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Prevalence and Predictors of Neonatal Sepsis among Neonates Admitted at the Newborn Unit of Kenyatta National Hospital, Nairobi, Kenya

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Abstract

Background: Neonatal sepsis is one of the primary causes of neonatal morbidity and mortality especially in developing countries. Despite the availability of different preventive interventions, in Kenya, the burden of neonatal sepsis remains critically high. **Aim:** To determine the prevalence and predictors of neonatal sepsis among newborns admitted at the newborn unit of Kenyatta National Hospital, Kenya. **Methods:** This is a hospital-based, cross-sectional study design carried out among 196 neonates and their mothers at the new born unit of Kenyatta National Hospital. A systematic random sampling technique was employed to select the study subjects. Data on the possible contributing factors of neonatal sepsis was collected using a semi-structured questionnaire. Statistical analyses were performed using the statistical package for the Social Sciences (SPSS: version 22). Data were descriptively analyzed into frequencies and proportions. The chi-square test of independence and binary logistic regression were employed to determine associations between the dependent (neonatal sepsis) and various independents variables. A multiple logistic regression model was carried out to determine the variables independently contributed to the occurrence of neonatal sepsis. **Results:** Our study revealed that the prevalence of neonatal sepsis was 28.6%. Neonates born of single mothers (AOR = 5.454, p = 0.012), mothers with history of UTI (AOR = 2.969, p = 0.013), PROM (AOR = 6.124, p = 0.001) and anaemia (AOR = 3.379, p = 0.010) were at higher risk to develop neonatal sepsis. Prematurity (AOR = 6.402, $p < 0.001$), low Apgar score at 5^{th} minutes (AOR = 8.212, $p < 0.001$) and history of invasive procedure (AOR = 2.464, p = 0.046) were the neonatal factors independently associated with neonatal sepsis. **Conclusion and Recommendations**: The prevalence of neonatal sepsis in Kenyatta National Hospital is high. This is another piece of evidence showing both maternal and neonatal-related factor had a significant effect on the risk

of neonatal sepsis. Provision of community-based health education is highly recommended to increase awareness of women on the risk factors of neonatal sepsis and their preventive methods such as anaemia and UTI during pregnancy. Healthcare providers should exercise a high standard of care when handling premature and babies with low Apgar score to reduce the risks of neonatal sepsis.

Keywords

Preterm Birth, Neonatal Sepsis, Predictors of Neonatal Sepsis, Kenya

1. Introduction

Neonatal sepsis, a systemic infection of neonates in their first month of life, is a major cause of morbidity and mortality in newborns [1]. Most of the neonatal death that occurs in low-and middle-income countries [2] is associated with neonatal sepsis [3]. Neonatal sepsis is highly prevalent in sub-Saharan African countries [4]. For example, the prevalence of neonatal sepsis is 45% in Ethiopia [5], 37.9% in Cameroon [6], 37.6% in Nigeria [7] and 34.1% in Tanzanian [8]. In Kenya, the prevalence of neonatal sepsis was reported at 29.3% [9].

Despite advances in healthcare system, sepsis is one of the major causes of morbidity and mortality in neonates worldwide [10] [11]. According to the World Health Organization (WHO), each year, four million newborn babies die during the first four weeks of their lives, of which 75% die prematurely during the first week of life [12] [13]. It is estimated that neonatal mortality rate in low and middle-income countries (LMICs) is 20 per 1000 live births, compared to 3 per 1000 in high-income countries [14]. Neonatal sepsis contributes to 17% death in Sub-Saharan Africa as compared to 6% in the developed countries [15]. In Kenya, despite the different mitigation interventions, the neonatal mortality rate is 22 deaths per 1000 live births [16].

Premature rupture of membrane (PROM) [8] [17], history of maternal urinary tract infection (UTI) during pregnancy, gestational age < 37 weeks, Apgar score < 7 at 5^{th} minute, history of artificial ventilation of the newborn, not crying immediately at birth [15] [18], delay in care seeking, and lack of access to well-trained health workers [10] [19] were identified as major contributing factors of neonatal sepsis. In the African region, lack of adequate resources delays in the diagnosis and prompt treatment of neonatal sepsis, major contributing factor to the high morbidity and mortality rates among the neonates. Diagnosis and treatment of newborns with infection is inadequate in many developing countries, because sick and premature newborns present with non-specific signs and symptoms [20], which requires sophisticated equipment and highly trained personnel. In Kenya, the main causes of neonatal death in 2015 were birth asphyxia, birth trauma, prematurity and sepsis [21].

