 Justification

The Sustainable Development Goal (SDG) 3 has the target for all countries to reduce neonatal mortality to at least 12 per 1,000 live births by the year 2030, an almost impossible task for Liberia to achieve at its current pace.(29) As one of the leading causes of under-five and neonatal mortality in Liberia, neonatal sepsis remains a major challenge requiring strategic and intentional interventions. In order for Liberia to make significant and sustainable progress toward meeting SDG target 3 by 2030, programs strategies and policy modifications are to be made based on a clear understanding of the underlying factors and determinants of neonatal sepsis. Such research data will also help inform and improve the quality of health services across the thousands of

communities in Liberia. The current study is intended to provide the needed data and provide a contextual understanding of the determinants and factors surrounding neonatal sepsis in Liberia.

2.3 Thesis Objectives

2.3.1 Overall Objective:

The main objective of the research is to explore the determinants of neonatal sepsis in Liberia with the goal of making recommendations to the Ministry of Health of Liberia and other stakeholders for improved neonatal care.

2.3.2 Specific Objectives:

1. To explore maternal factors of neonatal sepsis
2. To explore newborn associated factors of neonatal sepsis
3. To explore socio-cultural, and economic factors related to neonatal sepsis
4. To explore health care system related factors of neonatal sepsis
5. To identify best practices in addressing neonatal sepsis from Liberia and other Sub-Saharan regions
6. To make recommendations to MOH of Liberia and partners for policy and program modifications in maternal and child health

2.4 Methodology and Conceptual Framework

2.4.1 Methodology

The study is a literature review. Keywords, either individually or in combination, are used to search related articles in Google scholar, Google search, and others. These included maternal factors, age, parity, marital status, birth interval, knowledge, attitude and practice, socio-economic, paternal, and maternal education, employment, and place of residence. Other keywords included neonatal factors, age, sex, gestational age, and birth weight. Health care system factors, place and mode of delivery, antenatal care visits, quality of care, human resource,

political, economic, and sociocultural factors, good and poor neonatal outcome, Liberia, west Africa, Africa, Low in-come countries and globally. Please see annex 1 for search strategy.

PubMed, VU Library and other sites were used to retrieve Published, unpublished, peer reviewed articles and snowballing for relevant documents for this research. Gray literature and reports from WHO, UNICEF, UNFPA, Ministry of health of Liberia, the National Public Health Institute of Liberia and the John F. Kennedy Medical Center websites were used to gather additional information useful for this study. For the inclusion and exclusion,100 papers were retrieved some of which were published between 15 to 40yrs ago and papers published above 20yrs were excluded, while 66 papers from 2002 to present were considered, and papers from 2000's were included due to limited literature.

2.4.2 Conceptual Framework

Mosley and Chen conceptual framework of child survival was developed in 1984 with the objective of integrating social science and medical research to have a single outcome variable that combines mortality and morbidity. This framework described five categories of the total of 14 proximate determinants which include: Maternal factors (age, parity, birth interval) Environmental contamination (air, food, water, fingers, skin, inanimate objects, insect vectors), nutrient deficiency (calories, proteins, micronutrients), injury (accidental, intentional), and personal illness control (personal preventive measured, medical treatment). Determinants in the first four groups affect the rate at which children move from healthy to sick and factors in the last group influence the progress of their health through prevention and recovery with treatment. The list of proximate determinants was intended to be exhaustive with the indication that changes will occur in the child's health only if changes occur in one or more of the determinants.(30–32).

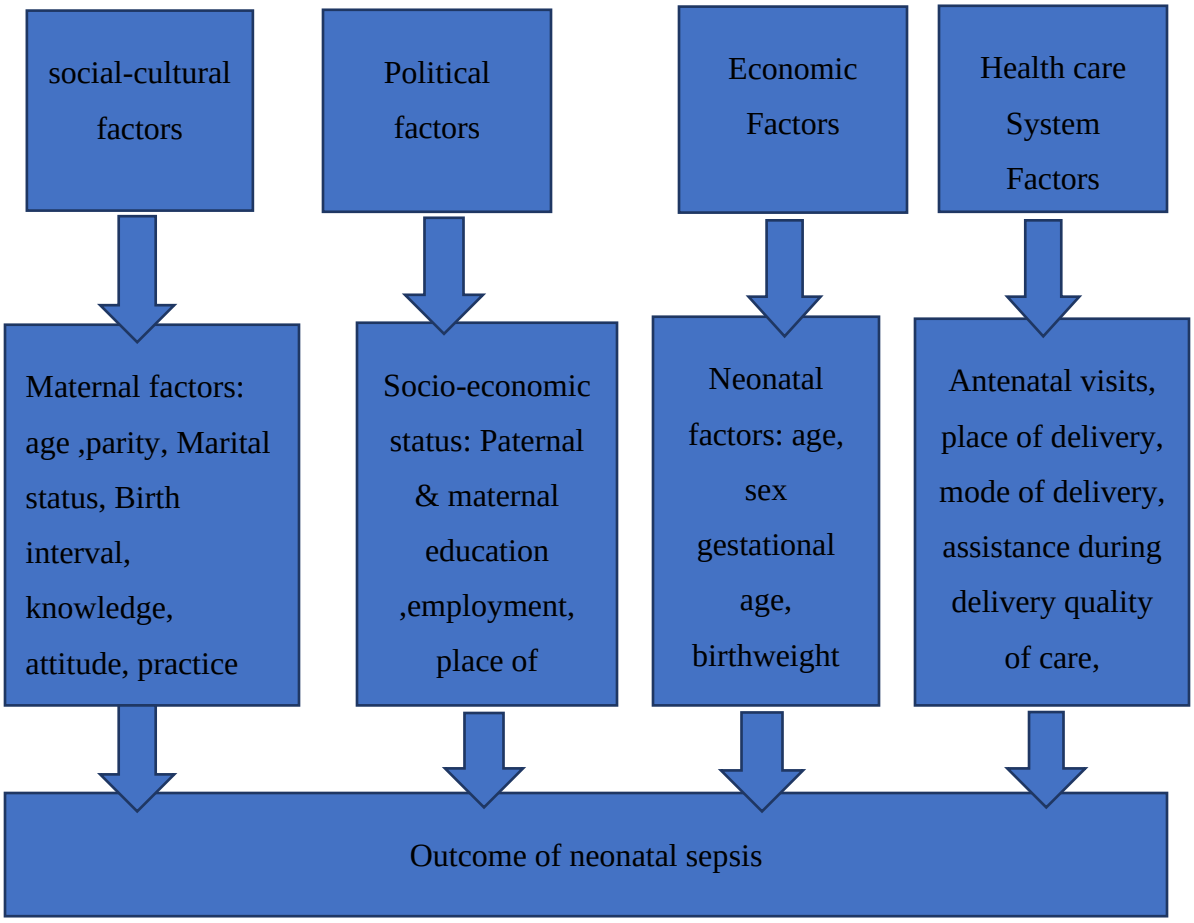

Figure 2: Framework for the Determinants of neonatal sepsis, adapted from Mosley and Chen (1984) and Titaley et al (2008)

Four conceptual frameworks were reviewed while searching for a framework to use, they include: the Mosley and Chen framework, Dahlgren, and Whitehead rainbow framework, the Social Ecological model and the Titaley frameworks. After reviewing how other studies analyzed the determinants, I then selected the Mosley and Chen, and the Titaley frameworks. These two frameworks were selected over the others because they are best fitted for the research on neonatal sepsis since their combination adequately summarized most of the common factors associated with neonatal sepsis in resource limited environment such as Liberia and as such their combination made it suitable for exploring the determinants of neonatal sepsis. Both frameworks were modified in the following ways: the maternal factors such as,

age, parity and birth interval were extracted from the Mosley and Chen and marital status, knowledge, attitude, and practice were added from literature to explore the determinants. From the Titaley framework the following components were extracted, place of residence, antenatal care visits, employment, assistance during delivery, place and mode of delivery. While neonatal factors; age, sex and birth weight were also gotten from the Titaley framework. Upon completion of the extractions, they were then regrouped under headings as in this research framework. The Dahlgren and Whitehead and Social Ecological Model were not selected because they include factors which are not consistent with those found in most resource limited environments like Liberia and therefore were not suitable for the research topic. The original frameworks are as attached in the annex.

