International Journal of Healthcare Sciences ISSN 2348-5728 (Online)
Vol. 13, Issue 1, pp: (145-159), Month: April 2025 - September 2025, Available at: www.researchpublish.com

Prevalence and Factors Associated with Neonatal Sepsis at Rwamagana Level II Teaching Hospitals in Rwanda

[1]Ms. Iyakaremye Christine, [2]Dr. Nasiru Sani, [3]Dr. Mochama Monica

[1](School of Public Health, Department of Public Health, Mount Kenya University)
[2](School of Public Health, Department of Public Health, University of Rwanda)
[3](School of Public Health, Department of Public Health, Mount Kigali University)

DOI: https://doi.org/10.5281/zenodo.15582935

Published Date: 03-June-2025

Abstract: **In Rwanda, one of the main causes of infant deaths is neonatal sepsis and it is claimed that 61 percent of newborns with low birth weight perished as neonates in 2017 due to sepsis. The main objective of this study was to assess prevalence and Factors associated with neonatal sepsis at Rwamagana Level II Teaching Hospital. A quantitative approach, non-experimental, retrospective cross-sectional study design was used. To determine factors and the prevalence of neonatal sepsis, Researcher randomly selected 238 neonatal files out of the 588 newborns admitted from June 2022 to December, 2023. Data on socio demographic traits, neonatal health-related information, maternal health-related information, and medical procedure health-related information were gathered using a standardized questionnaire. The data were collected from the files, and information was entered on the given questionnaire. To conduct Data analysis, we used IBM SPSS package version 23 where by a descriptive analysis was conducted in form of frequency tables and percentages, for social-demographic characteristics, the prevalence and factors associated with neonatal sepsis were presented in the form of percentages and frequency tables. Finally, the researcher examined factors for newborn sepsis using Bivariate and multivariate analysis. Results: Among 238 neonates, majority were males accounting for 51.18% (n=122) of the neonates while female neonates accounted for 48.82 %(n=116). the majority of neonates had low birth weight (< 2500gm), representing 50.47% (n=120) while 49.53% (n=118) had normal birth weight (≥ 2500mg) and no one who had either extremely high birth weight (>4000mg or extremely low birth weight (≤1000 or 1500mg). The largest group of neonates had delivered at Hospital, comprising 59.48% (n=142) of the sample. A smaller percentage had delivered at Health center (31.99%, n=76). Only a few of neonates (8.53%, n=20) had delivered at home. About gestational age of neonates admitted at Rwamagana Level II Teaching Hospital, majority (56.6%, n=135) of neonates were delivered at gestational age less than 37 weeks while the rest (43.4%, n=103) of neonates were delivered at gestational age that is equal or greater than 37 weeks. About sociodemographic factors of mothers, majority of mothers were multipara accounting for (82%, n=195) while the rest were primipara accounted for 18 %(n=43). The majority of mothers had attended ANC visits, representing 97% (n=231) while 3% (n=7) did not received any visit. The most proportions of mothers had prolonged labor (82%, n=195) compared to normal labor (18%, n=43). Regarding the Birth attendant and vaginal examination, the largest group of mothers had examined more than four times, comprising 91% (n=217) of the sample. The prevalence of neonatal sepsis at Rwamagana Level II Teaching Hospital was 14.8%. Regarding the factors associated with neonatal sepsis bivariate and multivariate analysis revealed that being in age group (p= 0.025) and gestational ages (p=0.004) were a statistically significant associated with neonatal sepsis. Strong association with sepsis was found with neonatal age from 0-3 days (aOR: 2.769; 95% CI 1.312–5.843; p = 0.008), and gestational weeks < 37 weeks or ≥37 weeks (aOR: 4.149; CI 1.1878–9.167; p ≤ 0.004).In conclusion, neonatal sepsis was high and implementing these recommendations such as community awareness programs as well as resource allocation can help reduce the prevalence of neonatal sepsis and improve overall neonatal health outcomes in Rwamagana Level II Teaching Hospital.**

Key words: **Prevalence, Neonatal Sepsis, Level II Teaching Hospitals, Rwamagana, Rwanda.**

1. INTRODUCTION

Sepsis refers to a dysregulated host response to infection that results in potentially fatal organ failure (Singer et al., 2016).According to (Adatara et al., 2019) the cause of 26% of newborn fatalities globally is neonatal sepsis. Neonates are extremely susceptible to sepsis; nevertheless, many nations do not have accurate incidence estimates for this age range (Fleischmann-Struzek et al., 2018). According to the Global Burden of Disease (GBD) Study 2016–2017, Globally there were 1.3 million newborn sepsis incident cases each year (James et al., 2018). According to (World Health Organization, 2024), In the first 20 days of life, 2.3 million children worldwide perished due to sepsis in 2022 and about 6500 neonatal fatalities occur each day, making up 47% of all child deaths under the age of five.

Low- and middle-income countries (LMICs) are disproportionately affected by the high prevalence of infectious illnesses that afflict newborns (Fleischmann et al., 2021).and inadequate access to medical facilities that are staffed and equipped appropriately (Nwankwor et al., 2019). According to (Ranjeva et al., 2018) Neonatal sepsis and subsequent long-term morbidity are estimated to have cost between 5.3 and 8.7 million disability-adjusted life years in sub-Saharan Africa alone in 2014. According to 2014 estimates, the region has seen an estimated economic cost from neonatal sepsis of up to US$469 billion.

In Tanzania, according to (Jabiri et al., 2016) neonatal sepsis significantly contributes to neonatal mortality and according to estimates 31.4% of newborns developed sepsis in Dar es Salaam. In Ghana, Newborn sepsis is falling, according to (Adatara et al., 2019), neonatal sepsis remains a substantial global and specifically African barrier to progress in lowering specific mortality rates. Additionally, newborns between the ages of 0 and 7 days had a 2.19-fold higher risk of developing sepsis than adults did.

The global newborn sepsis burden is largest in South Asia and sub-Saharan Africa and According to reports in 2013, 38.9% of all newborn deaths attributable to sepsis occurred in South Asia (Naghavi et al., 2017) and (Liu et al., 2016).Infections that result in sepsis account for one-fifth of the 2.7 million newborn fatalities globally each year, and they account for around 25% of neonatal deaths in South Asia and sub-Saharan Africa (Aseffa & Abathun, 2020). According to Aseffa and her colleague (2020), newborn sepsis is 40 times more common and fatality rates in middle-income nations are two times higher than in high-income countries (Aseffa & Abathun, 2020).

According to (Wakjira Basha et al., 2020) in 2016, the most common reason for infant mortality in Ethiopia was neonatal sepsis, which was responsible for more than one-third (33%) of all neonatal deaths. The 2016 Ethiopia Demographic and Health Surveys found that for every 1,000 live births, there were 29 neonatal deaths. On top of that, a 2017 investigation carried out in a few hospitals in Hashemene Town, Oromia Regional state, discovered that 190 (or 77.9%) of the 244 infants admitted to the NICU had newborn sepsis (Getabelew et al., 2018).

One of the main causes of infant deaths in Rwanda is neonatal sepsis (UNICEF Office for Rwanda, 2017). According to data from the UNICEF Office for Rwanda, in 2017 ,61 percent of newborns with low birth weight (less than 2500 gm) and 39 percent of newborns with low birth weight (normal birth weight) perished as neonates. According to the audited statistics, district/provincial hospitals were responsible for 63% of neonatal mortality, followed by healthcare facilities (24%), and families (4.5%). In addition, 89% of fatalities occurred within the first week, and 58% occurred within the first 48 hours of birth. Prematurity (32%), sepsis/infection (10%), and birth asphyxia (39%), among other factors, are the main causes of neonatal deaths. The audit also revealed that 49% of neonatal deaths were related to delayed care seeking, with 27% of late decisions made during childbirth and 24% of neonatal deaths being caused by insufficient neonatal case management (UNICEF Office for Rwanda, 2017).