Despite the heavy burden of neonatal sepsis and its related mortality, in

Kenya, data on prevalence and risk factors is limited. Identifying the current prevalence and its predictors of neonatal sepsis is critically important in designing strategies to prevent and/or establish effective treatment of neonatal sepsis. Identification of risk factors and timely initiation of treatments can significantly decrease neonatal mortality and morbidity [22]. To achieve sustainable development goal (SDG), reducing newborn and under-five mortality as low as 12/1000 and 25/1000, respectively, is one of the Global strategies of WHO in African countries by 2030. This could be achieved through better prevention and management of preterm neonates as the key strategy [23]. Therefore, this study was aimed at determining the prevalence and predictors of neonatal sepsis at the newborn unit of Kenyatta National Hospital, Kenya.

2. Methods

2.1. Study Setting

This study was conducted at the newborn unit of Kenyatta National Hospital (KNH), a level 6 referral and teaching public health facility in Nairobi. It is the biggest public hospital in Kenya and offers a wide range of outpatient and inpatient specialty services including emergency, obstetrics and gynaecology, medical, surgical, oncology, cardiology, diabetes, hypertension and paediatrics medicine and related interventions among others. Being a teaching and referral hospital, the hospital receives many high risk pregnancies and their outcomes. The newborn unit is one of the busiest wards of the hospital, rendering service under critical newborn care unit and kangaroo mother care. It is staffed with trained nurses, general practitioners, pediatricians and neonatologists.

2.2. Study Design, Sampling Method and Respondents

This was a hospital-based, cross-sectional study involved randomly selected respondents (n = 196) from the newborn unit of KNH. The study population comprises all neonates admitted to the newborn unit and their mothers. The sample size was determined by using Fischer's formula (Fischer *et al.*, 1998); $n = Z^2pq/d^2$) by considering 95% CI and 5% margin of error (d). The proportion of neonatal sepsis was taken from the study carried out by Muturi (2015) at Kisii level 5 hospital in Kenya at19.7%. Accordingly, $n = Z^2 p(1-p)/d^2$ = $(1.96)^2$ 0.197 $(0.803)/(0.05)^2$ = 243. However, since the target population during the study period was <10,000, sample size adjustment was done using the formula $nf = n/1 + n/N$, nf = 243/1 + 243/1020 = 196. Where "n" is the initially calculated sample size (243), N = total population in two months period (1020). Thus after adjusting, the final sample size was 196 subjects.

Sampling Method: A systematic random sampling method was used to select the study participants. During the study period, the newborn unit of KNH daily admitted an average of 17 neonates, which is equivalent to 1020 in two months, the duration the data collection would take to complete. The 1020 number of neonates in two months period was divided by the minimum adjusted sample

size (196) to get a sampling interval of 5. The first neonate to be included in the study was chosen randomly by blindly picking one of five pieces of paper named for the first five neonates in each day. After that, every fifth neonate who had been admitted to the newborn unit of KNH was included in the study until the desired sample size was attained.

2.3. Data Collection Method and Procedure

A pretested, semi-structured questionnaire was used to collect the data. Data were collected through interviewing mothers and reviewing neonates' medical records. The assessment comprised maternal socio-demographic, lifestyle characteristics, attendance of ANC clinic and IFAS intake, anaemic status, presence of any acute/chronic diseases during pregnancy, dietary and cultural beliefs during pregnancy, obstetric and gynecological, mode of deliver and place of delivry. Neonatal variables include; age, sex, birth weight, gestational age at birth, birth asphyxia, APGAR score, whether the cried immediately, history of resuscitation, suctioning and invasive procedures were captured from medical records.