CHAPTER THREE: FINDINGS

3.1 Maternal Factors of Neonatal Sepsis:

This section discusses maternal factors comprising of age, parity, marital status, birth interval, socio-economic status, knowledge, attitudes and practices.

3.1.1 Age, parity, marital

This section of the findings discusses the association between age, parity, marital status, and birth interval, in relation to developing or acquiring neonatal sepsis. In Liberia, early sexual intercourse and pregnancy have been observed in many teenage girls with the average age of first sexual intercourse among women being 16.1 years with up to 19% of women between 15-19 years having sex at the age of fifteen for the first time. Also, three out of ten girls get pregnant before they reach 19 years, while 37% of women aged 20-24 years gave birth to their first child at 18 years.(33)The risk and probability of unintended/unwanted pregnancies in these teenage women resulting from early exposure to sexual intercourse is often high with 90% of them being at risk of complications to both the mothers and their babies. The stigma associated with teenage pregnancy also prevents many of these girls and women from seeking the required prenatal care in a timely manner thus leading to late detection of possible complications. (10) Kpikpitse et al conducted a study in Ghana in 2014 where they found maternal age to be a notable factor for developing sepsis in the newborn with (p-value =0.017). The study showed women between the ages of 21-30 years were1.95 times less likely to have their newborn with sepsis, when with those below 20 years of age (OR 1.052) while women between 31 and 40 years were 61% less likely to have their newborns with sepsis compared to mothers below 20 years (OR 0.390). Also, women above 40 years were 52% less likely to have babies with sepsis compared to the women under 20 years (OR 0.480). Although study correlating maternal parity and the incidence of neonatal sepsis is not available in Liberia, the research done by Kpikpitse et al also found a significant association between maternal parity and neonatal sepsis. Neonates born to mothers who were pregnant for the first time (primiparous) were 3.56 times more likely to develop sepsis than those born to mothers

who had two or more pregnancies (multiparous) (OR 3.436, p=0.000), a finding that suggests that multiparity conferred some protection since primiparity was associated with inexperience in the child care during and after delivery hence the increased risk of neonatal sepsis.(34)(35)

Linkage between marital status and the risk of neonatal sepsis has also not been clearly established due to scarcity of such data from Liberia. However, data from other countries with socio-economic parameters have demonstrated the level of economic challenges women who are single mothers faced when compared with those with partners.(36) Such information can be extrapolated when comparing the up to fifty percent of Liberian women who are thought to be either single or without a defined partner. Even for the remaining fifty percent either married or in union, there is no available information linking their marital status and the risk of developing sepsis in their newborn. However, studies from other resource limited settings in sub-Sahara Africa like the one done in Kenya by Okube et al. in 2020 on the prevalence and predictors of neonatal sepsis, found that neonates born to single mothers were five times (AOR=5.454, 95% CI: 1.457 to 20.556, p=0.012) more likely to acquire neonatal sepsis when compared to neonates of married mothers.(37)

The risk of maternal and newborn complications such as preterm and low birth weight has also been shown to increase the risk of newborn infections and mortality when birth intervals are shorter than 24-month period as recommended by WHO. (38) In Liberia, there seems to be longer intervals between births for most of the women. The Liberia Demographic Health Survey (LDHS) 2019-2020 reported only 15% of all birth occurred within less than the 24 months, ranging between 7-23 months. The survey also found women having seven or more children had birth intervals relatively shorter at 36.4 months when compared with those having three children or less who had average birth intervals at 43.3 months. Data comparing neonatal infections and birth intervals are also not available for Liberia. However, a study done in 2016 by Mahande in Tanzania, another resource limited setting, compared birth intervals of less than 24 months with longer ones of 60

months or more and their relationship with adverse pregnancy outcomes for mothers and their neonates. They found that short birth interval had a significant association with increased risk of preterm birth (adjusted OR,1.52;95% CI: 1.31-1.74), low birth weight (adjusted OR;1.61; 95% CI: 1.34-1.72), and perinatal death (adjusted OR;1.63; 95% CI:1.22-1.91) while longer birth interval had increased odds of preterm birth and low birth weight (adjusted OR;1.13;95% CI:1.02-1.24 and 1.11; 95% CI:1.04-1.2) respectively. In addition, women who got pregnant within a moderate birth interval of 37-59 months were observed not to have the same elevated risk for preterm birth and low birthweight. (39)(40)

3.1.2 Maternal knowledge, attitude, and practice of postnatal cord care in relation to sepsis

This section of the research is focused on assessing the awareness of mothers about the risk of infections through the umbilical cord considered as an for the general knowledge and practices related to sepsis. According to the LDHS 2019-2020, childbearing mothers in Liberia are knowledgeable about hygienic care during the cutting of the umbilical cord. This was demonstrated with 76% of rural women being knowledgeable about the use of clean instrument for cord cutting compared to 53% of urban women. Even with births occurring outside a health facility, 66% of the respondents reported that providers used new metal instrument to cut the cord, another 33% reporting unnamed instruments of which 2% were sterilized by boiling. There were also another 37% of women who reported that unknown antiseptic was applied to their neonate's umbilical, while 33% of the babies had harmful substances such as mustard oil, animal dung, and ashes applied on their umbilical. Although the survey findings showed that on average mothers had good knowledge, attitude, and practice concerning cord care, there are some mothers who still have home deliveries and practiced the applications of harmful substances that predisposes neonates to sepsis.(33) Chidiebere et al in 2015 did a Nigerian population based study on umbilical cord care practices where 12,113 mothers were interviewed to assess their knowledge, attitude, and practices with 10,809 children under-five including

506 neonates involved. Almost half of the mothers, about 47.5%, reported that delivery packs were used for them, while 52.5% did not use pack during birth, with new or sterilized blades being used for 87.0% of the respondents to cut the cord while “used” or non-sterile blades were involved in 256 (4.3%) of the deliveries. The study also found in 8.6% of the deliveries, knives, scissors, and sickles were used to cut the cord. In 7065 (58.3%) of the 12,113 respondents reported that nothing was applied to the stump of the cord while was application of some substance on the umbilical stump was reported in 5048 (41.7%). The most common substances used on the stumps were methylated spirit applied for 1,521 (12.6%) and oil for 1,461 (12.1%) of respondents. For others, toothpaste was applied to 691 (5.7%), ash 339 (2.8%), powder for 304 (2.5%), while 504 (4.2%) had a mixture of other substances used to clean and dry the cord. Some respondents mentioned substances like Detol, turmeric, and animal dung that were also used on the cord.(41) The risk of infection and neonatal sepsis increases with the application of substances deemed harmful or those not recommended for cleaning and application to human tissue. Although data on the knowledge of mothers on what care was given at the time of birth or applied postnatal, there is still a paucity of data on the attitude on these mothers toward umbilical cord care.

