Original Article

Prevalence of Neonatal Hypothermia and Associated Risk Factors at a Referral Hospital in Northern Province, Rwanda

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Abstract

Background
Neonatal hypothermia is a global concern, contributing significantly to neonatal mortality. Lack of thermal protection is a significant challenge for newborns' survival in low- and middle-income countries, including Rwanda.

Objectives
To determine the prevalence of neonatal hypothermia and associated risk factors in the neonatology unit at a Referral Hospital in the Northern Province.

Method
A cross-sectional quantitative study design and a convenient sampling strategy were used. The study sample was comprised of 303 neonates admitted to the neonatology unit from October 2021 to January 2022. The frequency distribution was calculated, and Chi-square and logistic regression were used to determine the associations.

Results
The prevalence of neonatal hypothermia was 65.3%. The factors associated with hypothermia: having adolescent mothers (aOR = 26.9), prematurity (aOR = 9.4), not being breastfed within 1 hour of delivery (aOR = 9.7), health problems (aOR = 6.9), low birth weight (aOR = 10.3), night delivery (aOR = 6.0), and multiple births (aOR = 29.7).

Conclusion
The prevalence of hypothermia was high during the study period. Therefore, special attention to thermal care of the identified at-risk neonates is imperative to reduce morbidity and mortality in this vulnerable population.

Rwanda J Med Health Sci 2025;8(2):273-284

Keywords: Neonate, hypothermia, neonatology, risk factors, Rwanda

Background

Neonatal hypothermia is a global health problem and was associated with 2.4 million deaths within the first month of life in 2020. [1] In 2024, a study done in Kenya found that the prevalence of neonatal hypothermia was 17.5%.[2] Neonatal hypothermia is defined by the World Health Organization (WHO) as an abnormal thermal state in which the body temperature is below 36.5 degrees Celsius. [3] At birth, a wet newborn begins to lose heat immediately unless heat loss is averted through drying and placement in a warm environment.[3] The WHO recommends that all stable newborns, term or preterm, are placed on the mother's warm chest, known as skin-to-skin contact (SSC), to help the newborn maintain normal body temperature. [3]

Humans are homeothermic animals and must generate heat to maintain a body temperature at a constant level, regardless of environmental influences, using metabolic activity.[4] In utero, the core body temperature of the fetus is usually maintained consistently at about 1°C above the mother's.[3] Unlike an adult, a newborn has a less mature thermal regulatory system and therefore heat dissipates quickly. [3] The ambient temperature of the birthing room is often substantially cooler than from where the newborn has just come, namely, the warm environment of the mother. Newborns lose heat through four mechanisms which are evaporation, convection, conduction and radiation. The primary mechanism of losing heat is through conduction where babies are placed on a cold surface such as a weighing scale, or wrapped in a cold, wet blanket.[5]

The literature is abundant with studies about neonatal hypothermia. A cohort study conducted in 11 European countries reported that over half of newborns (53.4%) admitted to the Neonatal Intensive Care Unit (NICU) had hypothermia. That hypothermia was associated with an increased risk of early and late neonatal death.[6]Studies conducted in India and China reported an elevated hypothermia prevalence, especially among very preterm neonates (69.8%) and very low birth weight (VLBW) (70.4%) neonates.[6,7] A study in China showed that VLBW infants had a four times higher risk of mortality and other poor outcomes such as respiratory syndrome, intra-ventricular hemorrhage and late-onset neonatal sepsis when hypothermic.[8] A systematic review and meta-analysis of 12 studies in East African countries (Ethiopia, Djibouti, Somalia, Eritrea, Sudan, Kenya, and Uganda) revealed a high-pooled prevalence (57.2%) of neonatal hypothermia and associated factors including preterm, low birth weight (LBW), night-time delivery, and delayed breastfeeding initiation. [9] Similarly, two studies in Ethiopia reported a low 5-minute Appearance, Pulse, Grimace, Activity, and Respiration (APGAR) score, bathed within 24 hours of birth, and failure to practice SSC immediately after birth as additional risk factors associated with neonatal hypothermia.[8,9]

There have been two recent studies conducted in Rwanda addressing neonatal hypothermia. A cross-sectional study by Urubuto reported a 27% prevalence on admission to the neonatology unit at a tertiary hospital in the capital city of Kigali, and the leading risk factor was prematurity.[11] A second study by Musabyemariya and colleagues assessed the knowledge and thermal practices of new mothers at a provincial hospital in the Eastern province.[12]

However, little is known about the prevalence of hypothermia and its associated risk factors among neonates born in the Northern Province, which is the coldest part of the country. Therefore, the study aimed to determine the prevalence and associated risk factors of neonatal hypothermia at Ruhengeri Referral Hospital.