Nutritional status of the mothers was assessed using body mass index. Using standard protocols and techniques the mothers' body weight and height were measured. Body weight in light clothes was measured to the nearest 0.1 kg using a calibrated, Sohenle mechanical weighing scale. Respondent's height was measured using a portable stadiometer to the nearest 0.5 centimeters. BMI was calculated as weight in kilograms divided by the square of height in meters. According to the WHO [24], individuals with a body mass index (BMI) ≥ 30 kg/m^2 are categorized as obese, 25.0 - 29.9 kg/m^2 as overweight, 18.5 - 24.9 kg/m^2 as normal, while those with less than 18.5 kg/m^2 as underweight.

2.4. Validity and Reliability of the Study Tools

The tools were reviewed for content validity by experts in the field of neonatology and obstetrics to ascertain relevance and completeness. The recommendations and suggestions were incorporated in the final questionnaire. To measure reliability of the questionnaire, a test re-test method was employed whereby, a repeat pre-test was carried out after two weeks, and Cohen's kappa statistic was used to measure the level of agreement of the two results. The result of the repeated questions had a kappa value of 0.89 therefore, the questionnaire was considered reliable.

2.5. Ethical Consideration

Ethical approval to conduct this study was obtained from Kenyatta National Hospital-University of Nairobi Ethical Review Committee (KNH-UoN ERC) (Approval number (UP89/02/2019). We also sought study approval from the National Commission for Science, Technology and Innovation (NACOSTI) (Approval number NACOSTI/P/19/53639/2870). The institutional permission was granted by the administration of the Catholic University of Eastern Africa.

Consent was obtained from the study participants prior to data collection after explanation on study aim and objectives.

2.6. Data Analyses

Statistical analyses were performed using the statistical package for the Social Sciences (SPSS: version 22). Data were descriptively analyzed into frequencies and proportions. The chi-square test of independence and binary logistic regression were employed to determine associations between the dependent (neonatal sepsis) and various independents variables. A multiple logistic regression model with *backwark conditional* was carried out to determine the variables independently contributed to the occurrence of neonatal sepsis. A p-value of less than 0.05 was considered to be significant.

3. Results

3.1. Relationship between Socio-Demographics of the Mothers and Neonatal Sepsis

The majority of the mothers were in the age group of 20 - 35 years (74%, n = 145), married (95.4%, n = 187), Protestant (52%, n = 102), had secondary level of education (48%, n = 94) and unemployed (50.5%, n = 99). The study revealed that the prevalence of neonatal sepsis was 28.6%. Further analysis with a chi-square test of independence and Fisher's Exact Test revealed that age (X^2 = 3.395; p = 0.183), religion (X^2 = 1.415; p = 0.698), level of education (X^2 = 3.871; p = 0.269) and employment status (X^2 = 1.572; p = 0.456) of the mothers were not significantly associated with neonatal sepsis. However, neonates born of single mothers were more likely (X^2 = 11.909; p = 0.001) to develop neonatal sepsis compared to those neonates born of married mothers (Table 1).

3.2. Relationship between Maternal Antenatal Care Visits and Neonatal Sepsis

Most, (61.2%, n = 120) and (75.5%, n = 148) of the mothers had started attending ANC and taking IFAS after 12 weeks of gestation, respectively. A majority (65.3%, n = 128) had attended ANC 4 or more times during the entire pregnancy. However, most (77.6%, n = 152) of them took the IFAS for ≤ 6 months. Analysis with binary logistic regression revealed that total number of ANC visits and duration IFAs intake were significantly associated with neonatal sepsis. Neonates born of mothers who visited the ANC for less than 4 times during the entire pregnancy were 2.5 times (COR = 2.500, 95% CI = 1.319 - 4.738; p = 0.005) at higher risk to develop neonatal sepsis compared to neonates born of mothers who attended the ANC 4 or more visits. Moreover, neonates born of mothers who took IFAs for ≤6 months were 3 times (COR = 3.105, 95% CI = 1.231 - 7.830; p = 0.016) more likely to develop neonatal sepsis compared to those neonates born of mothers who took IFAS for more than 6 months. However, gestational age at first ANC visit (p = 0.229) and gestational age where the

Table 1. Relationship between socio-demographics of the mothers and neonatal sepsis.