3.2 Socioeconomic Status: Parental Education, Employment, and Place of Residence

3.2.1 Parental education

Maternal education, though not a direct factor causing neonatal sepsis, has been shown to be related to other factors with direct linkage. In Liberia, The LDHS 2019-2020 reported 52% of women were educated compared to 75% of men interviewed during the survey. The survey reported that the mother’s education played a major role in child survival and the reduction of neonatal infections. Women with higher education had fewer children, averaging 2.0 compared to those without education who averaged about 5.0 children. Education was noted to place women in better positions of getting paid jobs which enabled them to acquire household wealth and empowerment in decision making to seek

healthcare services. Educated mothers were more likely to have a better understand of the benefits of early initiation of breast feeding, a practice known to help build the immunity of neonates against infections. They were also found to adhere to health educational messages and more aware of the consequences of poor adherence to pre and postnatal care. Education was also linked to higher health facility-based deliveries at 89% compared to the 66% found in uneducated mothers.(33) About 78% of women with higher educational status notably utilized maternal health services compared to 62% of those with primary education and 49% of those with no level of education. Educated mothers were more likely to adhere to medical advice given by health workers, including the practice of proper hygienic care and regular hand washing at home, activities deemed crucial in preventing neonatal sepsis.(22)

Similarly, while not related to neonatal sepsis but to under 5 mortalities, research has also shown the link between maternal education and child survival. In Uganda and Malawi, Andriano et al did a study in 2019 where they found a correlation found between maternal education and mortality wherein an added year of increase in a mother's education had a 10.0% reduction in the probability of children dying before they were five years with the odds of 2.9% in Malawi, while in Uganda an addition of one year increase in maternal education lowered the probability of dying by 16.6% with odds of 4.9%. They also found financial barriers to seek medical care, health seeking behavior and the mother's ability to reject domestic violence as underlying factors on the impact of maternal education on child mortality. They discovered that being more educated increased women's ability to use health facility and give them added knowledge about AIDS transmission in Malawi, while it increased the accumulation of wealth and improved women control over sickness in Uganda. They observed in both countries that education exposed women to the use of modern contraceptives but did not find significant effect of education on empowerment as regarding women participation in household decision making.(42)

3.2.2 Maternal and paternal employment and place of residence

Liberia has a higher likelihood for the employment of men than women with an 81% to 61% rates respectively. Employment also increases with age as older men 45-49 years being employed at 97% rate when compared to 83% of women in same age group. Even amongst younger men and women between the ages of 15-19 years who have a lowered employment rate, men still have 54% employment than women at 33%. In addition to the lower employment rates amongst all age groups of women, decisions about healthcare are predominantly taken by men with an 80% to 20% rates between men and women respectively.(33) This means for majority of women with a male partner, having sufficient knowledge about neonatal sepsis and the general health of their newborns or themselves may not be a guarantee for a better outcome since the these decisions are largely made by another person which may also be dependent on the finances and priority at that moment. These may include the decision to attend antenatal care during pregnancy, seek hospital versus home based delivery, regular neonatal visits for immunization and during ailment. The timeliness of these decisions is most left to the male partners, decisions that may also be dependent upon the ability to afford such services, a factor that could lead to late diagnosis and impact the outcomes of pregnancies and newborn with respect to neonatal sepsis. Indeed, a community cohort study done by Kayom et al.in Uganda in 2018 on the burden and factors associated with clinical neonatal sepsis showed that lack of paternal financial support was an independent associated factor of neonatal sepsis with (OR 4.09,95%CI: 1.60-10.39). They also found that neonates whose mothers did not receive support from their fathers were four times more likely to develop sepsis than those whose mothers did receive paternal support (43).

In Liberia, there is still a significant disparity in access to health facility between urban and rural residents, with 59% of rural communities encountering difficulty in accessing health facilities compared to 36% of urban communities. One of such examples is found in Gbapolu County, a remote county in Liberia with very poor road network with more than 75% of the population reporting some difficulties in reaching a health facility as per

the LDHS 2019 results. The survey also reported urban women had better health care opportunities than rural women with 89% of pregnant mothers in the urban areas much more likely to receive prenatal care than 85% of rural women. Although there is only 4% difference, it was found that women attending antenatal care in urban health facilities were more likely to get superior services including urine testing, tests for blood infections, ultrasonography to detect early complications, than those in rural or remote locations, with better access to facility-based delivery, clean water, and the practice of better hygiene that minimized transmission of infections to the unborn.(33) Even in urban locations, mothers living in poor or underserved slum communities in Liberia have been noted to have poorer hygiene practices with disproportionate levels of risks also contribute to neonatal infections and other waterborne illnesses in the newborn.(44) Such observations have also been made in other resource limited countries as was reported in a study done in 2012 by Mark et al. in Nigeria where they found lower socio-economic status and place of residence as predisposing factors to the development of neonatal sepsis. In their findings, neonates born to mothers residing in slum communities were twice more likely to acquire sepsis than those born to mothers in better living conditions and neonates born to mothers from the lower socio-economic class were usually exposed to sepsis due to poor hygiene, living in overcrowded homes, lack of access to clean water for bathing babies, poor feeding practices, improper cord care, and being unable to attend full vaccinations and prenatal care.(45–47)

3.2.3 Neonatal Associated Factors: age, sex, gestational age, and birth weight of neonates:

Greene-Cramer et al. in 2019 did a study on the causes of neonatal death where they found that among 263 neonates who died, 81% happened within 0-7 days, and 14.2% was due to sepsis which they attributed to the lack of early postnatal care within the first 24 hours of life. (48) Adatara et al. in 2018 in a study on the risk factors of neonatal sepsis in Ghana revealed that younger neonates below 7 days old were 9.4 times more likely to develop sepsis than those neonates who were older than 7 days [AOR=9.40 (95% CI

4.24,20.81),p<0.001] The possible explanation could be newborn babies have temporary immunity passed onto them from their mothers and they cannot produce antibodies to protect themselves against infections, a condition that exposes newborns to early childhood infections and illnesses. Some of them are born through the process of maternal complications leading to prolong postnatal hospitalization that makes them prone to acquiring infections at an early age.(49)

Sex of Neonate: Although no study was found in Liberia that links the sex of a newborn to the risk of developing neonatal sepsis, the LDHS of 2019 reported male neonates were more likely to die at 45 deaths per 1,000 live births compared to female neonates at 30 deaths per 1,000 live births. These deaths are influenced by inherent congenital characteristics of either them or their mothers which could be genetic, or immunological. (33) In 2019, a study done by Agnche et al. in Ethiopia observed that male neonates were 3.7 times more likely to acquire sepsis compared to female neonates [AOR=3.73;95% CI (1.76,7.89)], a factor which could be due to their biological make up and their lower immunity than females(50)

Gestational Age/Weight: Babies born before 37 weeks of gestation are prone to early hospitalizations and could develop infections due to their low immunity. In 2017, Liberia recorded 22,000 babies born preterm with 1,100 below the gestational age of 28 weeks, while 1,200 developed preterm complications and died, most of which were due to exposure to infection from medical interventions and equipment used for respiratory support. (51) **:** According to the LDHS in 2019, 36% of neonates in Liberia were born low birth weight below 2.5 kilograms, with 19% of them being born to teen mothers predisposes neonates to bacterial and nosocomial infections as they are not fully matured. (33)However, there are limited data on the prevalence of low birth weight in Liberia as reported by the Country nutrition profile of Liberia. (52) In 2017, Geyesus et al. did a study in Ethiopia which indicated that babies born at gestational week less than 37 weeks were almost 9 times more likely to acquire sepsis than neonates at gestation above 37 weeks [AOR=8.99 (95%CI:4.175-19.38). They discovered that babies who were born very

low birth weight <1.5 kilograms were 12 times more likely to have sepsis than those with normal birth weight 2.5 kilograms or above. This could probably be due to their body inability to produce antibodies to fight against infections at an early age.(53)

3.3. Healthcare System Related Factors

3.3.1 Number of antenatal care visits, place of delivery, mode of delivery, and assistance during delivery:

Antenatal care visits: Antenatal care visit has been one of the mechanisms used by healthcare providers in the early identification, management, and prevention of maternal infections, and possible maternal and fetal complications during pregnancy and delivery. The 2019 LDHS reported that 87% of women 15-49yrs had attended the minimum of four antenatal visits, while 71% did so in their first trimester. It was discovered that the more antenatal visits mothers made, the higher their chances of giving birth in health a facility and with skilled assistance. Indeed, among mothers who made four ANC visits and more, 85% of them delivered in health facilities compared to 62% of mothers who made one to three visits, and 28% of mothers who made no visits. Home delivery was noted to be higher amongst mothers with no antenatal visits at 73% when compared to the 37% of those with one to three visits and 14% for mothers with four or more ANC visits. Meanwhile, only 28% of deliveries done at home were assisted by skilled providers, and 56% of their babies did not receive timely post-natal care within the recommended 48 hours of birth. (34) Okube et al. in 2020 did a study in Kenya reporting the total number of antenatal care visits and the full course of iron and folic acid supplements intake had a significant association with developing neonatal sepsis. Mothers who made less than four antenatal visits during pregnancy had babies that were 2.5 times (COR=2.500,95% CI:1.319-4.738, p=0.005) at a higher risk of developing sepsis compared to neonates whose mothers made four or more visits. Furthermore, neonates were 3 times (COR=3.105,95% CI=1.231-7.830, p=0.016) more likely to have sepsis if their mothers took iron and folic acid supplements for less than six months compared to babies who mothers took supplements for more than six months. (38)