Factors for neonatal sepsis are often numerous, and they are divided into groups based on when the condition first appears. Premature membrane rupture (greater than 18 hours), fetal distress, maternal pyrexia (less than 38 C), or overt illness like a UTI, gastroenteritis, or gonorrhea are factors for early sepsis start. Numerous vaginal examinations, premature birth, a previous child's history of GBS infection, and the presence of GBS bacteria during current pregnancy are additional Factors(Aseffa and Abathun, 2020). Long-term hospitalization, such as with a preterm newborn in a NICU, the presence of foreign bodies like intravenous catheters and endotracheal tubes, as well as cross-infection by caregivers and other patients, are additional Factors for late-onset sepsis (Gollehon, 2019). Neonatal mortality in Rwanda is 20 per 1000 live births, and neonatal infection is the third leading cause of neonatal mortality after prematurity and birth asphyxia.

Neonatal sepsis is a problem in Rwamagana as well, according to the one study on neonatal health done by (Kayinamura et al., 2010) at RPH neonatal sepsis was the third most frequent diagnosis, accounting for 30% of cases, and one of the main causes of early neonatal mortality. Therefore, this study assessed the prevalence and associated factors of neonatal sepsis at Rwamagana Level II Teaching Hospital and the results of this study helped to update the newborn sepsis rates and Factors at Rwamagana Level II Teaching Hospital. The main objective of this study was to assess prevalence and factors associated with neonatal sepsis at Rwamagana Level II Teaching Hospital in Rwanda.

It was guided by the following specific objectives:

i. To determine prevalence of neonatal sepsis at Rwamagana Level II Teaching Hospital in Rwanda.

ii. To identify the factors associated with neonatal sepsis at Rwamagana Level II Teaching Hospital in Rwanda.

2. THEORETICAL FRAMEWORK

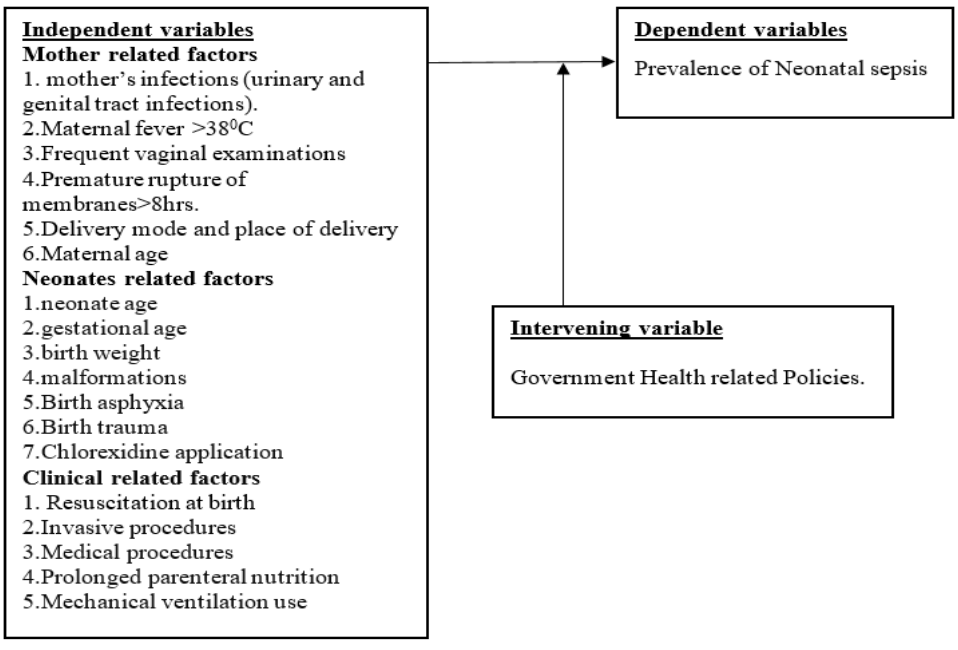
The social ecological model is primarily a multi-level, systems theory framework for analyzing and understanding social systems and interactions between individuals and environments. It was applied to epidemiology in 1996 by Mervyn Susser and Ezra Susser and in 2005, Urie Bronfenbrenner fit the model to its current design as and within a systems theory (*Ezra Susser, MD, DrPH*, 2022).Social-ecological Model was developed at first time by Psychologist Bronfenbrenner's in 1970s, in united states of America, Michigan university to further understanding of the dynamic interrelations among various personal and environmental factors (Cherry, 2023). According to(Kilanowski PhD, 2017) the CDC have adapted the social ecological model for various health promotion endeavors to include the spheres of interpersonal, organizational, community, and policy.

Furthermore CDC used a four-level social-ecological model to better understand violence and the effect of potential prevention strategies(*The Social-Ecological Model*, 2022).In addition, this model was also used by (Newman-Temmerman et al., 2015) in their research article called Global Estimates of Prevalence and Incidence of Four Curable Sexually Transmitted Infections in 2012 Based on Systematic Review and Global Reporting where they found that the global prevalence and incidence of urogenital chlamydia, gonorrhea, trichomoniasis, and syphilis in adult men and women aged 15 to 49 years remain high, with nearly one million new cases of curable STI acquired each day.

This makes them to use the Socio-Ecological Model to develop a practical solution to reduce the effect of STDs in their society. This model is also applied to this study of assessing the prevalence and factors associated with neonatal sepsis because of access to and outcomes of preventive services in neonates and children in general vary based on features of children's social ecology, including family and community contexts. The proposed five-stage socio-ecological model considers multiple contextual dimensions of pediatric protecting from neonatal sepsis such as individual, interpersonal, organizational, community or population, and public policy(Graif et al., 2021). The social ecology of children, which includes family and community settings, has a significant impact on the availability, application, and results of pediatric and developmental screenings; nevertheless, models of pediatric preventive care currently seldom take these social dynamics into account.

This five-stage ecological model can be used to assess prevalence and Factors associated with neonatal sepsis at Rwamagana Provincial Hospital in Rwanda because of Each of stage represents specific facets and components of both societies and how they may relate, either positively or negatively to the neonatal sepsis. In addition, its effectiveness of comprehending the many forms of assistance and prospective directions for future advancements in the developmental and medical examinations for children. Therefore, Regular care of children and neonates could be enhanced by implementing this strategy, potentially leading to better individual and population outcomes in Rwamagana provincial hospital.

3. CONCEPTUAL FRAMEWORK



Source: (Researcher,2023)

Figure 1: Conceptual Framework

4. RESEARCH METHODOLOGY

1. Research design

Quantitative approach, Retrospective cross-sectional study design was conducted among neonate admitted at Rwamagana Level 2 Teaching Hospital from June to December 2023. Where the researcher assessed prevalence and factors associated with neonatal sepsis.

Research Setting

A public institution, Rwamagana Level 2 Teaching Hospital is located 60 kilometers from Kigali in the Eastern Province's Rwamagana District, Kigabiro Sector, and Nyagasenyi cell. It was established in 1949 as a medical facility for mine workers. It changed its name to Public District Hospital in 1952. Upgraded to Rwamagana Level II Teaching Hospital on May 14, 2014. May 14th, 2014. Rwamagana Level 2 Teaching Hospital offers specialized curative and preventive health care in the four major specialities of Surgery, Paediatrics, Gynecologic-obstetrics and Internal Medicine. Rwamagana Level 2 Teaching Hospital is an open health research field and offer evidence-based clerkship teaching of multidisciplinary health disciplines including under and post graduate medical trainees, general and hospital nursing, midwives, lab technicians, and other paramedics trainees. Neonatology service of Rwamagana Level II Teaching Hospital had average monthly admission of 72 neonates, have three rooms, whereby it has the first room to take care of those neonates who needs special care like varying temperature that room have seven incubators then the second room is for neonates who needs kangaroo mother care it has 8 beds and the other room for neonates who are with their mother and are not critically ill have ten beds. In addition to that have thirteen nurses and one pediatrician who work in those services.

