International Journal of Contemporary Pediatrics
*Oluwafemi RO et al. Int J Contemp Pediatr. 2026 Jul;13(7):1049-1056*
https://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20261891

**Original Research Article**

# Neonatal hypothermia in a tertiary health facility in Ondo state: prevalence, outcomes and way forward

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**Received:** 29 April 2026
**Accepted:** 08 June 2026

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## ABSTRACT

**Background:** Hypothermia, by the World Health Organization (WHO) is defined as a core temperature of less than 36.5$^0$C. It is one of the neonatal emergencies which increases morbidity and mortality in the newborn period if not resolved quickly. The study sets out to determine the prevalence, associated factors, outcomes and possibly proffer solution to the problems.
**Methods:** This was a prospective study in which all babies admitted into the Special Care Baby Unit (SCBU) in the University of Medical Sciences Teaching Hospital, Akure were monitored for hypothermia over a nine-month period.
**Results:** A total of 145 neonates were admitted over the study period. The overall prevalence of hypothermia was 51.7%, with preterm neonates significantly more affected than term neonates (59.3% vs 46.5%, p=0.02). Moderate hypothermia was more common among preterm neonates while mild hypothermia predominated among term neonates. Radiant warmer use was the most common form of thermal care (80.0%), while skin-to-skin care was utilized in only 3.4% of cases. Time of delivery (p=0.011) and low Apgar score (p=0.042) were significantly associated with hypothermia. The overall mortality was 4.1%.
**Conclusions:** Neonatal hypothermia was prevalent in over half of admitted neonates, with prematurity, low Apgar score, and time of delivery and mode of delivery as significant risk factors. Strengthening thermal care practices, particularly skin-to-skin care utilization and consistent delivery room protocols, remains essential to reducing hypothermia related neonatal morbidity and mortality in this setting.

**Keywords:** Hypothermia, Neonates, Outcomes, Way forward

## INTRODUCTION

The newborn baby generally behaves like a poikilothermic individual in which the baby takes on the environmental temperature. The WHO defines neonatal hypothermia as core body temperature of less than 36.5$^0$C.[1] Normal rectal temperature in term and preterm infants is 36.5$^0$C to 37.5° C, however, cold stress may occur at lower temperatures whenever heat loss requires an increase in metabolic heat production. Hypothermia can increase the morbidity and mortality in the newborn period if not resolved quickly. [2] It is indeed a global problem that occurs in neonates born both at hospitals (32%-85% of babies) and homes (incidence range from 11%-92%), but the problem is commoner in developing countries (>90%).[1,3]

### *Pathophysiology of neonatal hypothermia*

Thermal equilibrium can generally be dictated by relative humidity, exposure, air flow, direct contact with cool surfaces, closeness to cold objects, and environmental air temperature. Neonates are prone to rapid heat loss with consequent hypothermia because

they have higher surface area to volume ratio. This is worse in low-birth-weight neonates. The neonates loose heat by many ways:[8]

*Radiation*

When the bare skin of the baby is exposed to an environment that contains objects of cooler temperature, the baby becomes cold.

*Evaporation*

This happens when the baby loses heat because wet amniotic fluid on the baby's body is left uncleaned.

*Conduction*

The baby loses heat by conduction when placed in contact with a cold surface or object.

*Convection*

Baby loses heat by convection when a flow of cold ambient air carries heat away from the neonate.

Prolonged, unrecognized cold stress may divert calories to produce heat, and this leads to weight loss. Neonates have a metabolic response to cooling that involves chemical (non-shivering) thermogenesis by sympathetic nerve discharge of norepinephrine in the brown fat. The brown fat is located in the nape of the neck, between the scapulae, and around the kidneys and adrenals, it responds by lipolysis followed by oxidation or re-esterification of the fatty acids that are released. These reactions produce heat locally, and a rich blood supply to the brown fat helps transfer this heat to the rest of the neonate's body. This reaction increases the metabolic rate and oxygen consumption two to three folds. Therefore, in preterm neonates who present with respiratory insufficiency cold stress may also result in tissue hypoxia and neurologic damage. Activation of glycogen stores can cause transient hyperglycemia and when hypothermia persists, hypoglycemia and metabolic acidosis are resultant effects with consequent increased risk of late onset sepsis and mortality. Despite described compensatory mechanisms, neonates, particularly low-birth-weight babies, have limited capacity to thermoregulate and are prone to decreased core temperature. This happens even before temperature drops and this is reason that, in most developed climes, incubator is used to provide the thermoneutral environment for baby to prevent hypothermia.