Place and Mode of Delivery: The 2019 LDHS reported that 95% of deliveries in Liberia were vaginal deliveries with the remaining 5% being through Cesarean section. About 80% of births were within a health facility while the remaining 20% occurred at home. The average time spent in a health facility for an uncomplicated vagina delivery was about 3 days maximum for the mother and baby to be discharged home while a minimum of 3 days or more hospital stay was required for cesarean section based on the indication of the surgery.(33) Geyesus et al. in 2019 did a hospital-based study in Ethiopia in which they found vagina deliveries exposed neonates to sepsis. Their researched revealed that babies who were born through vagina delivery were 2 times more likely (AOR:2.22,95% CI=1.24-4.32) to have early onset of sepsis than neonates who were born through cesarean. The possible explanation was the vaginal canal is colonized by different microbes that could be transferred to the neonates during delivery. However, they did not find association with place of delivery.(54)

Assistance during Delivery: The type, qualification, and level of experience of the birth attendant may also be a contributing factor in the onset of neonatal sepsis. About 84% of all births in Liberia are assisted by skilled providers including doctors, Nurses, and midwives while the remaining 16% by are done by traditional birth attendants. According to WHO, access to assistance during labor and delivery provides trusted emotional, psychological, and practical support which may lead to better outcomes for mothers and newborns. Unfortunately, there was no study found in relation to delivery assistance and sepsis.

Quality of Care during Delivery: The Ebola Virus Disease outbreak contributed and compounded the challenges and constraints faced by the healthcare system in Liberia, affecting both the quantity and quality of healthcare services. Several health facilities were either closed or partially opened during the Ebola outbreak with health facility-based deliveries dropping from 65% to 28%, while deliveries done by skilled providers decreased from 61% to 31% with home-based delivery also on an increase.(55) According to a report by WHO in 2016, approximately 44% of women who delivered at home did

not have skilled attendants at birth thus exposing them to death in case of complications.(56) As a result, the maternal mortality rate in Liberia increased from 688 per 100,000 live births in 2014 to 913 per 100,000 live births in 2019.(55) In addition to the impact of the Ebola, the COVID-19 pandemic has also worsened the quality of service delivery through prolong waiting time for patients including pregnant women and their newborns, unavailability of essential drugs and medical supplies in public health facilities as well as inefficient resource allocation to the secondary health care level.(11) These conditions have seen a rise in neonatal deaths from 26 deaths per 1,000 live births in 2013/2014 to 37 deaths per 1,000 live births in 2019.(55).

3.3.2 Human resource, health workers knowledge, attitude, and practices of sepsis

The health system has a national responsibility of policy making, planning, mobilization, and allocation of resources, while the decentralization of service delivery is done at the county, district, and community levels. The 2015 health facility assessment reported there were a total of 35 hospitals, 51 health centers, 618 clinics and 137 pharmacies in Liberia. This means each health facility, regardless of the level, was serving about 5,500 people with 22% of these health facilities being privately owned and for profit. Below is a table of the health workforce.

Table 2: Health workforce of Liberia (District health information DHIS2 MOH Data person).

No.	Indicators	Year	
		2014	2022
1.	Number of Nurses	2301	3061
2.	Number of Doctors	123	351
3.	Number of Midwives	901	1139
4.	Physician Assistants	203	239
5.	Hospitals	32	38
s6.	Number of Health Centers	51	61
7.	Number of Clinics	621	780
8.	Percent (%) of Private Facilities	21%	38%

9.	Number of Pharmacies	401	590

Although Liberia has seen some increases in both the number of health care facilities and cadres of healthcare providers since 2014, there is still a huge gap from the ideal number, a grossly uneven distribution of professionals between urban and rural settings and continuous attrition of needed workforce from rural to urban facilities or even to other countries. There were also a high number of deaths amongst healthcare workers (184 persons) due to the Ebola outbreak between 2014 and 2016. These conditions have also created an uneven distribution of workload for the few professionals in rural and poor urban communities. These trends have led to underperformance, prolonged waiting time for pregnant women and a general dissatisfaction of patients causing an even more increased use of unqualified and poorly trained traditional birth attendants and increased home-based deliveries. In addition, disease outbreaks such as the Ebola and covid-19 put an even greater strain on the health sector that led to budget cuts, inadequate supplies, reduced or limited-service provisions for other diseases and conditions as was seen in 2014 with limited supplies for infection, preventions, and control (IPC) materials and measures, poor quality of care, limited qualified health workers and reduced patients' confidence in the healthcare sector. These poor working conditions were also compounded by lack of continuous medical education (CME) and in-service trainings, lack of opportunities for career advancement especially for those serving in rural and peri-urban slum communities. Gross decline in the attendance at outpatient department (OPD) either due to short-term closures, fear, and health care providers behavior led to a significant drop-in maternal health care and vaccinations services with patients who managed to attend health facilities receiving less than the required minimum, factors that contributed to the increased use of home-based birth and an increased risk of infection to both the newborn and mother.(10)(11)

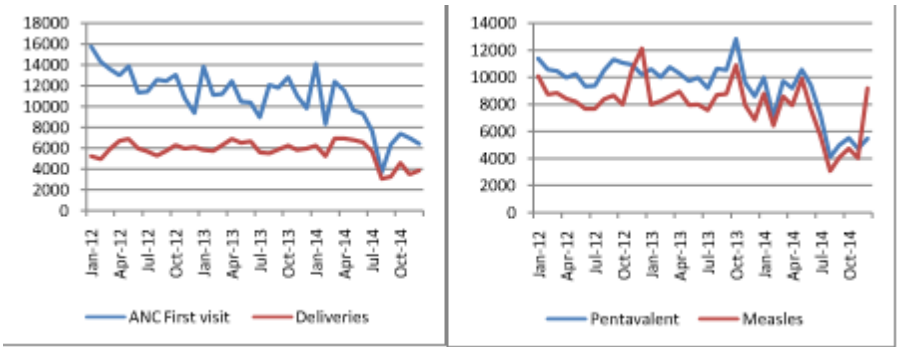

Figure 3 Utilization Trend for key maternal and Child health interventions.(10)

3.4 Socio-cultural Practices

Female genital mutilation (FGM) is one of the major cultural practices that exposed pregnant mothers who are victims and their neonates to complications during childbirth. FGM is considered as a ritual of initiation of women and girls into the entry of the Sande society, a traditional secret society for females in Liberia. The prevalence of FGM in Liberia is estimated at 38.2% among childbearing women aged 15-49 years and it is practiced more in rural areas at 52.3% than 29.9% in urban locations. It is mostly practiced in the northwestern region at 68.3%, followed by 54.2% in the north central region and least practiced at 2.9% in the south-eastern part of Liberia. It is more common among Muslim women than Christian women at 58.6% and 34.7% respectively.(57) The scaring caused by this practice leads to easy tearing during labor and delivery, fibrous tissues and adhesions develop that also prevent full dilatation of the vaginal opening hence increased episodes of bleeding and prolonged labor, increased caesarian section, episiotomies, and obstetric fistulas. All the above complications predispose the newborn to an increased risk of infection.(58)(59) According to Lori et al. in 2011, cultural childbirth practices in Liberia far originated from traditional religious beliefs that were rooted in secrecy surrounding pregnancy and childbirth, lack of power and authority for women, and mistrust for the health care system. According to their findings, young females were taught by the circumcisers who also doubled as traditional midwives/birth attendants commonly called “Zoe” on domestic responsibilities, childcare and respect for

the elders. Issues of pregnancy and childbirth are done with high level of secrecy as they are made to believe the myths of preventing evil spirits or individuals from casting dangerous spells that could put the mother and or the unborn baby at risk. Pregnant women or girls who have had such trainings and exposure especially in rural communities, may opt to either labor alone in secrecy or inform a very few trusted individuals including the mother-in-law, a practice that has consistently led to delay in seeking care at health facilities and an increased rates of home deliveries and complications.(60) In addition, community and traditional elders, partners or spouses, are also major decision makers for some of the women based on information passed on from close relatives and not directly from them, a further delay that results in late complications such as hemorrhage, retained placenta and prolonged ruptured of membrane. Multiple unhygienic vaginal examinations by traditional birth attendants, a habitual trend of lying about the actual timing of rupture of the protective membrane holding the amniotic fluid, also expose newborns to infections. Laboring women, regardless of the risk of complications, have to wait for the arrival of their spouse or elders in the event the laboring started in the absence of these decision makers, a cause for additional delay to seek facility-based care in a timely manner. The research by Lori et al also noted that pregnant women were often fearful of skilled attendants at healthcare facilities and the entire hospital environment, lack of privacy, being attended to by the opposite sex, conditions that influence many of these women to prefer unskilled traditional birth attendants during pregnancy and childbirth. Antenatal visits, early detection of complications and infection, and the treatment or management of these complications are rather left to these birth attendants or street peddlers of unknown medicines.(60)