Methods

Design
A cross-sectional design was used to determine the prevalence of neonatal hypothermia and associated risk factors among neonates on admission to the neonatology unit.

The study site was the Ruhengeri Referral Hospital, located in the Northern Province, which is Rwanda's coldest region.

Study population

The study population consisted of all neonates admitted to the neonatology unit at Ruhengeri Referral Hospital from 4 October 2021 to 4 January 2022.

Sample size and sampling procedure
Sample size

Sample size was calculated using the Cochran formula where n=(z^2 pq)/e^2 . Based on a 95% confidence interval and a projected 27% prevalence from the similar study done in Kigali.

$$n = \frac{1.96^2 \times 0.27(1-0.27)}{0.05^2} = 303$$

Sampling procedure

The total sampling procedure was used to recruit the participants where all neonates admitted to the neonatology unit during the study period were included in the study until the sample size is reached.

Data collection tools and procedures
Instrument

Data were collected using a structured questionnaire composed by two sections. The questionnaire was adopted from a recently published Master's thesis by Birhanu Wondimeneh about neonatal hypothermia and associated factors among newborns admitted to governmental hospitals in Addis Ababa, Ethiopia.[13] The questionnaire was slightly modified to fit the Rwandan context where a question about social category called ubudehe was added, and an ethnicity question was removed from the demographic data. The section about medical diagnosis on admission was also removed because the data were collected on admission before a patient meet the doctor, so the medical diagnosis was not yet known. The final questionnaire had two sections composed of 26 items and was written in two languages, Kinyarwanda and English, so participants had a choice and to minimize communication barriers.

It was divided into two sections with the Participants' demographic data in section one, and information about hypothermia in section two.

Section 1 consisted of maternal and neonatal demographic characteristics. It had 10 items: the age, religion, residence, level of education, occupation, Ubudehe category, number of antenatal care contacts, gestational age, sex of the newborn and age of the neonate.

Section 2 consisted of 16 items about hypothermia and related risk factors: birth weight, time of birth, the time between bathing a neonate and taking the temperature, gestational age, admission temperature, using the warm intra-facility transportation, having a health problem, perform skin-to-skin contact immediately after birth, breastfeed the newborn within one hour after birth, resuscitate the newborn immediately after birth, APGAR score at birth, having maternal obstetrical complication during pregnancy or labor and delivery, pregnancy type, method of delivery, place of delivery or place of birth if out of hospital.

Data collection was completed by one researcher (first author) who approached mothers with newborns in the neonatology unit. The researcher gave the mothers information about the study, including ethical standards of confidentiality and anonymity. If they agreed to participate, they signed the consent form. Data were collected using the self-administered questionnaire and coded using a study ID instead of personal identifying information. Data were collected from the neonates' mothers, including birth and referral-related history, and neonates themselves, such as temperature and other health parameters. Information from the completed forms was entered in the Statistical Package for Social Sciences (SPSS) daily to prevent data loss. Data were collected three days a week (Monday to Wednesday) from 7:00 am to 5:00 pm to coincide with the master's program schedule for a period of three months.

Measures

In this study, there were two types of variables namely the dependent and independent variables. The dependent variable which is neonatal hypothermia was measured by taking axillary temperature of the neonates using the mercury thermometer. The dependent variable had two categories, which were "Yes" if the neonate had temperature below 36.50C or "No" if the neonate had temperature of 36.50C or above. The independent variables which consisted by 16 factors that can affect the neonatal hypothermia were measured and operationalized based on WHO standards. These included: birth weight, time of birth, the time between bathing a neonate and taking the temperature, gestational age, admission temperature, using the warm intra-facility transportation, having a health problem, perform skin-to-skin contact immediately after birth, breastfeed the newborn within one hour after birth, resuscitate the newborn immediately after birth, APGAR score at birth, having maternal obstetrical complication during pregnancy or labor and delivery, pregnancy type, method of delivery, place of delivery or place of birth if out of hospital. These independent variables were categorized by "Yes" if the neonate had the risk or "No" if the neonate did not have the risk and was done based on the risk factors of hypothermia confirmed by WHO in the standards of care for the newborns.[3]

Data analysis

The data were analysed using SPSS (version 25). Descriptive statistics, such as frequency of distribution tables and percentages were used to summarize data. Logistic regression was used to analyse the relationship between independent variables (age of the mother, residence of the mother, education level of mothers, occupation of the mother, antenatal care contact) as predictors and estimates how each predictor affects the adjusted odds ratios (aOR) of neonatal hypothermia as the outcome.