The thermoneutral environment is the optimal temperature zone for neonates; it is defined as the environmental temperature at which metabolic demands (and thus caloric expenditure) to maintain body temperature in the normal range (36.5 to 37.5° C rectal) are lowest.

***Etiology of neonatal hypothermia***

Risk factors for neonatal hypothermia include prematurity, low birth weight, environmental factors such as unpreparedness for delivery, delivery in inappropriate places, decreased subcutaneous fat, immature and transparent skin, high body water content, immature metabolic mechanism, altered skin blood flow, sepsis, perinatal asphyxia needing prolonged resuscitation and low environmental temperature are other common risk factors.[1]

***Classification of hypothermia***

Hypothermia can be classified as mild ($36^0$C to $36.4^0$C), moderate ($32^0$C to $35.9^0$C) or severe ($<32^0$C).[6]

***Aim***

The study sets out to determine the prevalence, associated factors, outcomes and possibly proffer solution to the problems.

## METHODS

This was a hospital based prospective documentation of the medical records of all neonatal admissions in the Neonatal Intensive care unit (NICU) of the University of Medical Sciences Teaching Hospital, Akure, Ondo State, Nigeria from January to September, 2023. The hospital is a referral centre for all other private hospitals, primary and secondary government hospitals in Ondo State and ally communities. The hospital provides specialized care in areas of medicine, surgery, paediatrics, obstetrics and gynaecological services. The neonatal ward is a level III NICU which has a capacity for 20 admissions and receives babies from the labour ward and the operating theatre of the hospital.

***Patient recruitment***

Medical records of all consecutive neonatal admissions into the NICU over a nine-month period were documented in the excel sheet and reviewed. All categories of babies of all gestational ages were included while babies with congenital anomalies were excluded.

Body temperature records are part of the normal routine vital signs in the NICU. Hypothermia was defined as temperature $<36.5^0$C and the babies were categorized into three: mild hypothermia (36.0-$36.4^0$C), moderate hypothermia (32.0-$35.9^0$C) and severe hypothermia ($<32.0^0$C). Other relevant data such as gestational age, birth weight, age at admission, gender, indication for admission, mode of delivery, care the baby received at birth (resuscitation and how baby was kept warm), time of the day when baby was delivered, APGAR scores at 1 and 5 minutes, age at first feeding, other vital signs like heart rate, respiratory rate, blood oxygen saturation ($SpO_2$) and other co-morbidities were all documented.

Mothers' data such as age, parity, occupation and level of education, were also obtained and entered into the excel sheet.

***Data analysis***

Data were exported from the Microsoft-excel spreadsheet into the statistical package for social sciences (SPSS) version 25.0 for analysis. Descriptive statistics such as mean, standard deviation and percentages were done as appropriate, $p<0.05$ was taken as significant.

## RESULTS

Table 1 showed clinical characteristics of babies, 132/145 (91.1%) were admitted within 24 hours of delivery and 13/145 (8.9%) were admitted after 24 hours of delivery. Seventy-five (51.7%) were male children and 70/145 (48.3%) were female children. Two babies (1.4%) were extremely preterm with weight of less than 1,000 gm, 10 (6.9%) were very preterm with weight ranging between 1,000 to 1,499 gm, 5 (3.4%) were moderately preterm with weight range between 1,500 and 2,499 gm while 42 (29.0%) were late preterm. A total of 59/145 (40.7%) neonates were preterm babies and 86/145 (59.3%) were full term babies with weight range between 2,500 to 4,000 gm and above. Sixty-five (44.8%) were delivered by spontaneous vertex delivery while 80 (55.2%) were delivered by c-section, 135/145 (93.1%) were born by Christian parents and 10/145 parents (6.9%) practice Islam. The 139 (95.9%) babies survived and were successfully discharged home while 6/145 (4.1%) died.