3.5 Political and Economic Factors

As the Ministry of health has been overburdened with competing priorities and inadequacy of resources, the emergence of COVID-19 has brought some constrains to the delivery of maternal and child health services in Liberia. Politicians have diverted most of the public funds towards COVID-19 and several senatorial bi-elections which led to lack of essential material supplies in public health facilities that caused declined in

maternal and child health services utilization by 30% between April and August 2020 and 25% decreased in immunization coverage within the first six months.(61) According to the Liberia SDG Voluntary National Review 2020 report, poverty is a nationwide issue that is affecting the entire population of Liberia.. The poverty level has mainly affected the health, education, and living standards of the people. However, the poverty rates are higher in the rural communities at 71.6% than urban areas at 31.5%. Although the urban poverty rate is considered notably lower than rural, there has been a high concentration and number of people, with over 275,000 poor people in the most populated county of Montserrado which also houses the national capital Monrovia. A UNICEF 2014 report found 63.4% of the Liberian children to be sufferers of multidimensional poverty with more than half of the 2,179,015 children in Liberia or an estimated 1,825,143 living on less than 1.25 United States dollars daily. Rural communities have a higher burden of such poverty as fertility is higher at a rate of 5.5 children per woman. Based on the high level of poverty in the country, children born in poor households faced inequity in the provisions of right to education, survival, and better living conditions, and are deprived of access to nutritional foods that are supposed to develop their immunity and help them grow well. Therefore, they are at risks of stunting, lack access to healthcare, safe drinking water and unavailability of toilet or sanitation facilities at home.(55) Mothers from these poverty-stricken homes without adequate nutrition continue to have neonates that are either born underweight or become underweight due to lack of proper feeding, conditions that increase the risk of infection from their poor immunities caused by malnutrition. The high rate of poverty has led to increase fertility in the rural areas with increased in teenage pregnancy at 55% in rural Liberia indirectly contributing to neonatal sepsis. (27)

3.6 Evidence of Best Practices Regarding the Reduction of Sepsis among Neonates

3.6.1 Chlorhexidine trial in a teaching hospital in Kenya

Currently, the World Health Organization has recommended the use of 4%chlorhexidine and has added it to the essential drugs list to be used on the umbilical cord in home settings to replace harmful traditional substances.(62)

In 2013, Liberia adopted a national policy for the application of chlorhexidine on the stump of the umbilical for all deliveries with the Ministry of Health, USAID, and UN Commission on Life-Saving Commodities starting a piloted implementation of the product in a number of health facilities in seven of the 15 counties. Results from these pilot projects were inconclusive due to the abrupt disruption as a result of the Ebola outbreak as well as the reports of adverse and harmful events and neonatal outcomes from misapplication due to the lack of information, education, and communication materials to support the usage of the chlorhexidine.(27)

Although Liberia did not complete the process of validating the use of chlorhexidine cord care, clinical studies from other resource limited countries in Africa showed promising results. In a randomized controlled trial done in a teaching hospital in Kenya included 540 healthy full-term neonates who were recruited within 12 hours of delivery and had normal birth weights of 2.5 kg or higher and APGAR score of 8 or more. Neonates were randomized and placed into three groups of 4.0% Chlorhexidine, 70% alcohol as test group and dry cord care as a control group. The process used block randomization in order to reduce imbalance in the differences staff shifts and to equate the numbers in different care groups. All the babies born from 6pm to 6am were placed in one group and inversely. Their mothers consented and randomly choose from a shuffled color-coded card (NBI (chlorhexidine), MSA (Alcohol), and KSM (dry cord care) that assigned newborn babies in to the three groups.(63)

The Intervention: Chlorhexidine and alcohol solutions were applied to the umbilical cords within 12 hours of birth and the process was repeated two times daily for 7 days. Consequently, group 1 and 2 were assigned to apply the 4% chlorhexidine and the 70% alcohol every 12 hours respectively, and in the control group the cords were cleaned and dried as per WHO recommendation. Soiled cords were wiped with sterile cotton wool balls already soaked in boiled-cooled water. In the test groups, proper hand washing was done with soap and water, after which three sterile cotton balls were soaked with either chlorhexidine or alcohol solutions were used to gently cleanse the stump of the cord from

up down and 5 mm radius around the skin. The investigator in the hospital demonstrated the first application and was followed by the caretakers who continued the process two times daily at home upon discharged unto seven days. Adequate sterile cotton wool balls and chlorhexidine were supplied to the mothers and caretakers. Caretakers were educated according to their cluster in all groups and were advised on follow-up throughout the neonatal period. There was follow-up on day three, fourteen, twenty-one and twenty-eight upon discharged to check on the neonates for signs of cord infections. Mothers and caretakers were told to take the babies back to the hospital on day seven for follow-up cord swab. They were also educated on signs of umbilical cord infections and to report it immediately if any. Phone calls were made on designated dates to inquire about the neonates.(63)

Effectiveness of the chlorhexidine on the prevention of cord infections

Neonates in the dry cord care and alcohol group had a higher risk of cord infections compared to those in the chlorhexidine group. Neonates in the dry cord care group were 1.95 times more likely to have infections (AOR=1.95, 95% CI=1.13-3.38, p=0.017) compared to the chlorhexidine group. Likewise, neonates in the alcohol group were almost twice at risk of developing cord infections with (AOR=1.98, 95% CI=1.15-33.40, p=0.014) than neonate in the chlorhexidine group. The chlorhexidine application remarkably reduced the risk of cord infection as compared to the alcohol and dry cord care. Taking into consideration the long-time effectiveness of chlorhexidine and the cost involved that could be a barrier, the product should be applied every other day. And caretakers should be educated on the significance of it in preventing cord infections. (63) With the continuation of the process in Liberia, increased community awareness and health education will improve the situation of misapplications.

3.6.2 Clean delivery kits for home births intervention from Tanzania

Hygiene during delivery and in the first few days of the neonate is an essential component of preventing neonatal sepsis. In a cross-sectional intervention study done in Tanzania to

determine the effectiveness of a clean delivery kit in preventing umbilical infection and maternal sepsis involving 3262 pregnant women recruited during antennal visits between the age range 17 to 45 years, clean delivery kits containing plastic sheet, clean razor blade, a string for cord tie, and a bar of soap were given to each of the participants. Village health workers (VHWs) were included in the study to visit those who had given birth on postpartum day five, take them through some questionnaires and check the umbilical cord for signs of infection. Delivery attendants were taught to wash their hands before the procedure, while mothers were told to bath and shave before delivery. Among the pregnant women who received the kits, 1935 (59%) used either a component of the kit or the full kit. Of the 3058 babies born, the mothers used the preferred components of the kit in 1820 (59.5%) of them. The study found use of clean delivery kit, clean versus old instrument to cut the cord, a mother's bath before delivery and shaving before delivery as independent associated factors influencing cord infection. The findings show that mothers who did not use at least the plastic sheet in the kit were three times (OR:3.2:95% CI=1.8-5.63) more likely to develop genital infection than those who used the plastic sheet, while women who did not bath before delivery were almost three times (OR:2.6;95% CI=1.40-4.71) to have genital infection than those who bathed. Also, 1.5% of the 820 women who birth attendants washed their hands during delivery had genital infections compare to 8.0% of those women who birth attendants did not wash hands before vagina examination.