Ethical considerations

Data collection started after obtaining approval from the University of Rwanda, College of Medicine and Health Sciences, Institutional Review Board with the reference number CMHS/IRB/181/2021, and from the ethics committee of Ruhengeri Referral Hospital. All mothers were given information about research ethics, given the opportunity to ask questions, and provided written consent. The mother had right to voluntarily participate in the study or not. The confidentiality was also assured using data anonymization, secured storage and preventing any data access by another person except those who are doing the study. The participant also has the right to withdraw in the study at any time without being asked why or having any effect on his care services needed at hospital.

Results

A total of 303 mothers and their neonates participated in the study at Ruhengeri Referral Hospital during the three months of data collection.

Demographic characteristics of the mother

The majority of participants were: private employees, in the age-group of 21-55 years called mature mothers, educated at the primary level, and were affiliated to the Roman Catholic Church. Most mothers were from rural areas and in Ubudehe category II. Only a third of the participants had attended three antenatal care visits. [Table 1]

Prevalence of neonatal hypothermia

Table 1 also shows the prevalence of neonatal hypothermia. Nearly all adolescent mothers had a neonate with hypothermia. Majority of mothers who had either no formal education or had only primary level schooling, or lived in a rural area, had a higher frequency of neonate hypothermia than their counterparts. Nearly three-quarters of mothers who were famers had a higher frequency of neonates with hypothermia than other occupations. Majority of mothers who did not attend ANC had a higher frequency of neonates with hypothermia than mothers who did attend ANC. Most Adventists mothers had a higher frequency of neonates with hypothermia than other religions. Majority of mothers in Ubudehe category I had a higher frequency of neonates with hypothermia than other categories.

Table 1. Maternal Demographic Characteristics and neonatal hypothermia (n=303)

Variables	Hypothermia		Total
	Yes (n=198)	No (n=105)	n(%)
Age group (years)			
16-20	69(97.1)	2(2.9)	71(23.1)
21-55	130(55.8)	102(44.2)	232 (76.9)
Educational level attained			
No school	24(70.6)	10(29.4)	34(11.2)
Primary	137(71.0)	56(29.0)	193(63.7)
Secondary	37(52.9)	23(47.1)	70(23.1)
Advanced diploma	0(0.0)	6(100)	6(2.0)
Religion			
None	0(0.0)	2(100)	2(0.7)
Roman Catholic Church	95(64.6)	52(35.4)	147(48.5)
Protestant	43(62.3)	26(37.7)	69(22.8)
Adventist	56(72.7)	21(27.3)	77(25.4)
Islam	4(50)	4(50)	8(2.6)
Residence			
Urban	50(58.8)	35(41.2)	85(28.1)
Rural	148(67.9)	70(32.1)	218(71.9)
Occupation			
Public employee	4(36.4)	7(63.6)	11(3.6)
Private employee	187(94.4)	88(83.8)	275(90.7)
Student	10(62.5)	6(37.5)	16(5.3)
None	0(0.0)	4(100)	4(1.3)
Ubudehe category			
I	37(69.8)	16(30.2)	53(17.5)
II	114(68.3)	53(31.7)	167(55.1)
III	47(59.5)	42(40.5)	79(26.1)
IV	0(0.0)	4(100)	4(1.3)
Antenatal Care Visits			
0	10(71.4)	4(28.6)	14(4.6)
1	30(69.8)	13(30.2)	43(14.2)
2	42(60.9)	27(39.1)	69(22.8)
3	69(67.6)	33(32.4)	102(33.7)
4	47(62.7)	28(37.3)	75(24.8)
Delivery			
Assisted delivery	181(91.4)	98(93.3)	279(92.1)
Unassisted delivery	17(70.8)	7(29.2)	24(7.9)

Neonatal Demographic Characteristics

Table 2 shows that the majority of neonates in the neonatology unit were male and preterm, and that most neonates were one to seven days of age.