Characteristics	Neonatal Sepsis Status		Total	Chi	df	p-value
	Yes	No				
Maternal age (years)	N (%)	N (%)	N (%)			
Below 20	7 (41.2)	10 (58.8)	17 (100)	3.395	2	0.183
20 - 35	43 (29.7)	102 (70.3)	145 (100)			
Above 35	6 (17.6)	28 (82.4)	34 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Marital status						
Married/cohabiting	45 (25.1)	134 (74.9)	179 (100)	11.909	1	0.001
Single	11 (64.7)	6 (35.3)	17 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Religion						
Protestant	32 (31.4)	70 (68.6)	102 (100)	1.415		0.698*
Catholic	22 (25.6)	64 (74.4)	86 (100)			
Muslim	2 (33.3)	4 (66.7)	6 (100)			
Pagan	0 (0.0)	2 (100.0)	2 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Education level						
Non-primary	13 (23.6)	42 (76.4)	55 (100)	3.871	2	0.269
Secondary	33 (35.1)	61 (64.9)	94 (100)			
Tertiary	10 (21.3)	37 (78.7)	47 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Employment						
Employed	7 (21.9)	25 (78.1)	32 (100)	1.572	2	0.456
Self-employed	17 (26.2)	48 (73.8)	65 (100)			
Unemployed	32 (32.3)	67 (67.7)	99 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			

*Fisher's Exact Test.

mothers started IFAS intake (p = 0.793) were not significantly associated with neonatal sepsis (Table 2).

3.3. Relationship between Maternal Health-Nutritional Status and Neonatal Sepsis

A good number, (47.4%, n = 93), of the mothers reported having UTI during pregnancy. Majority of the mothers take tea/coffee (88.8%, n =174), consumed above three meals in a day (58.7%, n = 115) and had normal body mass index (MBI) (65.8%, n = 129). Most (55.6% n = 109) of the mothers were anaemic (Hb < 11 g/dl). Further analysis with a chi-square test of independence revealed that

Table 2. Relationship between maternal antenatal care visits and neonatal sepsis.

Maternal related factors	Neonatal Sepsis Status		Total	COR (95% CI)	p-value
	yes	no			
Gestational age at first ANC visit	N (%)	N (%)	N (%)		
At or before 12 weeks	19 (25.0)	57 (75.0)	76 (100)	1.493 (0.776 - 2.872)	0.229
After 12 weeks	37 (30.8)	83 (69.2)	120 (100)	Reference	
Total	56 (28.6)	140 (71.4)	196 (100)		
Total number of ANC visits					
Less than 4	28 (41.2)	40 (58.8)	68 (100)	2.500 (1.319 - 4.738)	0.005
4 and above	28 (21.9)	100 (78.1)	128 (100)	Reference	
Total	56 (28.6)	140 (71.4)	196 (100)		
Gestational age started IFAs intake					
After 12 weeks	41 (27.7)	107 (72.3)	148 (100)	1.103 (0.532 - 2.285)	0.793
Before or at 12 weeks	15 (31.3)	33 (68.8)	48 (100)	Reference	
Total	56 (28.6)	140 (71.4)	196 (100)		
Duration of IFAs intake					
6 Months and below	50 (32.9)	102 (67.1)	152 (100)	3.105 (1.231 - 7.830)	0.016
Above 6 months	6 (13.6)	38 (86.4)	44 (100)	Reference	
Total	56 (28.6)	140 (71.4)	196 (100)		

neonates born of mothers with history of UTI and anaemia were at higher risk to develop neonatal sepsis. Neonates born of mothers who had history of UTI during pregnancy were more likely ($X^2 = 10.904$; $p = 0.001$) to develop neonatal sepsis compared to those who were born of mothers without history of UTI. Similarly, Neonates born of anaemic mothers were significantly ($X^2 = 9.840$; $p = 0.002$) at higher risk of developing neonatal sepsis compared to those neonates born of mothers who did not have anaemia during pregnancy. Whereas, intake of tea/coffee ($X^2 = 3.461$; $p = 0.063$), daily number of meals ($X^2 = 0.842$; $p = 0.359$) and body mass index ($X^2 = 3.566$; $p = 0.241$) of the mothers were not significantly associated neonatal sepsis (Table 3).

