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Original Article

Prevalence and factors associated with neonatal hypothermia among deceased neonates after admission to neonatal intensive care unit at Butajira General Hospital, Ethiopia

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Abstract

Introduction: *Despite substantial progress, neonatal mortality remains high globally with sub-Saharan Africa and South Asia leading with the burden. In Ethiopia, neonatal hypothermia is implicated in up to 79.6% of neonatal deaths. This study aims to describe the magnitude of the history of hypothermia among neonates deceased at Butajira General Hospital neonatal intensive care unit.*

Methods: *The study is a hospital-based cross-sectional study conducted among 189 deceased neonates. Data was collected by retrospective chart review for those deceased during September 2020 to February 2021 and primary data was collected from care takers for neonates deceased between March 2021 to August 2022. Data were analyzed using SPSS version 28. Bivariate and multivariate logistic regression analyses were performed to assess the association between neonatal hypothermia and potential risk factors. The strength of association was measured using adjusted odds ratios (AORs) with corresponding 95% confidence intervals (CIs).*

Result: *During the study period, a total of 189 neonates died, of which 109(57.7%) were male. At admission, 120(66.7%) of deceased neonates had respiratory distress syndrome and hypothermia was observed in 160(84.7%) of the cases. Low birth weight increased the odds of hypothermia by threefold (AOR = 3.25, 95% CI: 1.35–7.83). Preterm neonates had four times higher odds (AOR = 4.30, 95% CI: 1.73–10.69), while those admitted during the late neonatal period were 55% less likely to develop hypothermia (AOR = 0.47, 95% CI: 0.24–0.81).*

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***Conclusion**: Hypothermia is a major morbidity type among the deceased neonates where more than 80% of deceased neonates had history of hypothermia. Hypothermia is commonly identified among low birth weight neonates, preterm neonates, and those with younger age at admission to intensive care units. Implementing meticulous thermal care based on WHO's warm chain principles, especially for high-risk neonates, may reduce neonatal mortality in similar low-resource settings.*

***Keywords:** Neonatal death, neonatal hypothermia, Ethiopia*

Introduction

A recent World Health Organization (WHO) report showed that 2.3 million children died in the first 20 days of life in 2022, constituting about 47% of all under-5 deaths(1,2). Despite the substantial progress, neonatal mortality remains a pressing issue worldwide, with a higher burden on low-income countries and developing regions with limited resources, such as sub-Saharan Africa (more than 52% of neonatal mortality), and southern and central Asia(1,3,4). The leading causes of death among neonates include premature birth, birth complications (birth asphyxia/trauma), infections, and congenital anomalies(1). One important contributor to neonatal morbidity and mortality is neonatal hypothermia (5–8). In Ethiopia, neonatal hypothermia has been identified as a contributing factor in up to 79.6% of neonatal deaths, with the strength of this association increasing as neonatal body temperature decreases(7,8).

Given the scale of the problem, it is critical to understand how widespread hypothermia is in different settings. The global prevalence of neonatal hypothermia has been reported to range from 11% to 95%. Although prevalence varies by region, poorer countries bear a higher burden and experience worse outcomes compared to their developed counterparts. Ethiopia is one of the most affected countries concerning neonatal mortality and neonatal hypothermia(4,9,10). The prevalence of neonatal hypothermia in Ethiopia is estimated to be between 53% and 69.8% (11,12).

Various physiological, behavioral, environmental, and socioeconomic factors are significantly associated with neonatal hypothermia. Key factors include low birth weight, prematurity, delayed breastfeeding, and skin-to-skin contact, as well as neonatal health issues (13,14). Harmful practices, such as sprinkling cold water at birth and early bathing, also increase the risk (6,15). Inadequate thermal care during delivery and transport, along with insufficient attention from health professionals, further contribute to the problem(16).