For the umbilic cord, it was observed that 48 (3.9%) babies whose mothers did not use the kit developed sepsis compared to 5 (0.3%) infants whose mothers used the kit while mothers who did not bath before delivery babies form 5.6% of the cases with cord infection compared with 1.3% of cases among babies with mothers bathing before delivery. Using the essential components of a clean delivery kit was also found to help in the reduction of the risk of umbilical cord infections (AOR=13.1) and maternal genital infection (OR=3.2).(64)

3.6.3 Interventions to improve adherence to antenatal and postnatal care among pregnant women in Sub-Saharan Africa.

Because antenatal care can screen for potential risk of sepsis, and postnatal care is essential for timely intervention, adherence to such care can possibly decrease the incidence of neonatal sepsis. In a randomized control trial conducted to assess interventions to improve adherence to antenatal and postnatal care using five studies from different countries in sub-Saharan Africa, three from Uganda, one from Ghana and one from Tanzania, participants were clustered to measure ANC and postnatal care adherence. All the studies were comprised of a treatment group that received home visits and a control group that receive standard care without home visit, and none found statically significant difference in ANC attendance between treatment group that received home visits and control group that received standard care.(65)

Two studies applied behavioral interventions that used planning and incentive scheme to promote antenatal care and postnatal care utilization among pregnant women.(65) During antenatal visits, health care providers assisted women in the treatment group to formulate a pre-delivery plan that included place of delivery, importance of skilled delivery care, transportation arrangement, birth escort, home support and possible blood donor in case of emergency. Because of this plan, there was an increased attendants in postnatal care visit among the intervention group in the first month after delivery compared to the standard care control group (62% vs 32%, respectively; 95% CI:15.4-47.2, p=0.0009).(65) It was observed that women in the treatment group attended postnatal care three times earlier than those in the control group.(65)

On average, two of the five studies revealed the effectiveness of behavior interventions with incentives schemes to increase ANC and postnatal care attendance.(65) While the remaining three with the home visit intervention did not prove to have impact on antenatal care visit adherence.(65)

3.6.4 Promote male involvement in antenatal care in Tanzania

Although Liberia does not have a policy on male involvement in ANC care due to the myths and beliefs of pregnancy being a female issue, it is an important strategy that has been used in Tanzania to increase antenatal uptake. The below strategies were used to increase male involvement:

Health workers denied services to pregnant women who came to antenatal without their partners: a strategy meant to encourage voluntary counselling and testing for couple where pregnant women coming for their first ANC visits where mandated to bring their male partner along or denied service until the partners are available or formerly excused with a letter from village leaders with reasons for exemption. Unethical and corrupt practices on the part of some male partners conniving with village leaders to present false letters of exemption, pregnant women presenting false letters from health facilities to village leaders or from community leaders to healthcare providers along with the lack of local and regional policies and laws to support such strategy made it ineffective.(66) To ensure such strategy is effectively implemented in Liberia in increasing ANC visits with spouse or male partner involving, other incentivized outputs rather than denial of services would be a workable solution. Pregnant women without male support could be given the regular ANC care and those with partners given additional support including maternity or delivery packages.

Fast-tracking service to men attending antenatal care with their partners: health workers used this strategy by prioritizing men who accompanied their partners to improve male participation in antenatal care and to have a balance between clinic visits and in-come generating activities as men are the main providers for the family. If a pregnant woman came to antenatal care visit with her partner, they were seen by the health workers first. And this encouraged other women as they all wanted to leave early.(66)

Education and community sensitization: with this strategy, the community health workers in each village carried on sensitization by educating men and the entire

community stating the importance of involving male to participate in pregnancy and childbirth. Public meetings, community outreach activities, radio and mobile phone messages were used in the education while health workers were invited to regular community meetings to speak on health issues. With some effectiveness in increasing male participation in ANC visits, these strategies were also found to create undue pressure for pregnant women as they struggled to convince male partners and were found to cause some stigma for women without stable partners. Additional education and consultation with these women and their partners could improve outcomes extensively. Traditional birth attendant, community health workers and midwives could be targeted in Liberia especially in rural and urban slum communities where many pregnant women are seen at home by these cadets of healthcare workers.(66)

CHAPTER THREE: DISCUSSION OF RESULTS

The main objective of the thesis is to explore diverse factors associated with neonatal sepsis in order to make recommendations to the Ministry of Health of Liberia and other stakeholders for the improvement of neonatal health care in Liberia.

4.1 Maternal and Neonatal Factors

Age was found to be the most influential factor that determined neonatal sepsis. In Liberia sexual intercourse begins as early as 15 years with an average age of 16.1 years. Early sexual activity is associated with unintended or unplanned pregnancy that usually leads to high risk of complications for mothers, predisposing neonates to infections. The stigma from unintended pregnancy prevents young girls from seeking required antenatal care visits in a timely manner leading to late detection of possible complications for which some can be vertically transmitted to the unborn in case of infections. Increasing sexual and reproductive health education in communities, schools, religious and population-based institutions with the introduction of such programs into the educational curricula in schools targeting both young males and females will help to reduce the issue of early sexual intercourse and prevent unwanted teenage pregnancies. In addition, enforcement of the statutory rape laws in Liberia could also help to discourage sex with underage girls, thus improving the general age of sexual intercourse.

Lack of postnatal care in the first 24 hours of birth has also been associated with an increased risk of sepsis. With a significant part of the population in Liberia still having home deliveries with no access to post-natal care services especially in rural areas, this may be one of the contributing factors to neonatal sepsis in the country. This could be mitigated by ensuring home deliveries are either eliminated or programs to ensure women who deliver at home get the requisite post-natal care.

Short birth interval less than 24 months was not seen as a major risk factor of neonatal sepsis in Liberia since majority of the women have prolonged birth intervals far exceeding WHO recommendation.

Preterm birth exposed neonates to infections from the use of medical equipment that help them breathe, as preterm babies usually have respiratory difficulty. Maternal knowledge about the use of clean and sterile instruments to cut the umbilical cord was on the average good, but there still existed some practices of traditional substances like animal dung, ashes and mustard oil being applied to the umbilical cord of the babies serving as a risk factor to the development of sepsis.

4.2 Healthcare System, Political and Economic Factors

Maternal complications leading to neonatal sepsis are influenced by policy implementation failures, infectious disease outbreak, human resource gaps, financial resource, and material resource challenges. In 2013, the Health Ministry of Liberia adopted a chlorhexidine cord care policy to reduce neonatal sepsis which was then validated in June 2017 to have a countrywide scale-up of chlorhexidine cord care for five years beginning 2017 to 2021 in all the fifteen counties. The policy planned to cover 75% of babies born in health facilities in 2017, 85% by the end of 2018, and extend to communities in 2019. It was also envisaged to scale up by the end of 2019 and ensure all neonates delivered in the communities and health facilities would have had equal access. However, the process was abruptly halted due to the COVID-19 outbreak which saw both the Government of Liberia and donors redirect essential health programs and funding towards the fight to contain the spread of the virus. Local, regional and international financial institutions scaled back significantly as the world economies took a downturn. Shortage of healthcare workers either due to death as seen with the loss of close to 200 during the Ebola, increased attrition from rural facilities to urban ones or outside the country for better incentives and access to opportunities cause severe shortages and an overwhelming burden for the health system as these professionals could not be replaced at the same attrition rates. In addition, Liberia saw redirection of its limited resources toward

the COVID-19, had political multiple bi-elections and other competing priorities that saw several public health facilities drastically cut down essential services including maternal and reproductive health services with long period of delayed or total lack of essential drugs and materials such as gloves, hand sanitizers and soap. A drastic decline in the utilization of maternal and child health services were seen during this period with only 25% in vaccination coverage between April and August 2020. Moreover, antenatal care visits also dropped significantly due to genuine fear amongst pregnant women of contracting Ebola or COVID-19 from health workers or at health facilities since these were seen as the hot zones. Myths and misinformation surrounding the treatment and vaccines during these outbreaks caused many to reject or delay their children from getting essential postnatal vaccinations as almost all the vaccines were considered either Ebola or corona vaccines by these parents with fear of getting either from being given the vaccines. Limited community outreach also meant reduced opportunities for pregnant women and parents who could not access health facilities during such periods with some still rejecting such services for fear of contracting either COVID-19 or Ebola. Although the antennal visits have gradually improved as reported by the demographic health survey, rural women still limited access due to distance, transportation, and cost for which more home deliveries are being done in the absence of proper hygiene.