Target Population

The group of people known as the study population was chosen based on inclusion and exclusion criteria related to the variables being examined (Ibrahim & Marcaccio, 2023). The study population will be neonates from day 0 to day 28 of life and who was admitted in neonatology service at Rwamagana Level 2 Teaching Hospital from June to December 2023. Neonatology services have admitted 588 neonates from June to December 2023. Only 238 neonatal files were enough to represent the whole study population.

Sample Design

Sample Size

The number of individuals chosen from the general public who were thought to be representative of the real population in that particular study is referred to as the sample size (Henly, 2018). In order to generalize the results to the population, a sample size must be sufficient. Utilizing the formula provided by Taro Yamane in 1967, a sample was obtained for this study.

$n = \frac{N}{1+N(e^2)}$ Where e: is the marginal error fixed at 5% = 0.05, n: is the sample size, and N: is the entire population (Fox & Hunn, 2009)

Let's compute the sample size with this formula.

N= 588, e= 0.05, n is sample size

$$n = \frac{N}{1+N(e^2)} = \frac{588}{1+588(e^2)} = \frac{588}{1+588(0.0025)}$$

$$= \frac{588}{1+1.47} = \frac{588}{2.47} = 238.05$$ this is approximately to 238 neonates.

After using this formula, Researcher had 238 neonates which were equal to 238 neonatal files where data was picked from. With all babies admitted to Rwamagana neonatology services between June and December 2023 as the study population, this formula was used to evaluate the prevalence of neonatal sepsis and Factors connected to neonatal sepsis.

Sampling Technique

First, a simple random sampling strategy was used to determine the prevalence of neonatal sepsis. Researcher did this by gathering all the neonatal admission files from June to December 2023, writing the file number on each paper, and then randomly selecting papers from the file until reaches the desired sample size. In assessing factors, Researcher took that files

that was used for assessing prevalence and was also used them to found out factors. Therefore, the files were picked up to be used for gathering data and this was of good important because it was useful in decrease of confounding variables.

Data Collection Methods

Data Collection Instrument

Primary data were obtained using a structured questionnaire administered in English or Kinyarwanda language. The questionnaire was pre-tested in a health facility outside the study area in order to establish its validity and reliability .The researcher decided to use this questionnaire because it was developed based on reviewed related literature on Factors of neonatal sepsis such as low APGAR score in the fifth minute, resuscitation at birth, , hypertensive disorders, bleeding disorder, UTI/STI, PROM and others(Nyma et al., 2020).

It had five sections and a total of 36 questions. First, there was 8-question section on the socio-demographics of the mother and the newborn; then, there were 15 questions on factors connected to maternal health; then, there were 6 questions on factors related to neonatal health; and, finally, there was a section on health care. It consisted of six questions and practice-related elements, with the fifth portion determining whether a newborn has been diagnosed with neonatal sepsis. The data collected from neonate files will record them on study tool for each part with a cross (x) in the box and their writing in the space provided. At the Rwamagana Level 2 Teaching Hospital, researcher will examine the prevalence and factors of newborn sepsis using the information recorded on the questionnaire.

Data Collection Procedure

Researcher begun the process of collecting data at Rwamagana Level II Teaching Hospital after receiving permission from the data collection center, and did so by first providing information regarding the research, such as the study's purpose, considerations to be made during the data collection period, and tools that was used to the administration of Rwamagana Level II Teaching Hospital, especially neonatal patients. Finally, after the explanation of the research to the available head of neonatal services, other healthcare professionals and after obtaining consent from the hospital's administration to have access to the concerned files Researcher started by filling of information from the file picked randomly to the questionnaire so as to answer the questions provided on the questionnaire without writing down their names. The answers that were provided, acted as basis for analysis and conclusion.

5. RESEARCH FINDINGS AND DISCUSSION

Socio-demographic characteristics of neonates admitted at Rwamagana Provincial Hospital

Table 1: Socio-Demographic Characteristics of Neonates

Variables		Freq(n=238)	Percentages (%)
Gender			
	Male	122	51.18
	Female	116	48.82
Birth weight			
	< 2500	120	50.47
	≥ 2500	118	49.53
Mode of delivery			
	Caesarean	185	77.73
	Vaginal	53	22.27
Place of birth			
	Hospital	142	59.48
	Health center	76	31.99
	Home	20	8.53
Gestational Age (Weeks)			
	< 37	135	56.6
	≥ 37	103	43.4
Apgar at 10min			
	≤ 6	57	23.81
	> 7	181	76.19
Malformation/Neonate			
	Yes	26	11
	No	212	89

Mechanical ventilation/Neonate			
	Yes	2	1
	No	236	99
Resuscitated			
	Yes	14	6
	No	224	94
Neonatal sepsis			
	Yes	35	14.8
	No	203	85.2
Age group in days			
	0-3 days	208	87.44
	4-28 days	30	12.56

Source: Primary data, 2024

The study involved both males and female neonates, with the majority of males accounting for 51.18% (n=122) of the neonates. The slight majority were female neonates accounted for 48.82 %(n=116). The majority of neonates had low birth weight (< 2500gm), representing 50.47% (n=120) while 49.53% (n=118) had normal birth weight (≥ 2500mg) and no one who had either extremely high birth weight (>4000mg or extremely low birth weight (≤1000 or 1500mg). This distribution suggests that most neonates admitted at neonatal units of Rwamagana Level 2 Teaching Hospital were are at a higher risk for various health issues, both immediately after birth and later in life as well as increased susceptibility to infections. The sample had a higher proportion of neonates who delivered through Caesarean section (77.73%, n=185) compared to spontaneous vaginal delivery (22.27%, n=53), indicating that caesarean delivery predominantly take on the vaginal delivery at Rwamagana Level 2 Teaching Hospital. Regarding the place of delivery, the largest group of neonates had delivered at Hospital, comprising 59.48% (n=142) of the sample. A smaller percentage had delivered at Health center (31.99%, n=76). Only a few of neonates (8.53%, n=20) had delivered at home. About gestational age of neonates admitted at Rwamagana Level 2 Teaching Hospital, majority (56.6%,n=135) of neonates were delivered at gestational age less than 37 weeks while the rest (43.4%,n=103) of neonates were delivered at gestational age that is equal or greater than 37 weeks. This demonstrates that most neonated admitted at Rwamagana Level 2 Teaching Hospital were premature while the rest were at term.

The majority (89%,n=212) of neonates had no malformation while the rest (11%,n=26) of neonates had got malformation, most of neonated(99%,n=236) did not received mechanical ventilation while the rest (1%,n=2) received mechanical ventilation. The sample had a higher proportion of neonates (94%, n=224) who did not resuscitate in their life while the rest (6%, n=14) of neonates had been resuscitated.