Table 2. Neonatal Demographic Characteristics (n=303)

Variables	n (%)
Gender	
Male	162 (53.5)
Female	141 (46.5)
Gestational age	
Preterm	170 (56.1)
Term	133 (43.9)
Days of life	
< 1	104 (34.3)
1-7	174 (57.4)
8-28	25 (8.3)

Prevalence of Neonatal Hypothermia (n=303)

The prevalence of hypothermia was 65.3% in the study sample at the time of data collection (Figure 1).
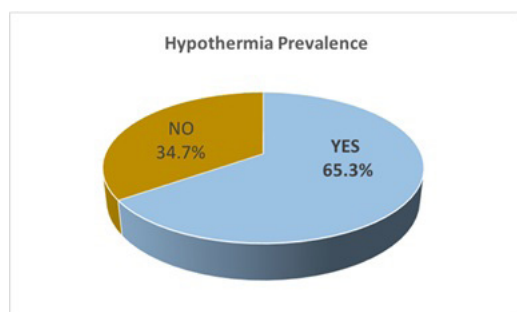
Health problems of neonates

Figure 2 shows the number of neonates with health problems. The neonatal health problems included congenital malformation, respiratory distress, jaundice, bleeding disorders, and lymphoedema.
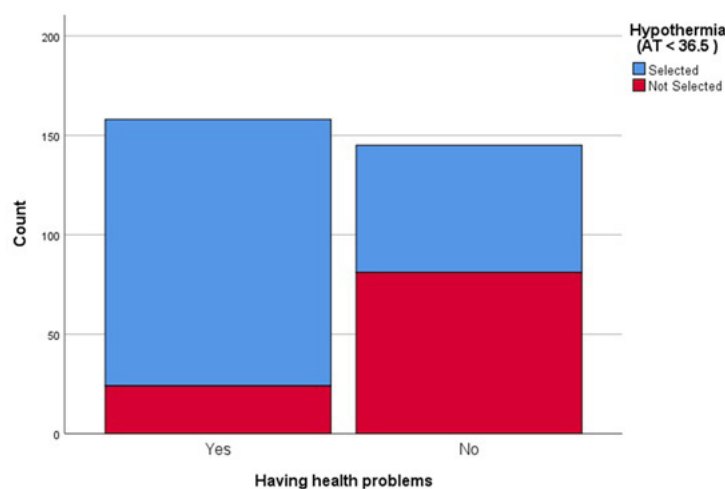

Figure 2. Graph representing neonates with health problems (Hypothermia mean temperature less than 36.5 degree Celsius)

Neonates of mothers with obstetrical complications

The figure above shows neonates whose mothers had obstetrical complications during pregnancy, labor, and delivery (Figure 3). An obstetrical complication was defined as one or more of the following: preeclampsia, obstructed labor, prolonged labour, ante-partum haemorrhage, PROM, PPROM, uterine myoma or oligohydramnios.
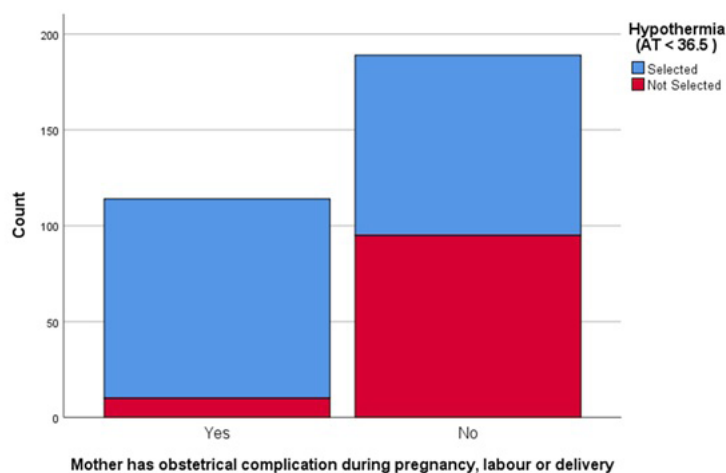

Figure 3. Graph of neonates of mothers with obstetrical complications

Risk Factors Associated with Neonatal Hypothermia

Table 4. A bivariate analysis was used to determine the factors statistically associated with neonatal hypothermia. Maternal factors found included being born from an adolescent mother (16-20 years), which increased the risk nearly 32 times (aOR=31.8, p<0.001 CI=1.7, 14.0) more than from an older mother. Maternal obstetrical complications during pregnancy, labor or delivery increase the neonates' risk 13 times (aOR=9.2, p<0.001 CI=1.6, 5.45) compared to their mothers having no obstetrical complications. A neonate, as part of a multiple birth, was nearly 19 times (aOR=18.7 , p<0.001 CI=1.34, 6.3) more at risk of hypothermia than a singleton.