These challenges could be improved by ensuring emergency and disaster funds, including those for disease outbreaks, are budgeted and secured from partners and the national government annually, setting essential health services including those related to reproductive, maternal and child health services, IPC services, drugs and essential supplies are provided even during major outbreaks. Staffing and access to improved services and opportunities for healthcare providers especially in rural communities could also help reduce attrition rates.

4.3 Best Practices in Addressing Neonatal Sepsis and Reducing Umbilical Cord Infections

Chlorhexidine cord care has been proven safe and recommended by WHO to prevent cord infections. With Liberia previously starting this practice in few health facilities and having some promising initial results prior to its abrupt end due to the COVID-19 outbreak, it could be worth exploring this avenue again. As the study in Kenya showed chlorhexidine has been proven to be effective in preventing umbilical cord infections and reducing neonatal sepsis, Liberia can still consider the continuation of the chlorhexidine intervention ensuring that IECs materials are available at all facilities and even in the communities to avoid misapplication that could be harmful as in the case previously.

Also, the findings from Tanzania showed an association between provision of clean delivery kits and reduction in the risks of neonatal sepsis. These findings were also noted in Liberia as poor hygiene during delivery and post-natal cord care contributed to higher infection rates in neonates and mothers. The introduction and implementation of such program especially in rural and difficult to reach communities will also help to improve newborn safety during delivery and reduce the incidence of neonatal sepsis. Traditional birth attendants and midwives, community health workers and other cadets attending to births could be targeted initially. A regular follow up supervision schedule should be made to ensure they are practicing as instructed.

4.4 Findings and linkages from other Sub-Sahara African Countries

Young maternal age was found as a determinant of sepsis in Liberia and similar to other studies in Ghana by Kpikpitse et al. in 2014 and Alemayehu at al. in 2020 in Ethiopia. Parity was observed to predispose neonates to sepsis in Democratic Republic of Congo by Nyenga et al. in 2021 and in Ghana by Kpikpitse et al. in 2014, but not found in Liberia due to limited data. While marital status was not link with sepsis in Liberia, it was found in Kenya as a factor of neonatal sepsis where Okube et al. in 2021 revealed that neonates were 5 times more likely to have sepsis if they were born by single mothers compared to

those born to married mothers. Similarly, birth interval was considered a predisposing factor of sepsis in Liberia and in line with the findings of Mahande et al. in 2016 in Tanzania that short birth interval increases the risk of preterm birth and perinatal death. In Liberia, mothers were aware that using unclean instrument to cut the umbilical cord and application of harmful substances on the cord caused infection, yet it was practiced among some mothers and this finding was similar to the one by Chidiebere et al. in 2015 in Nigeria. Surprisingly, parental education only focused on mothers' education leaving out the fathers, and the available study in Malawi and Uganda only made the link of mothers' education with preventing neonatal death not considering that neonates died in many instances as a result of preventable illnesses. Regardless of these findings, there is a clear association between educational level, socio-economic status, and the ability of mothers to have fewer children and make better choices with hospital-based deliveries attended by more skilled professionals. Parent employment status found no satisfactory link with sepsis as expected, as Kayom et al. in 2018 in Uganda tried to establish link by discussing that neonates were 3.8 times more likely to have sepsis if their mothers did not receive financial support from the fathers compared to those who mothers did. Findings in Liberia discovered age to predisposed neonates to sepsis, and very young babies from birth to seven days were associated and same was found in Ghana in 2018 by Adatara et al. Whereas the sex of the child too was an associated factor in Ethiopia by Agnche et al. in 2018 where being male exposed them to sepsis than being a female., unfortunately Liberia had no data to prove. Another factor found in Liberia was gestational age and this was in line with Ethiopian Geyesus et al in 2017.Antenatal visits less than four and vaginal delivery were predisposing factors found in Liberia and similar to Okube et al.in 2020 in Kenya and Geyesus et al in 2017 in Ethiopia. There is a need for further research in Liberia to establish the link between early marriage, adolescent mothers, and neonatal outcomes.

4.5 Reflection on the Framework

Regarding the conceptual frame it was helpful in guiding the process of literature search and in presenting the findings. However, some of the determinants considered to be important factors in the setting of Liberia were not available, such as sex of the neonate, maternal parity, and marital status. Sex has been shown in Liberia to contribute to neonates' death, but no source available for sepsis. The framework was a combination made from two original frameworks with some other external components added to fit this research and I would propose it to be used, and recommend the inclusion of stigma, early marriage, and traditional cord practices in similar study only if the study background does not have limited data like Liberia.

4.6 Thesis Strength and Limitations

The study identified through findings some socio-cultural, economic, and political factors as well as barriers faced by pregnant women that also affect their unborn babies, all of which contribute to early newborn infections. However, data relating to the topic was scarce from the research setting, and the analysis on the health care system, political, and socio-economic factor were very limited. Therefore, the findings were contextualized against the background of Ebola, COVID-19, and the civil war. even though there were some findings available from similar context in Sub-Saharan Africa. In addition, the research also revealed issues surrounding the secrecy pregnant women portrayed during labor in Liberia had its origin from the Sande society, a traditional group where FGM is widely practiced. Pregnant women subscribing to this practice were more likely not to attend antenatal visits and preferred home delivery, conditions that put them at an even higher risk of complications including premature rupture of membrane, maternal fever during labor, meconium-stained amniotic fluid, eclampsia, sexually transmitted infections, and urinary tract infections. Many of these complications were also found to be factors associated with the risks of developing neonatal sepsis in several studies which were outside the scope of this research. Local data on best practices in Liberia were grossly

limited but inferences were made based on findings from other Sub-Saharan countries with nearly similar setups.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Neonatal sepsis is still a major health issue in Liberia with several underlying factors contributing to newborn continuous exposure to infection. Young maternal age with its associated unplanned teenage pregnancy is considered one of the factors influencing neonatal sepsis as women and girls begin sexual intercourse at an early age. Poverty and low socio-economic status were found to be associated with an increased fertility rate amongst rural women, another factor that underlines the risks of newborn infections in Liberia due to difficulties in acquiring the necessary resources for healthcare during pregnancy and delivery or maintaining personal and community hygiene. Inadequate financial and health resources to provide infection, prevention, and control materials for facility delivery and urban rural disparities in healthcare were also found to contribute to neonatal sepsis.

5.2 Recommendations

The recommendations made here are evidence from the thesis findings that will help to reduce neonatal sepsis in Liberia.

5.2.1 Recommendations on the full implementation of the chlorhexidine cord care policy and finance at national level:

The government of Liberia should focus more on the full implementation of the validated chlorhexidine cord care policy and ensure that all the 15 counties benefit from the implementation process. The implementation should be at various levels starting from the ministry of health to the health districts and regional hospitals in each county with community rollout included. And the government should also finance hygiene kits for cord care practice at the community level as it is an effective intervention strategy.

- The government should review its budgetary allocation to health to ensure that there are sufficient funds available to procure chlorhexidine, essential

drugs, infection prevention and control materials, and adequate supplies for maternal and child health service delivery especially in the rural areas where mothers covered longer distances to health facility just to realize that there are no supplies.

- The government should make serious commitment and investment into health research, trainings, community-based programs, and maternal and reproductive health services need to be done to ensure Liberia reduces the current trends in neonatal infections and pregnancy related outcomes for the newborn in order to reach the MDG 4 and 5.