Socio-demographic characteristics of mothers with neonates admitted at Rwamagana Level 2 Teaching Hospital

Table 2: Socio-Demographic Characteristics of Mothers

Variables		Freq(n=238)	Percent(%)
Parity	Primipara	43	18
	Multipara	195	82
ANC Visits			
	Yes	231	97
	No	7	3
Prenatal care visits			
	Once	2	1
	Two times	10	4
	Three times	133	56
	Four times	93	39
Duration of labor	Normal labor	43	18
	Prolonged labor	195	82
Birth attendant/Vaginal examination			
	Between 1 and 4 times	21	9
	More than 4 times	217	91

Fever on Labor			
	No	238	100
Amniotic Fluid/foul smelling			
	No	238	100
PIH/Eclampsia on pregnancy			
	No	238	100
Vaginal Bleeding on pregnancy			
	Yes	5	2
	No	233	98
UTI/STI on Pregnancy			
	No	238	100
Chorioamnionitis/delivery			
	No	238	100
History of PROM on delivery			
	No	238	100
	Total	238	100

Source: Primary data, 2024

The study involved both multipara and primipara mothers, with the majority of multipara mother accounting for (82%, n=195) of the mothers. The slight majority were primipara mothers accounted for 18 %(n=43).The majority of mothers had attended ANC visits, representing 97% (n=231) while 3% (n=7) did not received any visit. The most proportions of mothers had prolonged labor (82%, n=195) compared to normal labor (18%, n=43), indicating that prolonged labor predominantly take on normal labor among mothers with neonates admitted at Rwamagana Level 2 Teaching Hospital. Regarding the Birth attendant and vaginal examination, the largest group of mothers had examined more than four times, comprising 91% (n=217) of the sample. A smaller percentage had examined between one and four times (9%, n=21). The sample had a higher proportion of mothers (100%, n=238) who did not have fever on labor, amniotic fluid with foul smelling, Pregnancy induced hypertension, urinary tract infections or sexually transmitted infections on pregnancy as well as chorioamnionitis and there was no history of Pre mature rapture of membrane (PROM) on pregnancy, while a smallest proportion of mothers (2%, n=5) had vaginal bleeding.

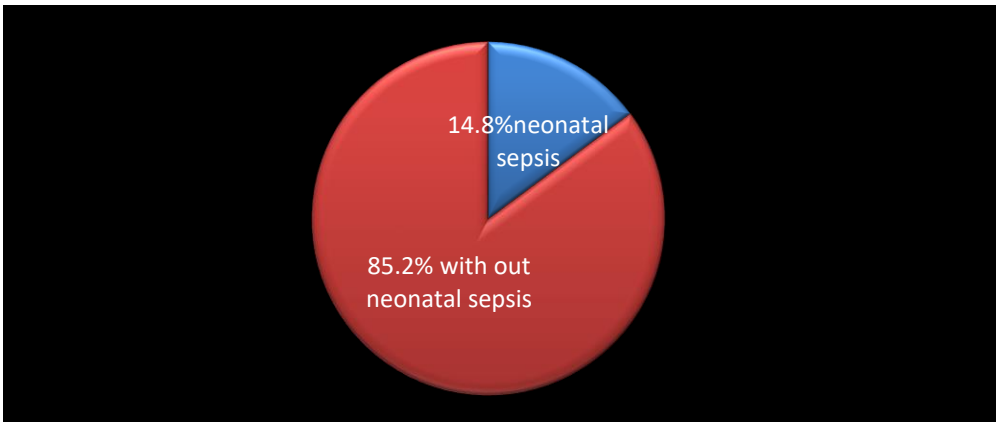
Prevalence of Neonatal Sepsis among Neonates

Table 3: Prevalence of Neonatal Sepsis

Variables	Frequency (n=238)	Percent (%)
Laboratory/Neonatal Sepsis		
Yes	35	14.8
No	203	85.2
Total	238	100

Source: Primary data, 2024

This above table indicates that the majority (85.2%, n=203) of neonates have not been diagnosed with neonatal sepsis while the rest (14.8%, n=35) had sepsis. Therefore, the prevalence of neonatal sepsis was 14.8% at Rwamagana level 2 teaching Hospital.



Source: **Primary data, 2024**

Figure 2: Prevalence of Neonatal sepsis at Rwamagana Level 2 Teaching Hospital

The figure above presents the prevalence of neonatal sepsis among neonates admitted at Rwamagana Level 2 Teaching Hospital, Rwanda. Out of 238 neonates, 34(14.8%) had neonatal sepsis while 203 (85.2%) of neonates had not the sepsis. This indicates that the prevalence of neonatal sepsis at Rwamagana Level 2 Teaching Hospital was 14.8%.

Table 4: Bivariate Analysis of Factors Associated with Neonatal Sepsis

Variable	Category	Sepsis Developed (Yes)	% (Yes)	Sepsis Not Developed (No)	% (No)	Chi-Square (X^2)	p-value
Sex	Male	122	14.68%	107	87.96%	0.137	0.733
	Female	116	15.75%	100	86.41%		
Age group (days)	0-3 days	208	22.67%	184	88.62%	5.013	0.025
	4-28 days	30	6.79%	23	77.36%		
Birth weight	< 2500 g	120	18.02%	102	84.98%	6.026	0.157
	≥ 2500 g	118	12.42%	106	89.47%		
Types of delivery	Caesarean	185	8.51%	86	91.49%	3.975	0.163
	Vaginal	53	46.02%	282	85.98%		
Malformation/Neonate	Yes	26	3.36%	22	87.06%	0.012	0.964
	No	212	27.05%	184	87.24%		
Gestational age (weeks)	< 37 weeks	135	21.46%	114	84.1%	104.520	0.004
	≥ 37 weeks	103	9.00%	94	91.26%		
Apgar score	≤ 6	57	7.37%	49	87.06%	0.307	0.671
	≥ 7	137	16.00%	121	88.24%		

Source: Primary data, 2024

The findings from table above indicates the bivariate analysis that was performed and revealed that being in age group (p= 0.025) and gestational ages (p=0.004) in the context of factors associated with neonatal sepsis suggests that there were a statistically significant associated with neonatal sepsis. Regarding the multivariate analysis, there was no significant association between Apgar score and neonatal sepsis (p=0.671). Strong association with sepsis was found with neonatal age from 0-3 days ($p = 0.008$), and gestational weeks < 37 weeks or ≥37 weeks ($p \leq 0.004$).

Table 5: Bivariate of Maternal Factors Associated with Neonatal Sepsis

Variable	Category	Sepsis Developed (Yes)	% (Yes)	Sepsis Not Developed (No)	% (No)	Chi-Square (X^2)	p-value
Parity	**Primipara**	43	8.47%	39	91.53%	1.095	0.277
	Multipara	195	13.78%	168	86.22%		
Duration of Labor	**Normal labor**	43	14.29%	36	85.71%	0.035	0.905
	Prolonged labor	195	12.77%	170	87.23%		
Fever on Labor	**Yes**	212	12.88%	215	87.12%	0.022	0.843
	No	26	11.54%	23	88.46%		

Source: Primary data, 2024

The findings from table above indicates the bivariate analysis of maternal factors associated with neonatal sepsis that was performed and revealed that there was not statistically significant with neonatal sepsis. Therefore, being either primipara or

multipara (p= 0.277), having four times of ANC visits (p=0.673), duration of labor (p=0.905), presence of fever on labor (p= 0.834) and other maternal factors in the context of factors associated with neonatal sepsis suggests that there were not a statistically significant associated with neonatal sepsis.