To address these factors, international and national bodies have developed preventative strategies including the WHO's "warm chain"; procedures taken at birth and in the following days: preparing a warm delivery room, immediate drying, skin-to-skin contact, keeping newborns with mothers, immediate

breastfeeding, postponing bathing and weighing, appropriate clothing and bedding, warm transportation and resuscitation, and training health professionals and families (15). Ethiopia implements the warm chain as part of essential newborn care (ENBC) (14). However, these measures are often inadequately implemented in health institutions and rarely in home deliveries, increasing the risk of neonatal hypothermia(16).

While hypothermia remains a leading contributor to death among neonates, the scarcity of studies on neonatal hypothermia in Ethiopia poses obstacles to the prevention and effective management of cases. Furthermore, identifying population-specific risk factors can potentially help curate preventive efforts and eventually contribute to the reduction of neonatal mortality, helping Ethiopia attain the Sustainable Development Goal (SDG-3) of ensuring healthy lives and promoting well-being for all ages (13,14). While hypothermia is highly preventable, it still contributes to neonatal deaths. Strengthening data on this particular topic will help to call relevant stakeholders to action with the intent of shaping policies and resource allocation. Hence, this research aims to contribute to the literature with a focus on the high-risk groups of neonatal deaths.

The objective of this study is to determine the prevalence of neonatal hypothermia among deceased neonates at Butajira General Hospital and to identify possible factors associated with hypothermia. The ultimate goal is to provide actionable data that can inform targeted strategies to reduce neonatal mortality.

Methodology

Study Design and Period

The study is a hospital-based cross-sectional study conducted among 189 deceased neonates at the Neonatal Intensive Care Unit (NICU) of Butajira General Hospital from September 2020 to August 2022. Data was collected by retrospective chart review using medical records of deceased neonates for those deceased during September 2020 to February 2021 and primary data was collected from caretakers for neonates deceased between March 2021 to August 2022. Thus, the total period of data spans from September 2020 to August 2022.

Study Setting

Butajira is located 138 km south of Addis Aba-ba. It is divided into three smaller districts- Meskan, Silti, and Mareko- which are part of the Central Ethiopia Region. According to the 2007 Census, the town has a total population of 33,406, of whom 16,923 are males and 16,483 are females(17). The study was conducted at Butajira General Hospital, the largest hospital in Butajira. The hospital has one delivery room and a small 12-bed neonatal ICU. During the study period there were 1,390 neonatal admissions and 189 neonatal deaths were reported.

Source and Study Population

All neonatal admissions to the NICU of Butajira Hospital served as the source population, while the study population consists of all deceased neonates that occurred in the NICU of Butajira General Hospital during the study period.

Inclusion Criteria

Neonates, who fulfilled all four of the following criteria were eligible to be enrolled in this study

- Live birth
- Gestational age: Above 28 weeks
- Birth weight of above 1,000g
- Death within 28 days of delivery

Exclusion Criteria

The study excludes all deaths occurring after 28 days of delivery, neonatal deaths below a gestational age of 28 weeks, births with a weight of less than 1,000 g, and stillbirths.

Sample Size Determination

As this study focused on deceased neonates over a defined period, a census approach was used to enumerate all neonates deceased during the selected duration of time. All deceased neonates in the NICU of Butajira General Hospital between September 2020 and August 2022 were included in the study and no formal sample size calculation was performed.

Data collection and quality control

Data were collected using a structured pretested questionnaire that included the mother's socio-demographic characteristics, neonatal risk factors for hypothermia, and obstetric and environmental factors related to hypothermia. Five neonatal nurses working in the NICU gathered the data under the supervision of one pediatrician. A one-day training session and orientation were provided for the data collectors and supervisors. The questionnaire was pretested at Yekatit 12 Hospital.

Data processing and analysis

The collected data were checked for consistency, clarity, reliability, validity, and accuracy. It was processed and analyzed by SPSS version 28. Descriptive statistics were employed to analyze the study findings. Bivariate and multivariate logistic regression was used to find association between hypothermia and risk factors. On bivariate analysis, candidate variables were identified at a p value <0.20, and factors that had a significant association were entered into multivariate regression to control confounders.