Other factors that were statistically associated with hypothermia included the following: A low Birth Weight (BW) neonate (<2500 grams) was 10 times (aOR=9.2, p<0.001

Table 3. Risk Factors Significantly Associated with Neonatal Hypothermia (n=303)

Variables	Hypothermia			AOR	CI	P-value
	Yes n (%)	No n (%)	COR			
Maternal age (years)						
10-20	68 (97.1)	2 (2.9)	**26.93**	**31.8**	1.7-14.0	**<0.001**
21-55	130 (55.8)	103 (44.2)				
Birth weight (grams)						
< 2500	132 (88.6)	17 (11.4)	**10.35**	**9.2**	1.6-3.6	**<0.001**
≥ 2500	66 (42.9)	88 (57.1)				
Birth time						
Night-time	140 (82.4)	30 (17.6)	**6.09**	**4.2**	4.4-6.13	**<0.001**
Day time	58 (43.6)	75 (56.4)				
Gestational age (weeks)						
< 37	146 (85.9)	24 (14.1)	**9.47**	**20.01**	1.9-2.8	**<0.001**
≥ 37	52 (39.1)	81 (60.1)				
Health problems						
Yes	133 (84.7)	24 (15.3)	**6.90**	**8.7**	0.00- 1.7	**<0.001**
No	65 (44.5)	81 (55.5)				
Breastfed <= 1 hour of birth						
No	186 (100)	0 (0.0)	**9.75**	**9.6**	1.79 - 6.0	**<0.001**
Yes	12 (10.3)	105 (89.7)				
Obstetrical complications						
Yes	104 (91.2)	10 (8.8)	**10.51**	**13.2**	**1.6 - 5.45**	**<0.001**
No	94 (49.7)	95 (50.3)				
Pregnancy type						
Twin	44 (97.8)	1 (2.2)	**29.71**	**18.7**	1.34 - 6.3	**<0.001**
Singleton	154 (59.7)	104 (40.3)				
APGAR at first minute						
Less than 7	57(64.0)	32(36.0)	**9.75**	**3.7**	1.6 - 15.4	**<0.06**
7 to 10	141(65.9)	73(34.1)				
Ubudehe category						
Category I&II	147(66.8)	73(33.2)	**0.26**	**1.4**	0.1 - 64	**0.581**
Category III&IV	51(61.4)	32(38.6)				
Neonatal asphyxia						
Yes	80(64.5)	44(35.5)	**0.94**	**0.64**	1.3 – 2.6	**0.800**
No	118(65.5)	61(34.1)				
Temperature to bath time						
Less 60 minutes	5(45.5)	6(54.5)	**0.42**	**0.2**	2.4 - 7.7	**0.58**
60 or more minutes	193(66.1)	99(33.9)				
Warm intra-facility transportation						
Not used	7(58.3)	5(41.7)	**0.73**	**8.8**	2.4 - 3.6	**0.602**
Used	191(65.6)	100(34.4)				
SSC immediately after birth						
No	102(65.0)	55(35.0)	**0.96**	**0.54**	2.6-5.4	**0.886**
Yes	96(65.8)	50(34.2)				

CI=1.6, 3.6) as likely to suffer hypothermia as a neonate above 2500 grams. A preterm neonate was about 20 times (aOR=20.01, p<0.001 CI=1.9, 2.8) more at risk than a term neonate. A neonate born at night was four times (aOR= 4.2, p<0.001 CI=4.4, 6.13) more at risk compared to those born during daytime. A neonate with health problems was nearly nine times (aOR=8.7, p<0.001 CI=0.00, 1.7) more at risk compared to those without health problems.

A neonate who was not breastfed within one hour of birth was nearly 10 times (aOR=9.6, p<0.001 CI=1.79, 6.0) more at risk of hypothermia compared to those breastfed within one hour of birth. Bivariate analysis other variables did not find statistical significance. They included low APGAR score at one minute and asphyxia, not being placed in SSC immediately after birth, temperature after neonates' bath, not using warm intra-facility transportation to neonatology, and the Ubudehe category.