Table 6: Bivariate Analysis of Hospital Related Factors Associated with Neonatal Sepsis

Variable	Sepsis Developed (Yes)	% (Yes)	Sepsis Not Developed (No)	% (No)	Chi-Square (X^2)	p-value
ANC Visits						
Yes	231	22.22%	7	77.78%	0.627	0.373
No	7	12.13%	324	87.87%		
Number of ANC Visits						
Once	2	22.64%	7	82.43%	3.401	0.065
Two times	10	12.98%	54	87.02%		
Three times	133	15.89%	117	88.23%		
Four times	93	12.65%	82	88.4%	0.673	0.411
Place of Delivery						
Hospital	142	15.85%	126	88.84%	3.365	0.3
Health center	76	14.81%	64	85.19%		
Home	3	16.67%	16	83.33%	0.417	0.342
Birth Attendant/Vaginal Examination						
Between 1 and 4 times	21	17.5%	99	82.5%	3.022	0.082
More than 4 times	217	12.3%	190	87.7%		

Source: Primary data, 2024

The findings from table above indicates the bivariate analysis of institutional factors associated with neonatal sepsis that was performed and revealed that there was not statistically significant with neonatal sepsis. Therefore, being either having four times of ANC visits (p=0.673), place of delivery such like Home, Health center (p=0.342,p=0.3) , and other Hospital factors in the context of factors associated with neonatal sepsis suggests that there were not a statistically significant associated with neonatal sepsis.

Table 7: Multivariate analysis of factors associated with neonatal sepsis.

Variable	Group	No (n)	% (COR)	No (n)	% (AOR)	aOR (95% CI)	p-value
Age group (days)	**0-3 days**	208	22.67%	184	88.62%	2.769 (1.312–5.843)	0.008*
	4-28 days	30	6.79%	22	77.36%	1	-
Gestational age (weeks)	**< 37 weeks**	135	21.46%	114	84.1%	4.149 (1.878–9.167)	<0.001**
	≥ 37 weeks	103	9%	94	91.26%	1	-

Source: Primary data, 2024

The findings from table above indicates the Multivariable analysis that was conducted only for the neonate factors that showed significant association with neonatal sepsis in bivariate analysis which were neonate age and gestational weeks. The group of infants aged 0-3 days has a Crude Odds Ratio (COR) of 2.769, indicating that infants in this age group are 2.769 times more likely to experience neonatal sepsis compared to those in the 4-28 day group , with a p-value of 0.008, which is statistically significant at $p < 0.05$.Neonates in this age group serve as the reference category with a COR of 1), meaning they have the baseline risk for the neonatal sepsis. After controlling for potential confounders, the Adjusted Odds Ratio (AOR) for neonates aged 0-3 days was 2.769 (95% CI: 1.312–5.843**)**. This suggests that even after adjustment, neonates aged 0-3 days still have 2.769 times higher odds of experiencing the neonatal sepsis compared to those aged 4-28 days.

The confidence interval (1.312–5.843) does not cross 1, supporting the statistical significance of the result. About Gestational Age (weeks), those of < 37 weeks (preterm) especially neonates born at less than 37 weeks of gestation have a Crude Odds Ratio (COR) of 4.149, which means they are 4.149 times more likely to experience neonatal sepsis compared to those born at 37 weeks or more, with a p-value < 0.001, indicating this result is highly significant. And those of ≥ 37 weeks (term) that born at or after 37 weeks of gestation are the reference group, with a COR of 1. After adjusting for confounding variables, the Adjusted Odds Ratio (AOR) for preterm infants (< 37 weeks) is 4.149 (95% CI: 1.878–9.167), indicating that preterm infants are still 4.149 times more likely to experience sepsis compared to full-term infants. The confidence interval (1.878–9.167) does not cross 1, confirming the statistical significance. Therefore, neonates in the 0–3-day age group are at significantly higher odds of the sepsis compared to those in the 4–28-day age group. Preterm infants have significantly higher odds of experiencing the sepsis compared to term infants (≥37 weeks). Both variables age group and gestational age show statistically significant results in relation to the neonatal sepsis, with adjusted results confirming the robustness of these associations.

Discussion of findings:

The objective of this study was to assess prevalence and factors associated with neonatal sepsis among neonates admitted in Rwamagana Level 2 Teaching Hospital, Rwanda and neonatal sepsis prevalence was 14.8%. Reducing maternal and children's mortalities is a global priority to achieve Sustainable Development Goals, and to implement United Nations Global Strategy for Women, Children and Adolescent health (Lawn, Joy E et al.,2014). Although Rwanda is one of the few nations in Africa to have met the fourth Millennium Development Goal, which aims to lower child mortality, the neonatal mortality rate remains extremely concerning. Neonatal sepsis is still a leading cause of neonatal morbidity and mortality in Rwanda, including in the Rwamagana Level 2 Teaching Hospital. The 14.8% neonatal sepsis prevalence found in this study is almost similar to results reported in the study done by (Yismaw et al., 2019) in Ethiopia where by the prevalence was11.7%. It is also consistency with the findings from the study done by (Kayom et al., 2018) in Uganda where the prevalence of neonatal sepsis was 11%.But it is lower compared to the study done by (Geyt & Hauck, 2016) in Kenya and (Olorukooba et al., 2020) in Nigeria where by the prevalence of neonatal sepsis was 23.9% and 37.6% respectively. The difference in neonatal sepsis prevalence may be due to the difference in the definitions of sepsis and the study settings in terms of infection prevention and control, staffing, funding, and policy.

Blood cultures were not routinely performed in suspected cases, with only 26(11%) of the cases of suspected sepsis confirmed by culture. This could be due to the long interval between sending and receiving the culture results that might push doctors to treat suspected sepsis empirically. The predominance of Group B streptococcal *bacteria* was noted and the sensitivity pattern was similar to the findings from the research conducted by (Geyesus et al., 2017)where the isolated bacteria were sensitive to ampicillin and Gentamycin. The findings of currentstudy are different from a study done in Sudan that reported susceptibility of *Klebsiella pneumoniae* of 87% toCiprofloxacin, and 81% to meropenem, which was caused by a variation of antimicrobial susceptibility patterns in bacteria (Niluka Dilrukshi et al., 2023).

Multivariable analysis revealed that small gestational age (pre term) and postnatal age (post term) were both statistically significantly associated with neonatal sepsis. Neonates aged 0-3 days were more likely to develop sepsis which is comparable with the study done by (G/eyesus et al., 2017) in Ethiopia neonates. Premature rupture of membrane, place of delivery, fever on labor Apgar Score < 7 at 10 min, low birth weight, meconium-stained amniotic fluid and foul-smelling amniotic fluid were not found to be associated factors, in contrast to the studies done by (Gebremedhin et al., 2016) in Ethiopia.

In this study results showed that Group B streptococcal bacteria was the most isolated bacteria found in neonatal and maternity wards. The study done in Morocco on neonatology environment reported the presence of different bacteria including Klebsiella pneumoniae, coagulase-negative staphylococci and other Enterobacteriaceae (John et al., 2015).

The presence of those bacteria isolates in the neonatal and maternity settings highlights the need to regularly monitor their environment and execute infection control by improving hygiene and sanitation. According to this study conducted at Rwamagana Level 2 Teaching Hospital , the prevalence of newborn sepsis was 14.8%, and there were noteworthy correlations between the condition and both gestational age (<37 weeks or ≥37 weeks) and neonatal age (0–3 days). However, the study's limitations include its cross-sectional design, which does not allow for causal inference, and the potential bias introduced by relying on self-reported data. The results were derived from a single institution, which limits the external validity and generalizability of the findings (Sauer et al., 2023; Adams et al., 2022). Therefore, in this study etitled as "Prevalence and Factors Associated with Neonatal Sepsis at Rwamagana Level II Teaching Hospital in Rwanda" was impossible to establish a causal link between the factors identified and neonatal sepsis. The chronological sequence of

events leading to newborn sepsis cannot be observed since the study was cross-sectional that only offer a snapshot of the data at one particular moment in time. Because of this, although the study discovered associations between newborn sepsis and variables including gestational age and neonatal age, it was unable to conclusively determine whether these factors cause sepsis directly or if they are only linked to its occurrence (Bintabara et al., 2023).