3.4. Relationship between Pregnancy Related Factors and Neonatal Sepsis

Most of the mothers were above 19 years old at their first pregnancy (69.4%, n = 136), had ≤3 number of pregnancies (81.1%, n = 159), had ≤3 children in the family and spontaneous virginal delivery (SVD) (52.6%, n = 103). Of the mothers, a good number (25%, n = 49) had history of PROM. Further analysis with a

Table 3. Relationship between maternal health-nutritional status and neonatal sepsis

Maternal related factors	Neonatal Sepsis Status		Total	Chi (X^2)	df	p-value
	yes	no				
History of UTI during pregnancy	N (%)	N (%)	N (%)			
Yes	37 (39.8)	56 (60.2)	93 (100)	10.904	1	**0.001**
No	19 (18.4)	84 (81.6)	103 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Intake of tea/coffee						
Yes	46 (26.4)	128 (73.6)	174 (100)	3.461	1	0.063
No	10 (45.5)	12 (54.5)	22 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Daily number of meals						
3 and below	26 (32.1)	55 (67.9)	81 (100)	0.842	1	0.359
Above 3	30 (26.1)	85 (73.9)	115 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Body mass index						
underweight	2 (66.7)	1 (33.3)	3 (100)	3.566		0.241*
Normal	38 (29.5)	91 (70.5)	129 (100)			
Overweight/obese	16 (25.0)	48 (75.0)	64 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Maternal anemic status						
Yes	41 (37.6)	68 (62.4)	109 (100)	9.840	1	**0.002**
No	15 (17.2)	72 (82.8)	87 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			

*Fisher's Exact Test.

chi-square test of independence revealed that the prevalence of neonatal sepsis is significantly ($X^2 = 16.133$; $p < 0.001$) higher among neonates born of mothers with history of PROM compared to those neonates born of mothers without history of PROM. However, there was no significant association between age of the mother at first pregnancy ($X^2 = 2.777$; $p = 0.096$), number of pregnancies ($X^2 = 0.963$; $p = 0.326$), number of children in a family ($X^2 = 0.862$; $p = 0.353$) and mode of delivery ($X^2 = 0.205$; $p = 0.651$) and neonatal sepsis (Table 4).

3.5. Neonates Related Factors Associated with Neonatal Sepsis

Majority of the babies were male (55.1%, n = 108), term (60.2%, n = 118), had low birth weight (54.6%, n = 107), immediately cried at birth (89.8%, n = 176), had Apgar score ≥ 7 at 5 minutes (68.9%, n = 135), and history of invasive procedure (70.4%, n = 138). Further analysis revealed that preterm neonates were 6.7 times (COR = 6.711, 95% CI = 3.369 - 13.367; $p < 0.001$) more likely to develop

Table 4. Relationship between pregnancy related factors and neonatal sepsis C.

Maternal related factors	Neonatal Sepsis Status		Total	Chi (X^2)	df	p-value
	yes	no				
Age at first pregnancy	N (%)	N (%)	N (%)			
19 and below	22 (36.7)	38 (63.3)	60 (100)	2.777	1	0.096
Above 19	34 (25.0)	102 (75.0)	136 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Number of pregnancies						
3 and below	43 (27.0)	116 (73.0)	159 (100)	0.963	1	0.326
Above 3	13 (35.1)	24 (64.9)	37 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Number of children in the family						
3 and below	45 (27.3)	120 (72.7)	165 (100)	0.862	1	0.353
Above 3	11 (35.5)	20 (64.5)	31 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
History of PROM						
Yes	25 (51.0)	24 (49.0)	49 (100)	16.133	1	<0.001
No	31 (21.1)	116 (78.9)	147 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			
Mode of delivery						
SVD	28 (27.2)	75 (72.8)	103 (100)	0.205	1	0.651
CS	28 (30.1)	65 (69.9)	93 (100)			
Total	56 (28.6)	140 (71.4)	196 (100)			