Operational definitions

This study defined normal temperature as an axillary temperature ranging from 36.5°C to 37.5°C.

- Hypothermia is defined as an axillary temperature of less than 36.5 °C.
- Mild hypothermia: Axillary temperature between 36.0 °C and 36.5 °C
- Moderate hypothermia: Axillary temperature 32.0 °C to 35.9 °C
- Severe hypothermia: Axillary temperature below 32.0°C
- Inborns – Neonates born at Butajira General Hospital
- Outborns: Neonates born outside of Butajira General Hospital

Variables

Dependent variable

- Neonatal hypothermia

independent variable

- Socio-demographic factors: residence, maternal age, parity.
- Neonatal factors: age, birth weight, gestational age, APGAR (Appearance, Pulse, Grimace, Activity, Respiration), CPR (Cardiopulmonary resuscitation)
- Obstetric factors: Antenatal care (ANC), delivery time, delivery mode, place of delivery, season of delivery, obstetric complications, and pregnancy type.

Results

Socio-demographic characteristics of study participants

Among 1,390 neonatal admissions from September 2020 to August 2022, the total neonatal mortality was 189(13.6%). As shown in Table 1, 112(59.3%) neonates were born to families living in rural areas. Additionally, 76(40.2%) of the mothers of the neonates were aged between 26 and 34, and 95 (50.3%) of the mothers of the neonates were multiparous (Table 1).

Table 1: Maternal Socio-demographic information of study participants, Butajira General Hospital, Central Ethiopia Region, Ethiopia, Sept 2020 - August 2022

Variable	Category	Freq. (%)
Residence	Urban	73(38.6%)
	Rural	112(59.3%)
	Unknown	4(2.1%)
Maternal Age	<18	2(1.1%)
	18-25	44(23.3%)
	26-34	76(40.2%)
	35-49	25(13.2%)
	Unknown	43(22.2%)
Parity	Primipara	58(30.7%)
	Multipara	95(50.3%)
	Unknown	36(19.0%)

Neonatal factors

Among the participants, 109(57.7%) of the deceased neonates were male. The majority, 165 (87.3%), of the neonates were admitted during the immediate neonatal period, within the first three days of birth. Regarding the birth weight, 61(32.3%) of the neonates had normal birth weight and 108 (57%) had low birth weight. On the other hand, 95(50.2%) were born preterm, 50(26.5%) were born with a known normal APGAR score, 40(21.2%) had a known history of cardiopulmonary resuscitation (Table 2).

Table 2: Neonatal birth outcomes and related characteristics, Butajira General Hospital, Central

Variable	Category	Freq. (%)
Sex of the neonate	Male	109(57.7%)
	Female	80(42.3%)
Age of neonate at admission	Immediate neonatal period (birth to 3rd day)	165(87.3%)
	Early neonatal period (4th to7th day)	14(7.4%)
	Late neonatal period (8th to 28th day)	9(4.8%)
	Unknown	1(0.5%)
Birth weight	Very low birth weight (VLBW): 1,000g – 1,499g	53(28.0%)
	Low birth weight (LBW): 1,500g – 2,499g	58(30.7%)
	Normal birth weight (NBW): 2,500g – 4,000g	61(32.3%)
	Unknown	17(9.0%)
Gestational Age	28w - <32w	42(22.2%)
	32w - <37w	53(28.0%)
	37w -42w	70(37.0%)
	>42w	1(0.5%)
	Unknown	23(12.2%)
APGAR Score	low (Apgar 0–3)	6(3.2%)
	Intermediate (Apgar 4–6)	56(29.6%)
	Normal (Apgar 7–10)	50(26.5%)
	Unknown	77(40.7%)
History of CPR	Yes	40(21.2%)
	No	67(35.4%)
	Unknown	82(43.4%)

Clinical characteristics

At admission, 126(66.7%) of the deceased neonates had respiratory distress syndrome, 54 (28.6%) had perinatal asphyxia, and 46(24.3%) were small for their gestational age, as shown in (Table 3).