Table 2 showed the characteristics of the mothers of the babies, 76/145 (52.5%) had 1 or 2 previous births (children), 63/145 (43.4%) had 3/4 previous births and 6/145 (4.1%) had five or more previous births. Ninety-nine mothers (68.3%) were booked (registered) and attended antenatal clinics regularly in the facility while 46/145 (31.7%) were not registered and did not attend antenatal clinic in the facility. Five (3.4%) of the mothers were less than 20 years of age, 54/145 (37.3%) were within the age range of 20-29 years, 78/145 (53.8%) were in the age range of 30-39 years and 8/145 (5.5%) were 40 years and above.

Table 3 showed that 35/59 (59.3%) of the preterm babies were hypothermic, 40/86 (46.5%) of the term babies were hypothermic and the prevalence of hypothermia among the preterm neonates was significantly higher than among the term neonates ($p=0.02$). The overall prevalence of hypothermia in this NICU was therefore 75/145 (51.7%).

Table 4 revealed that out of the children who had mild hypothermia, 15/42 (35.7%) were preterm babies and 27/42 (64.3%) were term neonates. Of the children who had moderate hypothermia, 20/33 (60.6%) were preterm babies while 13/33 (39.4%) were term babies. Sixty babies had normal temperature; of which 20/60 (33.3%) were preterm and 40/60 (66.7%) term babies ($X^2=4.91$; $p=0.018$). Ten babies had hyperthermia; of which 4/10 (40.0%) preterm and 6/10 (60.0%) were term babies.

Table 5 showed the risk factors for hypothermia among the neonates. One hundred and sixteen babies (80.0%) were cared for under the radiant warmer, 24 (16.6%) were wrapped in clothes and 5 (3.4%) had skin-to-skin care, radiant warmer care was significantly higher among the babies ($X^2=6.83$; $p=0.02$). Seventy-seven (53.1%) of the babies were delivered in the morning, 33 (22.8%) were delivered in the afternoon and 35 (24.1%) were delivered in the evening ($X^2=9.23$; $p=0.011$). Seventeen (11.7%) had APGAR score ≤3, 26 (18.0%) had APGAR score of 4-5, 12 (8.2%) had APGAR score of 6-7 and 90 (62.1%) had APGAR score of >7 ($X^2=7.45$; $p=0.042$).

**Table 1: Clinical characteristics of study participants (n=145).**

| Variables | N | Percentage (%) |
|---|---|---|
| **Age at admission (in hours)** | | |
| <24 | 132 | 91.1 |
| ≥24 | 13 | 8.9 |
| **Gender** | | |
| Male | 75 | 51.7 |
| female | 70 | 48.3 |
| **Gestational age (in weeks)** | | |
| Extremely preterm (<28) | 2 | 1.4 |
| Very preterm (28 to <32) | 10 | 6.9 |
| Moderately preterm (32 to <34) | 5 | 3.4 |
| Late preterm (34 to 36 +6 days) | 42 | 29.0 |
| Term baby (≥37 weeks) | 86 | 59.3 |
| **Birth weight (gm)** | | |
| <1000 | 2 | 1.4 |
| 1000-1499 | 10 | 6.9 |

Continued.

| Variables | N | Percentage (%) |
|---|---|---|
| 1,500-2499 | 45 | 31.0 |
| 2500-3999 | 84 | 57.9 |
| ≥4000 | 4 | 2.8 |
| **Mode of delivery** | | |
| SVD | 65 | 44.8 |
| Caesarean section | 80 | 55.2 |
| **Religion** | | |
| Christianity | 135 | 93.1 |
| Islam | 10 | 6.9 |
| **Outcomes** | | |
| Alive | 139 | 95.9 |
| Dead | 6 | 4.1 |