neonatal sepsis compared to term neonates. Neonates with low birth weight were 2.4 times (COR = 2.429, 95% CI = 1.257 - 4.695; p = 0.008) more likely to have neonatal sepsis compared to those neonates with normal birth weight. The odds of neonatal sepsis was significantly (COR = 5.739, 95% CI = 2.924 - 11.266; p < 0.001) higher among neonates who scored low Apgar score (below 7) at 5th minutes compared to those neonates scored above 7 at 5th minutes. Neonates who had history of invasive procedure were about 3 times (COR = 2.812, 95% CI = 1.272 - 6.216; p = 0.011) more likely to suffer from neonatal sepsis compared to neonates without history of invasive procedure. However, gender and crying immediately at birth were not significantly associated neonatal sepsis (Table 5).

3.6. Multivariate Analysis for the Predictors of Neonatal Sepsis

Binary logistic regression analysis was performed to model neonatal sepsis (presence or absence) as a dependent variable and the independent variables that revealed significant association at $p < 0.05$ during the bivariate analysis. Accordingly, the logistic model included the following factors: marital status, total

Table 5. Neonatal related factors associated with neonatal sepsis.

Neonate related factors	Neonatal Sepsis Status		Total	COR (95% CI)	p-value
	yes	no			
Gender	N (%)	N (%)	N (%)		
Female	26 (29.5)	62 (70.5)	88 (100)	1.206 (0.648 - 2.245)	0.555
Male	30 (27.8)	78 (72.2)	108 (100)	Reference	
Total	56 (28.6)	140 (71.4)	196 (100)		
Gestational age at birth					
Preterm (<37 weeks)	40 (51.3)	38 (48.7)	78 (100)	6.711 (3.369 - 13.367)	<0.001
Term (≥37 weeks)	16 (13.6)	102 (86.4)	118 (100)	Reference	
Total	56 (28.5)	140 (71.4)	196 (100)		
Birth weight					
Below normal	39 (36.4)	68 (63.6)	107 (100)	2.429 (1.257 - 4.695)	0.008
Normal	17 (19.1)	72 (80.9)	89 (100)	Reference	
Total	56 (28.6)	140 (71.4)	196 (100)		
Immediately cried at birth					
No	4 (20.0)	16 (80.0)	20 (100)	0.596 (0.190 - 1.869)	0.375
Yes	52 (29.5)	124 (70.5)	176 (100)	Reference	
Total	56 (28.6)	140 (71.4)	196 (100)		
APGAR Score at 5 minutes					
Below 7	33 (54.1)	28 (45.9)	61 (100)	5.739 (2.924 - 11.266)	<0.001
7 and above	23 (17.0)	112 (83.0)	135 (100)	Reference	
Total	56 (28.6)	140 (71.4)	196 (100)		
APGAR score at 10 minutes					
Below 9	38 (33.9)	74 (66.1)	112 (100)	0.502 (0.207 - 1.219)	0.128
9 and above	18 (21.4)	66 (78.6)	84 (100)	Reference	
Total	56 (28.6)	140 (71.4)	196 (100)		
History of invasive procedure					
Yes	47 (34.1)	91 (65.9)	138 (100)	2.812 (1.272 - 6.216)	0.011
No	9 (15.5)	49 (84.5)	58 (100)	Reference	
Total	56 (28.6)	140 (71.4)	196 (100)		

number of ANC visits, duration of IFAS intake, history of UTI during pregnancy, anemic status, history of PROM as maternal factors and maturity status at

birth, birth weight, Apgar score at 5 minutes and history of invasive procedure as neonatal factors. Backward conditional method was specified with removal at $p < 0.05$ to determine the independent predictors of neonatal sepsis as it removes the confounding variables until no further variables can be removed without a statistically insignificant loss of fit (last or reduced model). After considering all, maternal marital status, history of UTI during pregnancy, anaemic status, history of PROM and the neonates' maturity status at birth and Apgar score at 5 minutes and history of invasive procedure were independently associated with neonatal sepsis.