5.2.2 Recommendations at county level

- The county health officers, through their district health teams, should enforce rural outreach, and ensure logistics are available at all times to follow up on pregnant women who missed return antenatal visits.
- County health officers should prioritize adolescent sexual and reproductive health by ensuring active awareness, education and support are made available to young men and women. Such programs should also be incorporated into school curricula as well as community outreach manuals.
- There should be special training and continuous medical education for all cadets of healthcare providers associated with maternal and child health including skilled and unskilled midwives, nurses, and physician assistants on the management of FGM victims during pregnancy, labor, and delivery, early diagnosis and management of maternal and newborn infections and referrals. Pregnant women who are members of Sande society or who may have undergone FGM should be provided female special support including female birth attendants to encourage health facility-based deliveries.
- Every home delivery should be monitored by community health workers to ensure that the traditional midwives are practicing proper hand hygiene. Clean and sterile delivery kits, monetary incentives for referring at risk pregnancies to health facilities and ambulance services should be made

available for ease of referral. These support systems should be backed by regular supervision.

- Ensure health workers are evenly distributed between rural and urban centers with keen attention to ease of access and population being served. Additional support for rural health workers including training opportunities, extra incentives, utilities including housing, transportation, internet, communication, and family support should be mandatory.
- Provision of continuous health education, community awareness on cord care and the availability of clean delivery kits will help reduce the occurrences of newborn sepsis.

5.2.3 Recommendations at Practice Level (Best Cord Care Practice)

- Additional training and refresher courses on Infection Prevention and Control (IPC) should be mandatory at all levels of healthcare with regular and vigorous audits and weekly supervision to ensure healthcare related infections are reduced.
- Prenatal and post-natal care visits by community health workers including homes for newborns and pregnant women should be supported to ensure proper cord care, vaccination schedules are met, and prenatal visits are regular.
- To increase utilization of antenatal and postnatal care visits among young pregnant women in the rural region, healthcare providers seeing pregnant women during ANC visits should assist them in making a pre-delivery plan that includes importance of skilled delivery care, transportation arrangement, birth companion, home support and possible blood donation in case of emergency. Traditional midwives and community health workers within her community should form part of the plan for possible execution.
- Male involvement should be encouraged and even incentivized as they form an important part and control the financial and health seeking decisions for many women in Liberia.

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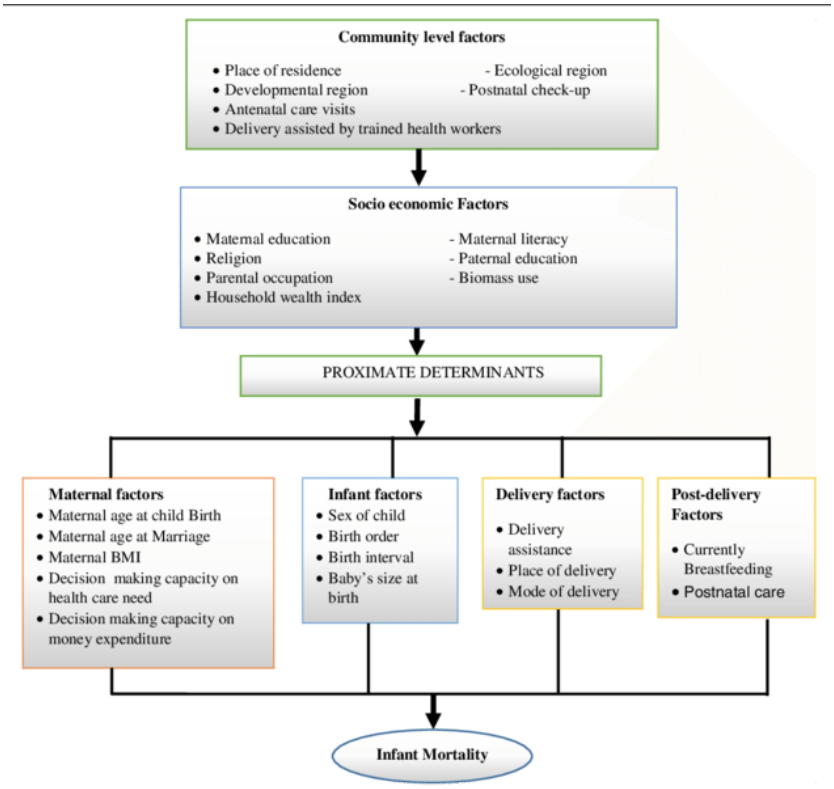
Annex 1: Search strategy: Using the specific objectives in combination with ‘’AND” and or “OR”

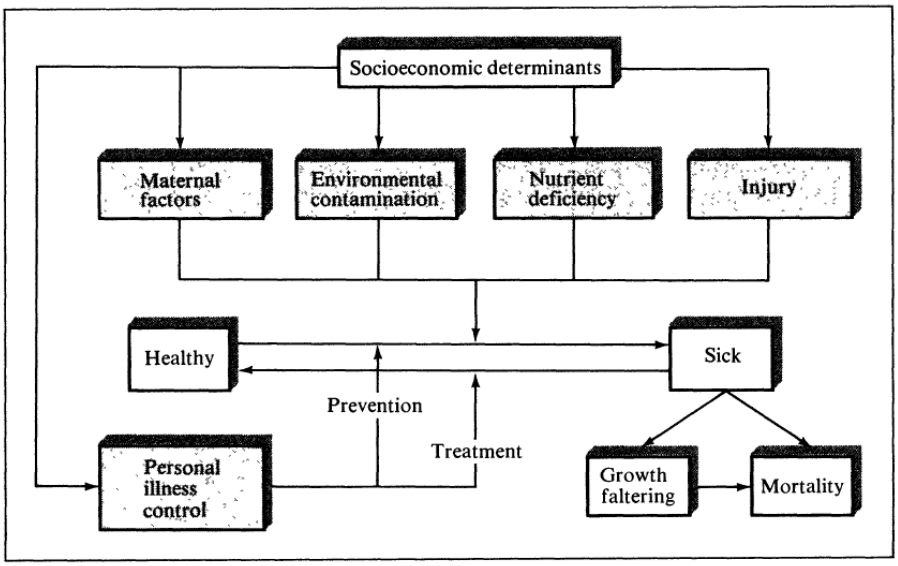
	Search engines/Literature	**Grey Literature**	**Key terms 1** **Core problem**	**Key terms 2 objectives**	**Key terms 3** **Geographical region**
To explore maternal factors of neonatal sepsis	Peer-reviewed published articles VU Library, PubMed, google scholar,	LDHS, WHO, UNFPA, UNICEF, United Nations, and Non-governmental organizations report, Government of Liberia (MOH) documents, National Public health Institute of Liberia website	Neonatal sepsis, Newborn Septicemia, newborn infection, Omphalitis, umbilical cord infection Prevalence of neonatal sepsis Postnatal cord care Knowledge, Attitude, Practice, Political, sociocultural, Economic Factors	Maternal Age, parity, birth interval	Liberia West Africa Sub-Saharan Africa Africa Global
To explore maternal socioeconomic and sociocultural	Peer-reviewed published articles VU Library, PubMed,	LDHS, WHO, UNFPA, UNICEF, United Nations, and Non-	socioeconomic status, application of traditional substances	Maternal education, Paternal	Best practices,

factors of neonatal sepsis	google scholar,	governmental organizations report, Government of Liberia (MOH) documents, National Public health Institute of Liberia website		education, Employment, Place of residence	"Sub-Saharan Africa "Neonatal sepsis Reduction" "Uganda" Prevention of neonatal sepsis" Umbilical cord care" Kenya"
To explore neonatal associated factors of sepsis	Peer-reviewed published articles VU Library, PubMed, google scholar,	LDHS, WHO, UNFPA, UNICEF, United Nations, and Non-governmental organizations report, Government of Liberia (MOH) documents, National Public health Institute of		Age, Sex of neonates' Gestational age, Birth weight Types, mode, and	

To explore health care system related factors of neonatal sepsis				assistance during delivery, ANC visits and quality of care during delivery	

Annex 2: Conceptual Framework




Socioeconomic determinants
Maternal factors
Environmental contamination
Nutrient deficiency
Injury
Healthy
Sick
Prevention
Treatment
Personal illness control
Growth faltering
Mortality