Another drawback was that the study only used data from one hospital, which may have limited how broadly the results may be applied. Not all medical facilities in Rwanda may be represented by Rwamagana Level II Teaching Hospital, especially those located in rural areas or in places with distinct healthcare infrastructure. The results may not be as applicable to other hospitals or situations across the nation, where newborn care practices and infrastructure may differ, due to this selection bias. Moreover, maternal health was not taken into consideration in the study, despite the fact that it may have an impact on the prevalence and factors of newborn sepsis (Munyaneza et al., 2022).

6. CONCLUSION

The aim of this study was to assess prevalence and factors associated with neonatal sepsis at Rwamagana Level Two Teaching Hospital in Rwanda. In conclusion, the prevalence of neonatal sepsis at Rwamagana Level Two Teaching Hospital is high. The study identified being, being in age group (p= 0.025) and gestational ages (p=0.004) in the context of factors associated with neonatal sepsis suggests that there were a statistically significant associated with neonatal sepsis.

7. ETHICAL CONSIDERATIONS

The Mount Kenya University's Research Ethical Committee granted the researcher ethical clearance. I discussed the goal of the study, study protocol, study advantages, and the confidentiality of patient information with the hospital director general, hospital staff in charge of research, as well as hospital personnel in charge of neonatology, prior to performing this study. The course of our study was risk-free. The data were gathered with the head of service's permission. Additionally, the participant's secrecy was ensured through the application of codes on their names. The researcher kept the data collected during this study in a secured cabinet for 10 years. The records were on password protected computers of the researcher only. The data that were collected will be used for the academic purpose.

REFERENCES

[1] Abate, B. B., Kassie, A., Wudu, M., and Getu, M. (2019). *Neonatal sepsis and its associated factors in East Africa: A systematic review and meta-analysis*, *2019*. https://doi.org/10.21203/rs.2.13554/v1

[2] Adatara, P., Afaya, A., Salia, S. M., Afaya, R. A., Konlan, K. D., Agyabeng-Fandoh, E., Agbinku, E., Ayandayo, E. A., & Boahene, I. G. (2019). Factors Associated with Neonatal Sepsis: A Case Study at a Specialist Hospital in Ghana. *Scientific World Journal*, *2019*, 0–2. https://doi.org/10.1155/2019/9369051

[3] Aseffa, A., and Abathun, T. (2020). *Prevalence of neonatal sepsis and associated factors amongst neonates admitted in arbaminch general hospital , arbaminch , southern Ethiopia , 2019*. *10*(1), 1–7. https://doi.org/10.15406/jpnc.2020.10.00404

[4] Coetzee, M., Mbowane, N. T., & de Witt, T. W. (2017). Neonatal sepsis: Highlighting the principles of diagnosis and management. *SAJCH South African Journal of Child Health*, *11*(2), 99–103. https://doi.org/10.7196/SAJCH.2017.v11i2.1244

[5] Fox, N., & Hunn, A. (2009). *Sampling and Sample Size Calculation Authors*. 1–36.

[6] Getabelew, A., Aman, M., Fantaye, E., and Yeheyis, T. (2018). *Prevalence of Neonatal Sepsis and Associated Factors among Neonates in Neonatal Intensive Care Unit at Selected Governmental Hospitals in Shashemene Town , Oromia Regional State , Ethiopia , 2017*. *2018*. https://doi.org/10.1155/2018/7801272

[7] Geyesus, T., Moges, F., Eshetie, S., Yeshitela, B., & Abate, E. (2017). Bacterial etiologic agents causing neonatal sepsis and associated Factors in Gondar, Northwest Ethiopia. *BMC Pediatrics*, *17*(1). https://doi.org/10.1186/s12887-017-0892-y

[8] Graif, C., Meurer, J., and Fontana, M. (2021). An Ecological Model to Frame the Delivery of Pediatric Preventive Care. *Pediatrics*, *148*(Suppl 1), s13–s20. https://doi.org/10.1542/peds.2021-050693D

[9] Hassan, J., Khan, S., Zahra, R., Razaq, A., Zain, A., Razaq, L., & Razaq, M. (n.d.). Role of Procalcitonin and C-reactive Protein as Predictors of Sepsis and in Managing Sepsis in Postoperative Patients: A Systematic Review. *Cureus*, *14*(11), e31067. https://doi.org/10.7759/cureus.31067

[10] Kayinamura, a M., Serubibi, Y., & Kakoma, J. B. (2010). *Article benefits of a neonatology service in a rural district hospital : case study of rwamagana district hospital / eastern province of*. *68*(4), 38–40.

[11] Kayom, V. O., Mugalu, J., Kakuru, A., Kiguli, S., & Karamagi, C. (2018). Burden and factors associated with clinical neonatal sepsis in urban Uganda: A community cohort study. *BMC Pediatrics*, *18*(1), 1–8. https://doi.org/10.1186/s12887-018-1323-4

[12] Kilanowski PhD, R., APRN, CPNP, FAAN,Jill F. (2017). Breadth of the Socio-Ecological Model. *Journal of Agromedicine*, *22*(4), 295–297. https://doi.org/10.1080/1059924X.2017.1358971

[13] Manandhar, S., Amatya, P., Ansari, I., Joshi, N., Maharjan, N., Dongol, S., Basnyat, B., Dixit, S. M., Baker, S., & Karkey, A. (2021). Factors for the development of neonatal sepsis in a neonatal intensive care unit of a tertiary care hospital of Nepal. *BMC Infectious Diseases*, *21*(1), 546. https://doi.org/10.1186/s12879-021-06261-x

[14] Nyishime, M., Borg, R., Ingabire, W., Hedt-Gauthier, B., Nahimana, E., Gupta, N., Hansen, A., Labrecque, M., Nkikabahizi, F., Mutaganzwa, C., Biziyaremye, F., Mukayiranga, C., Mwamini, F., & Magge, H. (2018). A retrospective study of neonatal case management and outcomes in rural Rwanda post implementation of a national neonatal care package for sick and small infants. *BMC Pediatrics*, *18*(1), 1–11. https://doi.org/10.1186/s12887-018-1334-1

[15] Shaha, C. K., Dey, S. K., Shabuj, K. H., & Chisti, J. (2012). Review Articles Neonatal Sepsis – A Review. *Bangladesh J Child Health*, *36*(2), 82–89.

[16] Tewabe, T., Mohammed, S., Tilahun, Y., Melaku, B., Fenta, M., Dagnaw, T., Belachew, A., Molla, A., & Belete, H. (2017). Clinical outcome and Factors of neonatal sepsis among neonates in Felege Hiwot referral Hospital, Bahir Dar, Amhara Regional State, North West Ethiopia 2016: A retrospective chart review. *BMC Research Notes*, *10*(1), 1–7. https://doi.org/10.1186/s13104-017-2573-1

[17] Migamba, S. M., Kisaakye, E., Komakech, A., Nakanwagi, M., Nakamya, P., Mutumba, R., Migadde, D., Kwesiga, B., Bulage, L., Kadobera, D., & Ario, A. R. (2023). Trends and spatial distribution of neonatal sepsis, Uganda, 2016–2020. *BMC Pregnancy and Childbirth*, *23*(1), 770. https://doi.org/10.1186/s12884-023-06037-y

[18] Ibrahim, Z., & Marcaccio, S. E. (2023). Study population. *Elsevier EBooks*, 103–105. https://doi.org/10.1016/b978-0-323-91259-4.00105-3

[19] Tong, P., & An, I. S. (2024). Review of studies applying Bronfenbrenner's bioecological theory in international and intercultural education research. *Frontiers in Psychology*, *14*(1233925). https://doi.org/10.3389/fpsyg.2023.1233925

[20] Fox, N., Hunn, A., & Mathers, N. (2009). Sampling and Sample Size Calculation.