Discussion

This cross-sectional study was done to assess the prevalence and associated risk factors of hypothermia among neonates admitted to neonatology at a referral hospital in the coldest province in Rwanda during the rainy season. Two-thirds of neonates, 200 (66.0%) were born in the hospital, while a third, 103 (34%), were born at another site, including 24 (7.9%) at home.

Hypothermia prevalence

The prevalence of hypothermia among neonates on admission to neonatology was 65.3%. Similar results were found by Yitayew [14] in a study conducted at the Dessie Referral Hospital in the Amhara region of Northeast Ethiopia that reported a 66.8% hypothermia prevalence rate among NICU admissions. In contrast, other studies reported lower prevalence rates, including 50.3% in Southwest Ethiopia,[15] 57.2% in a systematic review and meta-analysis in East Africa,[9] and 27% in a referral hospital in Kigali, the capital city of Rwanda.[11] Possible reasons for our higher prevalence rate over other sites could be the location of the Ruhengeri Referral Hospital, which is at a high altitude (1860 meters above sea level), and in the coldest region in Rwanda. Furthermore, our study was conducted during the rainy season which could have an effect the temperature of the neonates' environment.

Risk Factors

In this study, the age of the mother was significantly associated with neonatal hypothermia. The odds of neonatal hypothermia were nearly 32 times higher (aOR: 31.8; p<0.001 CI=1.7, 14.0) in neonates born from adolescent mother (16-20 years) than in neonates born from mature mothers (21-55 years). Similarly, other studies including a systematic review and meta-analysis in East Africa by Beletew [9] and Musabyemariya and colleagues in Rwanda,[12] reported that a young mother exposed the neonate to the risk of hypothermia. There are many possible reasons for this association. Many young mothers may not attend ANC for fear of stigma, may have poor knowledge about the prevention of hypothermia, and may lack other experiences in caring for a newborn. Furthermore, they will likely be single and have no support, which exposes them to a lack of help before recovering from the postpartum period, and not enough energy, good nutrition, and other resources to care for themselves and the neonate. Another factor associated with hypothermia was birth weight, where the odds of neonatal hypothermia were over 10 times (aOR: 9.2; p<0.001 CI=1.6,3.6) higher in LBW neonates than those with a birthweight of 2.5 kg or more. Similar findings were found in three other studies including Ukke and Tessema in Ethiopia, a systematic review and meta-analysis study done in East Africa and a cohort study by Dang et al in 2023.[9,16–17] The possible reason for this finding might be due to their thin and permeable skin exposing the newborn to heat loss, and also their weight has a significant effect on the transition from mild hypothermia to normothermic.[12,17,18] Birth time was the other risk factor significantly associated with neonatal hypothermia found in this study.

The odds ratio hypothermia for the neonates delivered at night-time was five times (aOR: 4.2; p<0.001 CI=4.4, 6.13) more likely to develop hypothermia than neonates delivered at daytime. This finding was similar to a study by Yitayew[14] in Northeast Ethiopia among newborns admitted to the NICU at Dessie Referral Hospital. This finding might be due to the temperature difference between daytime and nightime and also less surveillance and observation of the neonate at night.

Gestational age was also significantly associated with neonatal hypothermia. The odd of neonatal hypothermia were more than tuenty times (aOR: 20.01; p<0.001 CI=1.9,2.9) higher in preterm than term neonates. The possible reason for this finding might be that preterm neonates have a large surface area to body mass, minimal subcutaneous fat stores and limited capacity to generate heat from fat stores. This finding is in line with other studies conducted in Northeast Ethiopia, Rwanda, an East African systematic review and meta-analysis, Canada, and the US.[9,11,14,16,19]

Other factors associated with hypothermia include a neonate having a health condition. A neonate with a health problem is almost nine times (aOR: 8.7; p<0.001 CI=0.0-1.7) more likely to have neonatal hypothermia than a neonate without a health problem. This was also found in the systematic review and meta-analysis in East Africa, which reported newborns with a health problem such as congenital malformation, asphyxia, jaundice, respiratory distress, bleeding disorders, infection or meconium aspiration were more at risk of hypothermia and distress or sepsis in other studies.[9,20,21] This finding might be possibly the reason that a neonate with health problems is sometimes unable to be fed, which increases the risk of hypoglycemia that may lead to hypothermia; also the capacity to maintain body temperature may be related to the type of neonatal health problem as in a Rwandan study and a study done in Iran.[12,22]