Among the deceased neonates in the study period, 160(84.7%) had neonatal hypothermia, while 15(7.9%) had mild hypothermia; the majority, 110(58.2%), had moderate hypothermia, and 35(18.5%) had severe hypothermia, as illustrated in (Figure 1).

Table 3. Neonatal admission diagnosis of deceased neonates, Butajira General Hospital, Central Ethiopia Region, Ethiopia, September 2020 - August 2022

Admission Diagnosis	Yes Freq. (%)	No Freq. (%)
Respiratory Distress Syndrome	126 (66.7%)	63 (33.3%)
Pre-Term	100 (52.9%)	89 (47.1%)
Jaundice	12 (6.3%)	177 (93.7%)
Sepsis	103 (54.5%)	86 (45.5%)
Low Birth Weight	113 (59.8%)	76 (40.2%)
Perinatal asphyxia	54 (28.6%)	135 (71.4%)
Congenital Anomaly	26 (13.8%)	163 (86.2%)
Meconium Aspiration Syndrome (MAS)	27 (14.3%)	162 (85.7%)
Small for Gestational Age	46 (24.3%)	143 (75.7%)
Hypoglycemia	29 (15.3%)	160 (84.7%)

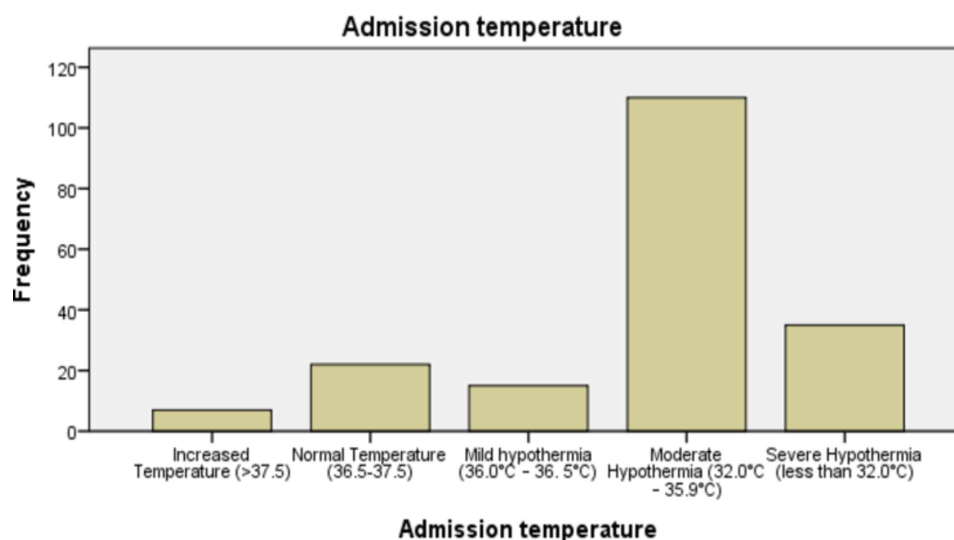

Figure 1: Admission temperature of neonates deceased at Butajira General Hospital, Central Ethiopia Region, Ethiopia, September 2020 - August 2022.

Obstetric Factors

The majority, 120(63.5%), of the mothers had ANC follow-ups before their delivery. 61 (32.3%) were delivered during the day. Most of the neonates 144 (76.2%) were born through spontaneous vaginal delivery (SVD). In our study, 150(79.4%) of the neonates were inborn, meaning they were born at Butajira General Hospital, while 3(1.6%) were born at home. Additionally, 62(32.8%) were born during the Bega season, corresponding to Ethiopia's summer season. As shown in Table 4, the birth of 28(14.8%) of the neonates was associated with obstetric complications. Furthermore, 35 (18.5%) of the neonates were born from twin pregnancies.