Neonates born of single mothers were 5 times (AOR = 5.454, 95% CI 1.457 to 20.556, p = 0.012) more likely to develop neonatal sepsis compared to neonates born of married mothers. Neonates born of mothers with history of UTI were about 3 times (AOR = 2.969, 95% CI 1.261 to 6.948, p = 0.013) more likely to develop neonatal sepsis compared to those neonates born of mothers without history of UTI. The odds of developing neonatal sepsis was significantly (AOR = 3.379, 95% CI 1.343 to 8.504, p = 0.010) higher among neonates of anaemic mothers compared to those neonates whose mothers did not have anaemia. Neonates born of mothers with history of PROM were 6 times (AOR = 6.124, 95% CI 2.984 to 14.625, p = 0.001) more likely to develop neonatal sepsis compared to those neonates born of mothers without history of PROM. The odds of developing neonatal sepsis was 6 (AOR = 6.402, 95% CI 2.731 to 15.006, p < 0.001) and 8 times (AOR = 8.212, 95% CI 3.419 to 19.722, p < 0.001) higher among preterm neonates and neonates with low Apgar score (<7) at 5th minutes compared to term neonates and neonates with ≥7 Apgar score, respectively. Moreover, neonates with history of invasive procedure were more than 2 times (AOR = 2.464, 95% CI 0.944 to 6.432, p = 0.046) more likely to develop neonatal sepsis compared to neonates with no history of invasive procedure (**Table 6**).

4. Discussion

The primary objective of this study was to determine the prevalence and predictors of neonatal sepsis among neonates admitted at the newborn unit of Kenyatta National Hospital, Nairobi, Kenya. Our study found a high prevalence, 28.6%, of neonatal sepsis associated with several maternal and neonatal factors. The maternal factors significantly and independently associated with neonatal sepsis were being single, history of UTI during pregnancy, anaemia and history of PROM. Of the neonates, prematurity, low Apgar score at 5th minutes and history of invasive procedure were the factors significantly associated with neonatal sepsis.

The high prevalence of neonatal sepsis found in this study is expected due to the fact that the study area is a national referral hospital, which receives neonates with severe complications as well as complicated pregnancies. Similar to our findings, a systematic review and meta-analysis conducted in East Africa found a prevalence of neonatal sepsis of 29.7% [25]. The prevalence of neonatal sepsis in the current study is lower than findings from Ethiopia at 45% [5], Tanzanian at

Table 6. Multivariate analysis on the predictors of neonatal sepsis.

Variable	AOR	95% CI		p-value
		Lower	Upper	
Full/first model				
Marital status				
Single	5.029	1.311	19.290	0.019
Married	Ref			
Total number of ANC Visits				
Less than 4	1.846	.766	4.448	0.172
4 and above	Ref			
Duration of IFAS Intake				
6 Months and below	2.261	.652	7.839	0.198
Above 6 Months	Ref			
History of UTI during pregnancy				
Yes	2.119	.849	5.285	0.107
No	Ref			
Anaemic status	2.788	1.042	7.455	0.041
Yes				
No	Ref			
History of PROM				
Yes	5.176	2.259	13.872	0.002
No	Ref			
Maturity status				
Preterm	5.969	2.388	14.919	0.000
Term	Ref			
Birth weight				
Low	.854	.316	2.307	0.756
Normal	Ref			
APGAR score at 5 minutes				
Below 7	7.926	3.208	19.587	0.000
7 and above				
History of invasive procedure				
Yes	2.794	1.021	7.650	0.046
No				
Reduced/last model				
Marital status				
Single	5.474	1.457	20.556	0.012
Married	Ref			

Continued

History of UTI during pregnancy				
Yes	2.960	1.261	6.948	0.013
No	Ref			
Anaemic status				
Yes	3.379	1.343	8.504	0.010
No	Ref			
History of PROM				
Yes	6.124	2.984	14.625	0.001
No				
Maturity status				
Preterm	6.402	2.731	15.006	0.000
Term	Ref			
APGAR score at 5 minutes				
Below 7	8.212	3.419	19.722	0.000
7 and above	Ref			
History of invasive procedure				
Yes	2.464	0.944	6.432	0.048
No				

34.1% [8], Cameroon at 37.9% [6] and Nigeria at 37.6% [7]. The difference in prevalence of neonatal sepsis could be explained by the difference in the clinical definition of sepsis at different settings.