Another variable that showed significant association to hypothermia in our study was a neonate not being breastfed within one hour of birth. The odds of hypothermia were nearly 10 times (aOR: 9.6; p<0.001 CI=1.79, 6.0) more likely in neonates who did not breastfeed within one hour than those who did breastfeed within one hour of life. This finding is similar to other studies by Ukke in Southwest Ethiopia and a systematic review about the association of feeding and birth weight with neonatal hypothermia.[16,23] This might be the reason that breastfeeding increases glycemia to maintain the body temperature, so those who are not breastfed lack the glycaemia needed to produce heat energy, which leads to hypothermia.[12,23]

Being born from mothers who had obstetrical complications during pregnancy, labor or delivery was also a risk factor associated with neonatal hypothermia. Neonates whose mother had an obstetrical complication were more than 13 times (aOR: 13.2; p<0.001 CI=1.6, 5.45) more likely to have hypothermia compared to those from mothers who did not. This finding was similar to the study conducted by Ukke, [16] in a Southwestern Ethiopian study showing obstetrical complications in pregnancy or labor such as preeclampsia, eclampsia, diabetes, obstructed/prolonged labor, APH, PROM or PPROM, sepsis or PPH. This might be the reason that women who develop obstetrical complications are more likely to be in need of special management such as cesarean section or instrumental delivery (vacuum or forceps), or the mother might be too sick to be in close contact with their infant in order to prevent hypothermia. Additionally, some obstetrical complications like Premature Rupture Of the Membrane (PROM) might have resulted in neonatal sepsis where a fall in body temperature is one of its clinical features Ukke.[16,24]

Multiple births were also a risk factor of neonatal hypothermia. The odds of having hypothermia was nearly 19 times (aOR: 18.7; p<0.001 CI=1.34, 6.3) higher for a neonate in a multiple pregnancy than those born a singleton.

Beletew reported a similar finding in a systematic review and meta-analysis in East Africa.[9,25] This might be the reason that neonates from a multiple pregnancy are at risk of preterm labour and birth, which consequently exposes them to hypothermia as premature babies can have health challenges. The other reason might be that mothers with multiple pregnancies are at high risk of different obstetrical problems like preeclampsia, gestational diabetes, placental problems and fetal growth problems; all these expose newborns from multiple births at high risk of neonatal hypothermia.[23] In addition, mothers with multiple births may not be able to do SSC as required so the newborns cannot benefit from the mother's heat and related thermoregulation.[26]

Limitations

This was a cross-sectional study, so the exposure to the population only occurred one time during the rainy season. The study was only conducted at one hospital and not multiple health facilities including private hospitals and other public health facilities that cover different areas of Northern Province. Also, a randomization method was not used as data collection time was limited and even though a consecutive sample method was used, the sample was relatively small. Another limitation or bias was that this study was conducted in the rainy season when temperatures are typically colder and inclusion and exclusion criteria were not clearly defined.

Future research

A comparison study conducted during the rainy and dry seasons on the Northern Province and other provinces would add to the body of knowledge gathered in Rwanda on neonatal hypothermia.After discovering the high prevalence hypothermia rate among neonates and relate risk factors, it would be good to do and interventional study to try to possibly remedy the problem. A qualitative study to access cultural and behavioral factors that may affect neonatal hypothermia.

Conclusion

A cross-sectional study was conducted on neonates in a district hospital in the northern province of Rwanda during the rainy season. The prevalence of hypothermia in this study was high at 65.3%. Neonates born to young mothers, prematurity, no breastfeeding within one hour of birth, neonatal health problems, LBW, night-time delivery, and multiple births were significant risk factors. Therefore, health care providers should pay special attention to the thermal care of neonates at risk in the hospital, in colder regions such as Northern Province, and neonates throughout Rwanda. Furthermore, they should warn mothers to assess the newborn's temperature and keep them warm, particularly adolescent mothers, and those with preterm or LBW neonates using different approved methods like skin-to-skin care.

Authors' contribution

DM conceived and designed the study, analyzed the data, and wrote the manuscript. BN revised the proposal and assisted in data collection. C M helped in data analysis and manuscript re-reading. PM assisted in data analysis and data interpretation. Finally, all authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflicts of interest.

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