[21] Abdurhaman Mustefa, Abera, A., Asegedech Aseffa, Tsigereda Abathun, Nega Degefa, Tadesse, H., & Yeheyis, T. (2020). Prevalence of neonatal sepsis and associated factors amongst neonates admitted in arbaminch general hospital, arbaminch, southern Ethiopia, 2019. *Journal of Pediatrics & Neonatal Care*, *10*(1), 1–7. https://doi.org/10.15406/jpnc.2020.10.00404

[22] Shehab El-Din, E. M. R., El-Sokkary, M. M. A., Bassiouny, M. R., & Hassan, R. (2015). Epidemiology of Neonatal Sepsis and Implicated Pathogens: A Study from Egypt. *BioMed Research International*, *2015*, 1–11. https://doi.org/10.1155/2015/509484

[23] Kayom, V. O., Mugalu, J., Kakuru, A., Kiguli, S., & Karamagi, C. (2018). Burden and factors associated with clinical neonatal sepsis in urban Uganda: a community cohort study. *BMC Pediatrics*, *18*(1). https://doi.org/10.1186/s12887-018-1323-4

[24] Shane, A. L., Sánchez, P. J., & Stoll, B. J. (2017). Neonatal sepsis. *The Lancet*, *390*(10104), 1770–1780. https://doi.org/10.1016/s0140-6736(17)31002-4

[25] Hosny Maher Sultan, Ateya Megahed Ibrahim, & Elmahdy, A. (2024). Neonatal sepsis: A review of current management strategies. *Journal of Neonatal Nursing*. https://doi.org/10.1016/j.jnn.2024.02.010

[26] Padari, H., Soeorg, H., Tasa, T., Metsvaht, T., Kipper, K., Herodes, K., Oselin, K., Hallik, M., Ilmoja, M.-L., & Lutsar, I. (2021). Ampicillin Pharmacokinetics During First Week of Life in Preterm and Term Neonates. *The Pediatric Infectious Disease Journal*, *40*(5), 464–472. https://doi.org/10.1097/INF.0000000000003061

[27] Hosny Maher Sultan, Ateya Megahed Ibrahim, & Elmahdy, A. (2024). Neonatal sepsis: A review of current management strategies. *Journal of Neonatal Nursing*. https://doi.org/10.1016/j.jnn.2024.02.010

[28] Coggins, S. A., & Glaser, K. (2022). Updates in Late-Onset Sepsis: Risk Assessment, Therapy, and Outcomes. *NeoReviews*, *23*(11), 738–755. https://doi.org/10.1542/neo.23-10-e738

[29] Chaurasia, S., Sivanandan, S., Agarwal, R., Ellis, S., Sharland, M., & Sankar, M. J. (2019). Neonatal sepsis in South Asia: huge burden and spiralling antimicrobial resistance. *BMJ*, k5314. https://doi.org/10.1136/bmj.k5314

[30] Charikleia Kariniotaki, Thomou, C., Despoina Gkentzi, Eleftherios Panteris, Dimitriou, G., & Eleftheria Hatzidaki. (2024). Neonatal Sepsis: A Comprehensive Review. *Antibiotics*, *14*(1), 6–6. https://doi.org/10.3390/antibiotics14010006

[31] Hassan, J., Khan, S., Zahra, R., Razaq, A., Zain, A., Razaq, L., & Razaq, M. (2022). Role of Procalcitonin and C-reactive Protein as Predictors of Sepsis and in Managing Sepsis in Postoperative Patients: A Systematic Review. *Cureus*, *14*(11), e31067. https://doi.org/10.7759/cureus.31067

[32] Puopolo, K. M., Benitz, W. E., & Zaoutis, T. E. (2018). Management of Neonates Born at ≤34 6/7 Weeks' Gestation With Suspected or Proven Early-Onset Bacterial Sepsis. *Pediatrics*, *142*(6), e20182896. https://doi.org/10.1542/peds.2018-2896

[33] Kharel, S., Ojha, R., Preethish-Kumar, V., & Bhagat, R. (2022). C-reactive protein levels in patients with amyotrophic lateral sclerosis: A systematic review. *Brain and Behavior*, *12*(3). https://doi.org/10.1002/brb3.2532

[34] Polin, R. A. (2012). Management of Neonates With Suspected or Proven Early-Onset Bacterial Sepsis. *PEDIATRICS*, *129*(5), 1006–1015. https://doi.org/10.1542/peds.2012-0541

[35] Briggs-Steinberg, C., & Roth, P. (2023). Early-Onset Sepsis in Newborns. *Pediatrics in Review*, *44*(1), 14–22. https://doi.org/10.1542/pir.2020-001164

[36] Khurmi, MBBS, MPH, M. S., Sayinzoga, MD, MSc, F., Berhe, MD, MPH, A., Bucyana MD, MPH, T., Mwali, MD, MPH, MMed, A. K., Manzi, MD, MPH, E., & Muthu, MBBS, MD, M. (2017). Newborn Survival Case Study in Rwanda - Bottleneck Analysis and Projections in Key Maternal and Child Mortality Rates Using Lives Saved Tool (LiST). *International Journal of MCH and AIDS (IJMA)*, *6*(2), 93. https://doi.org/10.21106/ijma.214

[37] Manandhar, S., Amatya, P., Ansari, I., Joshi, N., Maharjan, N., Dongol, S., Basnyat, B., Dixit, S. M., Baker, S., & Karkey, A. (2021). Factors for the development of neonatal sepsis in a neonatal intensive care unit of a tertiary care hospital of Nepal. *BMC Infectious Diseases*, *21*(1), 546. https://doi.org/10.1186/s12879-021-06261-x

[38] Abate, B. B., Kasie, A. M., Reta, M. A., & Kassaw, M. W. (2020). Neonatal sepsis and its associated factors in East Africa: a systematic review and meta-analysis. *International Journal of Public Health*, *65*(9), 1623–1633. https://doi.org/10.1007/s00038-020-01489-x

[39] World Health Organization. (2024, March 14). *Newborn mortality*. Www.who.int. https://www.who.int/news-room/fact-sheets/detail/newborn-mortality

[40] Pui-Ying Iroh Tam, Bekker, A., Olufunke Bosede Bolaji, Gwendoline Chimhini, Dramowski, A., Fitzgerald, F., Alemayehu Mekonnen Gezmu, John Baptist Nkuranga, Uduak Okomo, Stevenson, A., & Strysko, J. P. (2023). Neonatal sepsis and antimicrobial resistance in Africa. *The Lancet Child & Adolescent Health*, *7*(10), 677–679. https://doi.org/10.1016/s2352-4642(23)00167-0

[41] Liu, L., Oza, S., Hogan, D., Chu, Y., Perin, J., Zhu, J., Lawn, J. E., Cousens, S., Mathers, C., & Black, R. E. (2016). Global, regional, and national causes of under-5 mortality in 2000–15: an updated systematic analysis with implications for the Sustainable Development Goals. *The Lancet*, *388*(10063), 3027–3035. https://doi.org/10.1016/s0140-6736(16)31593-8

[42] Singer, M., Deutschman, C. S., & Seymour, C. W. (2016). The third international consensus definitions for sepsis and septic shock (sepsis-3). *JAMA*, *315*(8), 801–810. https://doi.org/10.1001/jama.2016.0287

[43] Jabiri, A., Wella, H. L., Semiono, A., Saria, A., & Protas, J. (2016). Prevalence and factors associated with neonatal sepsis among neonates in Temeke and Mwananyamala Hospitals in Dar es Salaam, Tanzania. *Tanzania Journal of Health Research*, *18*(4). https://doi.org/10.4314/thrb.v18i4.4