Table 4: Maternal obstetric factors and related characteristics, Butajira General Hospital, Central Ethiopia Region, Ethiopia, Sept 2020 - August 2022

Variables	Categories	Freq. (%)
Maternal ANC	Yes	120 (63.5%)
	No	17 (9.0%)
	Unknown	52 (27.5%)
Delivery Time	Day	61 (32.3%)
	Night	54 (28.6%)
	Unknown	74 (39.2%)
Deliver Mode	Spontaneous Vaginal Delivery (SVD)	144 (76.2%)
	Instrumental delivery	2 (1.1%)
	Cesarean section (CS)	18 (9.5%)
	Unknown	25 (13.2%)
Place of delivery	Inborn	150 (79.4%)
	Outborn	22 (11.6%)
	Unknown	17 (9.0%)
Place of delivery of out-born	Home	3 (1.6%)
	Other government Hospital	13 (6.9%)
	Private health Facility	3 (1.6%)
	Unknown	20 (10.6%)
Season of delivery	December to February	62 (32.8%)
	September to November	19 (10.1%)
	March to May	53 (28.0%)
	June to august	55 (29.1%)
Obstetric Complications	Yes	28 (14.8%)
	No	83(43.9%)
	Unknown	78(41.3%)
Pregnancy Type	Singleton	150 (79.4%)
	Twin	35 (18.5%)
	Triplet	3 (1.6%)
	More than 3	1 (0.5%)

Factors Associated with Hypothermia

Binary logistic regression was run between factors and hypothermia. After binary regression, factors with a P value<0.2 were entered into multivariate logistic regression to identify independent predictors. Multivariate logistic regression was conducted for the candidate variables. Neonates with low birth weight were three times more likely to develop hypothermia (AOR = 3.25, 95% CI: 1.35, 7.83). Neonates

with congenital anomalies were three times more likely to develop hypothermia (AOR = 3.62, 95% CI: 1.38, 9.47). Neonates admitted at late neonatal period had a 55% lower chance of developing hypothermia than those admitted at a younger age (AOR = 0.45, 95% CI: 0.25, 0.81). As shown in Table 6, neonates delivered preterm were four times more likely to develop hypothermia (AOR = 4.30, 95% CI: 1.73, 10.69). Neonates born at Butajira General Hospital were four times more likely to develop hypothermia compared to those born at home (AOR = 4.04,95, 95% CI: 1.28, 12.75).

Table 5: Bivariate and multivariate logistic regression analysis of factors associated with hypothermia, Butajira General Hospital, Central Ethiopia Region, Ethiopia, Sept 2020 - August 2022

Variable	COR (95% CI)	AOR (95% CI)	P Value
Low birth weight	4.13(1.76, 9.67)	3.23 (1.35, 7.83)	0.001*
Congenital anomaly	4.74(1.88, 11.93)	3.62 (1.38, 9.47)	0.002*
Age at admission	0.83 (0.64, 1.08)	0.45, (0.25, 0.81)	0.010*
Preterm	4.36(1.76, 10.80)	4.30, (1.73, 10.69)	0.001*
Hypoglycemia	4.52(2.51, 8.10)	3.32 (1.67, 6.59)	0.001*
Place of delivery	5.48(1.84, 16.2	4.04 (1.28, 12.75)	0.009*
Respiratory Distress Syndrome (RDS)	1.79(0.80, 3.99)	1.34(0.57, 3.12)	0.50
PNA	2.84(0.94, 8.60)	2.26(0.73, 7.03)	0.16
APGAR Score	0.60(0.37, 0.97)	0.66(0.40, 1.09)	0.11

Discussion

Over the study period, among 1,390 neonatal admissions from September 2020 to August 2022, 189(13.6%) were deceased. More than half (59.3%) of the mothers of the deceased neonates were from rural areas. In our study, 87.3% of the neonates were admitted during the immediate neonatal period. Among the deceased neonates, 32.3% had known normal birth weight, and 37% were born at term. Sepsis, low birth weight, and respiratory distress syndrome were the most common diagnoses that were included in the admission diagnosis of the deceased neonates.