The odds of having neonatal sepsis was higher among neonates born of single mothers compared to neonates born of married mothers. This can be explained by the fact that single mothers might not have adequate capacity to take care of their newborn and provide ideal environment due to lack of psycho-social support system and the pregnancy related stress. Pregnancy without psycho-social support system is stressful and can lead to ill-health for both the mother and the newborn. Stress results in increases in cortisol, norepinephrine and inflammation which affect the fetal environment and have implications for maternal and infant health. Women who experience high levels of stress during pregnancy have 25% - 60% higher risk for preterm delivery compared to women with low levels of stress [26].

Maternal history of UTI during pregnancy is a risk factor for neonatal sepsis. Our study found that neonates born of mothers with history of UTI during pregnancy were at higher risk of neonatal sepsis compared to neonates born of mothers without history of UTI. This finding is consistent with previous studies in Nigeria [7]. The possible explanation for this association is that colonization of infectious agent in the birth canal may contaminate the babies as they come out and predispose them to early sepsis [27]. Another maternal risk factor for

neonatal sepsis was PROM. Similar observations have been reported elsewhere in Tanzania [8], Ethiopia [28] [29] and Nigeria [7]. Early rupture of membrane exposes a newborn to ascending microorganisms from the birth canal into the amniotic sac and can predispose to neonatal sepsis after delivery [30]. This finding suggests prophylactic antibiotic therapy for neonates born to mothers with a history of PROM during pregnancy. Maternal anemia is a risk factor for neonatal sepsis. Our study found that neonates born of anaemic mothers were more likely to develop neonatal sepsis compared to neonates born of mothers without anemia. This finding is in agreement with a study conducted in Dhaka, Bangladish [31]. This could be explained by the fact that babies born of anaemic mothers are probably born with low immunity and other important proteins and therefore are more likely to suffer from neonatal sepsis.

Premature neonates were at higher risk of neonatal sepsis. This finding is in agreement with the several findings from studies conducted in referral hospitals of Ghana [18], Ethiopia [15] and Tanzania [8]. This could be explained by the fact that premature babies are at a higher risk of infection because of their immature immune system. Additionally, premature neonates are also more likely to be exposed to various invasive procedures, which might increase chances of neonatal infection. Further, premature babies are at higher risks of bleeding, respiratory distress syndrome, jaundice; all can put them at higher risk of bacterial infection. In this study, neonates with low 5th minutes Apgar score were 8 times more likely to develop neonatal sepsis. Similar findings have been reported in Ethiopia [15] [29], Tanzania [8] and Nigeria [7]. Neonates with low Apgar score tend to have poor adaptation to extra-uterine life due to the stress experienced during labour and, therefore, are more prone to infection [1]. This finding is important in guiding appropriate interventions of neonates by considering those with low Apgar score are managed with strict sepsis preventive measures. Finally, our study revealed that neonates who had history of invasive procedure/s were more likely to develop neonatal sepsis compared to neonates who did not have history of invasive procedure. Several studies have reported invasive procedures as significant risk factor for neonatal sepsis [5] [32] [33]. Invasive procedures such as intravenous catheters are recognized risk factors for serious bloodstream infections [34].

5. Limitations of the Study

Since the study was done on admitted neonates and in the biggest referral hospital in Kenya, the results might have limitation in generalizability to the entire population.

6. Conclusion

Another piece of evidence showing both maternal and neonatal-related factor had a significant effect on the risk of neonatal sepsis. The study identified socio-demographics, presence of acute/chronic diseases during pregnancy, as ob-

stetric complications as significant maternal factors associated with neonatal sepsis. Prematurity, low Apgar score and history of invasive procedure were the babies' factors significantly associated with neonatal sepsis. The present study fundamentally provided the reconfirming of data on this topic; however, these data are of paramount importance in health-policy making and health care performance in Kenya.

Authors' Contribution

Tekeste and Mercy conceptualized the research problem, design the study and involved in proposal writing and data acquisition. Tekeste carried out data analysis, interpretation and paper preparation. Mercy critically revised the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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