[44] Fleischmann-Struzek, C., Goldfarb, D. M., Schlattmann, P., Schlapbach, L. J., Reinhart, K., & Kissoon, N. (2018). The global burden of paediatric and neonatal sepsis: a systematic review. *The Lancet Respiratory Medicine*, *6*(3), 223–230. https://doi.org/10.1016/s2213-2600(18)30063-8

[45] Fleischmann, C., Reichert, F., Cassini, A., Horner, R., Harder, T., Markwart, R., Tröndle, M., Savova, Y., Kissoon, N., Schlattmann, P., Reinhart, K., Allegranzi, B., & Eckmanns, T. (2021). Global incidence and mortality of neonatal sepsis: a systematic review and meta-analysis. *Archives of Disease in Childhood*, *106*(8). https://doi.org/10.1136/archdischild-2020-320217

[46] Nwankwor, O. C., McKelvie, B., Frizzola, M., Hunter, K., Kabara, H. S., Oduwole, A., Oguonu, T., & Kissoon, N. (2019). A National Survey of Resources to Address Sepsis in Children in Tertiary Care Centers in Nigeria. *Frontiers in Pediatrics*, *7*. https://doi.org/10.3389/fped.2019.00234

[47] Ranjeva, S. L., Warf, B. C., & Schiff, S. J. (2018). Economic burden of neonatal sepsis in sub-Saharan Africa. *BMJ Global Health*, *3*(1), e000347. https://doi.org/10.1136/bmjgh-2017-000347

[48] James, S. L., Abate, D., Abate, K. H., Abay, S. M., Abbafati, C., Abbasi, N., Abbastabar, H., Abd-Allah, F., Abdela, J., Abdelalim, A., Abdollahpour, I., Abdulkader, R. S., Abebe, Z., Abera, S. F., Abil, O. Z., Abraha, H. N., Abu-Raddad, L. J., Abu-Rmeileh, N. M. E., Accrombessi, M. M. K., & Acharya, D. (2018). Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, *392*(10159), 1789–1858. https://doi.org/10.1016/s0140-6736(18)32279-7

[49] Newman, L., Rowley, J., Vander Hoorn, S., Wijesooriya, N. S., Unemo, M., Low, N., Stevens, G., Gottlieb, S., Kiarie, J., & Temmerman, M. (2015). Global Estimates of the Prevalence and Incidence of Four Curable Sexually Transmitted Infections in 2012 Based on Systematic Review and Global Reporting. *PLOS ONE*, *10*(12), e0143304. https://doi.org/10.1371/journal.pone.0143304

[50] https://doi.org/10.1080/1059924X.2017.1358971

[51] Nyma, Z., Rahman, M., Hasan, S. M. M., Roby, N. U., Khanam, F., Alam, M. E., & Ali, M. (2020). Prevalence and Associated Factors of Sepsis among Neonates Admitted into Neonatal Intensive Care Units of Public Hospitals in Dhaka. *Cureus*. https://doi.org/10.7759/cureus.7461

[52] *The Social-Ecological Model: A Framework for Prevention |Violence Prevention|Injury Center|CDC*. (2022, January 18). https://www.cdc.gov/violenceprevention/about/social-ecologicalmodel.html

[53] Golden, T. L., & Wendel, M. L. (2020). Public Health's Next Step in Advancing Equity: Re-evaluating Epistemological Assumptions to Move Social Determinants from Theory to Practice. *Frontiers in Public Health*, *8*, 131. https://doi.org/10.3389/fpubh.2020.00131

[54] Graif, C., Meurer, J., & Fontana, M. (2021). An Ecological Model to Frame the Delivery of Pediatric Preventive Care. *Pediatrics*, *148*(Suppl 1), s13–s20. https://doi.org/10.1542/peds.2021-050693D

[55] Kilanowski PhD, R., APRN, CPNP, FAAN,Jill F. (2017). Breadth of the Socio-Ecological Model. *Journal of Agromedicine*, *22*(4), 295–297.

[56] Shadbolt, R., We, M. L. S., Kohan, R., Porter, M., Athalye-Jape, G., Nathan, E., Shrestha, D., & Strunk, T. (2022). Neonatal Staphylococcus Aureus Sepsis: a 20-year Western Australian experience. *Journal of Perinatology*, *42*(11), 1440–1445. https://doi.org/10.1038/s41372-022-01440-3

[57] Olorukooba, A., Ifusemu, W., Ibrahim, M., Jibril, M., Amadu, L., & Lawal, B. (2020). Prevalence and factors associated with neonatal sepsis in a tertiary hospital, North West Nigeria. *Nigerian Medical Journal*, *61*(2), 60. https://doi.org/10.4103/nmj.nmj_31_19

[58] Geyt, J. L., & Hauck, S. (2016). G272 Epidemiological trends of neonatal sepsis in a county referral hospital in central Kenya. *Archives of Disease in Childhood*, *101*(Suppl 1), A154.1-A154. https://doi.org/10.1136/archdischild-2016-310863.264

[59] *Ezra Susser, MD, DrPH*. (2022, November 4). Columbia University Mailman School of Public Health. https://www.publichealth.columbia.edu/profile/ezra-susser-md

[60] Cherry, K. (2023). *A Comprehensive Guide to the Bronfenbrenner Ecological Model*. Very well Mind. https://www.verywellmind.com/bronfenbrenner-ecological-model-7643403

[61] Wakjira Basha, G., Abate Woya, A., & Kassa Tekile, A. (2020). Determinants of neonatal mortality in Ethiopia: an analysis of the 2016 Ethiopia Demographic and Health Survey. *African Health Sciences*, *20*(2), 715–723. https://doi.org/10.4314/ahs.v20i2.23

[62] Yismaw, A. E., Abebil, T. Y., Biweta, M. A., & Araya, B. M. (2019). Proportion of neonatal sepsis and determinant factors among neonates admitted in University of Gondar comprehensive specialized hospital neonatal Intensive care unit Northwest Ethiopia 2017. *BMC Research Notes*, *12*(1). https://doi.org/10.1186/s13104-019-4587-3

[63] Viswanathan, R., Patel, A., Basu, S., Chatterjee, S., Sardar, S. and Isaacs, D. (2011). Multi-drug-resistant gram-negative bacilli causing early neonatal sepsis in India. *Archives of Disease in Childhood: Fetal & Neonatal*, 97(3), pp. F182–F187. doi: https://doi.org/10.1136/archdischild-2011-300097.

[64] Yimenu Mehretie, Ashenafi Tazebew Amare, Geta Bayu Getnet, & Birhanu abie Mekonnen. (2024). Length of hospital stay and factors associated with very-low-birth-weight preterm neonates surviving to discharge a cross-sectional study, 2022. *BMC Pediatrics*, *24*(1). https://doi.org/10.1186/s12887-024-04532-5

[65] G/eyesus, T., Moges, F., Eshetie, S., Yeshitela, B., & Abate, E. (2017). Bacterial etiologic agents causing neonatal sepsis and associated Factors in Gondar, Northwest Ethiopia. *BMC Pediatrics*, *17*(1). https://doi.org/10.1186/s12887-017-0892-y

[66] Gebremedhin, D., Berhe, H., & Gebrekirstos, K. (2016). Factors for Neonatal Sepsis in Public Hospitals of Mekelle City, North Ethiopia, 2015: Unmatched Case Control Study. *PLOS ONE*, *11*(5), e0154798. https://doi.org/10.1371/journal.pone.0154798

[67] Niluka Dilrukshi, J Kottahachchi, Thushari Dissanayake, & Fernando, N. (2023). Antibiotic Sensitivity of Group B Streptococcus from Pregnant Mothers and its Association with Resistance Genes. *Medical Principles and Practice*, *32*(2), 126–132. https://doi.org/10.1159/000530525