The study reveals a high incidence of neonatal hypothermia among deceased neonates at Butajira General Hospital's NICU from September 2020 to August 2022. This prevalence far surpasses that observed in studies from various other countries, such as Kenya (17.5%)(18), Northern Uganda (51%)(19), Tanzania (22.4%) (20), Malawi (74%)(21), Nepal and India (11-92%)(11), Bangladesh (34%) (22) and Iran (53.3%) (23). Studies conducted in Ethiopia

have reported lower prevalence rates: Addis Ababa (64%)(14), Bahir Dar (Northern-Ethiopia) (67%) (24), Harrar (Eastern-Ethiopia) (66.3%) (25) and Gonder (Northwestern-Ethiopia) (69.8%) (12), emphasizing the persistent and critical nature of this issue in similar environments. It is important to note that factors such as sample size, temperature measuring sites, research settings (community and health institutions), different study periods, and socio-economic and cultural variations can potentially contribute to discrepancies in the results(13).

The majority (76.2%) of the deceased neonates were delivered via spontaneous vaginal delivery which could make neonates vulnerable to hypothermia if warm chain is not maintained. Moreover, 79.4% of the deceased neonates were admitted after having been delivered at Butajira General Hospital. 14.8% of the deceased neonates were born to mothers who had obstetric complications during delivery, which could lead to diversion of attention to the mother and, hence, inadequate attention being given to the neonate.

Our data shows that neonates who had low birth weight were three times more likely to develop hypothermia, reflecting the increased vulnerability of these groups, likely due to their greater surface area relative to body weight (26,27). This association is consistent with findings from a systematic review conducted in East Africa, which reported that low birth weight neonates were 1.33 to 8.51 times more likely to be hypothermic compared to normal birth weight newborns (13). These findings are further supported by studies from Gondar (Northwestern-Ethiopia), South-West Ethiopia (Jinka and Arba Minch), Uganda, Nigeria, Nepal, and Pakistan (12,16,19,27–29). Similar results were observed in a study from Nepal, where the association became stronger the lower the birth weight(29).

Our study found a significant association between preterm delivery and hypothermia, with preterm neonates being four times more likely to develop hypothermia than neonates born at term. This aligns with observations from a study conducted in Harrar (Eastern-Ethiopia), where preterm newborns were found to be 3.4 times more likely to experience hypothermia compared to term neonates(25). Similar trends were also reported in studies from Dessie (Northern-Ethiopia) (2.6 times) and Addis Ababa (Ethiopia) (4.8 times) (14,30). Several factors contribute to this increased vulnerability among preterm neonates, including their high surface area to body weight ratio and immature skin deficient in keratin, creating risks for evaporative heat loss. In addition, limited ability to generate heat, lack of insulating subcutaneous fat, and relative inability to vasoconstrict also play a part in heat loss(26,31).

A significant association was found between age at admission and hypothermia. Neonates admitted at a later age were 55% less likely to develop hypothermia than neonates admitted in the early neonatal period. These findings

align with studies from Addis Ababa, where neonates ≤ 24 hours old were twice as likely to develop hypothermia compared to those older than 24 hours(14), and from Nigeria, where hypothermia incidence was highest (72.4%) among neonates < 24 hours old and lowest among those > 168 hours old (35.3%)(32). This could be due to the maturation of the adaptive mechanisms that the body develops after birth.

According to our study, deceased neonates with hypoglycemia were three times more likely to develop hypothermia.. A study by Nurussen et al. done at St. Paul's Millennium Medical College showed a similar pattern, with hypoglycemia identified as an independent predictor of neonatal hypothermia(33). Another study done in Harar, Eastern Ethiopia, showed that the prevalence of hypothermia was among the highest among neonates who had hypoglycemia(25). This could be explained by physiologically reduced energy available for thermogenesis and reduced metabolic activity. In addition, this could be worsened by poor feeding of ill neonates,

Our study found that there was a significant association between congenital anomaly and hypothermia. Neonates with congenital anomalies were three times more likely to develop hypothermia than neonates without any malformations. Although there is not much evidence that compares hypothermia with congenital anomaly, impaired thermoregulation, associated low birth weight, prematurity, and a higher possibility of extended resuscitation could play a role in this association. In addition, this association calls for further studies to be done on this association.

In addition, this study showed that there was a significant association between the place of delivery and hypothermia. Neonates who were delivered at Butajira General Hospital (inborns) were four times more likely to develop hypothermia than neonates born at other places. This is in contrary to the study conducted at Dessie Referral Hospital, where delivery outside of the hospital, where the study was based, was six times associated with hypothermia (AOR=6.84) than those born inside the hospital (30). This could be explained by the open-air transportation of neonates from the delivery room to the NICU due to the setup of the hospital. The NICU and the delivery room of Butajira General Hospital are approximately 30 meters apart in an open-air environment, indicating a need for interventions to prevent hypothermia among newborns. Respiratory distress syndrome, perinatal asphyxia, and APGAR score were not significantly associated with hypothermia in our study.

Conclusion

Our findings demonstrate a high prevalence of neonatal hypothermia among deceased neonates at Butajira General Hospital's NICU. Although causality cannot be definitively established between hypothermia and neonatal death in our study, the strength of the associations between the independent variables and

hypothermia justifies enhanced preventive efforts. Optimizing the temperature in the NICU and minimizing the distance from the delivery room to the NICU could be helpful methods in the prevention of hypothermia. Preterm delivery and low birth weight could be partly prevented through more frequent ANC contacts of high-risk mothers before delivery. Implementing meticulous thermal care based on WHO's warm chain guidelines, particularly for high-risk neonates, could substantially reduce neonatal mortality in similar low-resource settings. More frequent feeding of ill neonates and strict blood glucose level follow-up at the NICU could prevent hypoglycemia.

Limitations of the Study

Even though data was collected over two years, the small sample size and the nature of the population under investigation (neonatal deaths) may limit the generalizability of the findings. Since the study population consisted of deceased neonates, we cannot conclude that neonatal mortality is attributable to hypothermia.

Abbreviations

ANC: Antenatal Care

AOR: Adjusted Odds Ratio

APGAR: Appearance, Pulse, Grimace, Activity, Respiration

BW: Birth Weight

CI: Confidence Interval

CS: Cesarean Section

CPR: Cardiopulmonary Resuscitation

ENBC: Essential Newborn Care

LBW: Low Birth Weight

MAS: Meconium Aspiration Syndrome

NICU: Neonatal Intensive Care Unit

NBW: Normal Birth Weight

RDS: Respiratory Distress Syndrome

SDG: Sustainable Development Goal

SVD: Spontaneous Vaginal Delivery

VLBW: Very Low Birth Weight

WHO: World Health Organization

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Availability of Data and Materials

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Authors' Contributions

AMH, the corresponding author, contributed to the conception and design of the study, analyzed and interpreted the results, and drafted the manuscript. LMM, AM, and AD: contributed to the conception, study design, and data interpretation and critically revised the manuscript. MS contributed to the study design, trained and supervised the data collectors, and critically revised the manuscript. FAG

participated in data interpretation and writing the manuscript. All authors read and approved the manuscript for publication.

Competing Interests

The authors declare that they have no competing interests.

Ethical consideration

Ethical clearance and approval were obtained from the ethical committee of Addis Ababa University with reference number 016/20/pedi. An official letter was submitted to Butajira General Hospital, and permission was granted to conduct the study.

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