**Table 2: Characteristics of mothers of the study participants.**

| Variables | N | Percentage (%) |
|---|---|---|
| **Parity** | | |
| P1-2 | 76 | 52.5 |
| P3-4 | 63 | 43.4 |
| P≥5 | 6 | 4.1 |
| **ANC booking status** | | |
| Booked | 99 | 68.3 |
| Unbooked | 46 | 31.7 |
| **Age (in years)** | | |
| <20 | 5 | 3.4 |
| 20-29 | 54 | 37.3 |
| 30-39 | 78 | 53.8 |
| ≥40 | 8 | 5.5 |

*P=Parity-number of deliveries (babies) the mother has, P1-2-one to two previous deliveries, P3-4-three to four previous deliveries, p≥5- five or more previous deliveries and ANC: antenatal.

**Table 3: Prevalence of hypothermia among the participants in relation to gestational age.**

| Gestational age (in weeks) | Hypothermic, N (%) | Non-hypothermic, N (%) | Total, N (%) | $X^2$ | P value |
|---|---|---|---|---|---|
| **Preterm** | 35 (59.3) | 24 (40.7) | 59 (100.0) | | |
| **Term** | 40 (46.5) | 46 (53.5) | 86 (100.0) | 5.51 | 0.02 |
| **Total** | 75 (51.7) | 70 (48.3) | 145 (100.0) | | |

**Table 4: Degree of hypothermia among the participants.**

| Degree of hypothermia | Preterm, N (%) | Term, N (%) | Row total, N (%) | $X^2$ | P value |
|---|---|---|---|---|---|
| **Mild** | 15 (35.7) | 27 (64.3) | 42 (100.0) | | |
| **Moderate** | 20 (60.6) | 13 (39.4) | 33 (100.0) | | |
| **Normal temp** | 20 (33.3) | 40 (66.7) | 60 (100.0) | 4.91 | 0.018 |
| **Hyperthermia** | 4 (40.0) | 6 (60.0) | 10 (100.0) | | |
| **Column total** | 59 (40.7) | 86 (59.3) | 145 (100.0) | | |

**Table 5: Risk factors for hypothermia.**

| Variables | N | Percentage (%) | $X^2$ | P value |
|---|---|---|---|---|
| **Care babies received at birth**: | | | | |
| Skin-to-skin care | 5 | 3.4 | | |
| Radiant warmer | 116 | 80.0 | 6.83 | 0.021 |
| wrapped | 24 | 16.6 | | |
| **Time of delivery** | | | | |
| Morning | 77 | 53.1 | | 0.011 |
| Afternoon | 33 | 22.8 | 9.23 | |
| Night | 35 | 24.1 | | |

Continued.

| Variables | N | Percentage (%) | $X^2$ | P value |
|---|---|---|---|---|
| **APGAR score** | | | | |
| ≤3 | 17 | 11.7 | 7.45 | 0.042 |
| 4-5 | 26 | 18.0 | | |
| 6-7 | 12 | 8.2 | | |
| >7 | 90 | 62.1 | | |

*APGAR score of ≤3=severe asphyxia, APGAR of 4-5=moderate asphyxia, APGAR of 6-7=mild asphyxia and APGAR of >7=normal

## DISCUSSION

### *Clinical-demographic factors*

A total of one hundred and forty-five babies were cared for in the in-born section of the NICU of the hospital over the nine-month period; January to September, 2023. The frequency of males and females were evenly distributed with a male: female ratio of approximately 1:1. The overall prevalence of prematurity during this period of study was high (40.7%) with extreme prematurity constituting 1.4%, very preterm neonates constituted 6.9% of total, moderate preterm were 3.4% while late preterm constituted 29.0% of total. The highest contributor to prematurity was late preterm while the other babies were full term. The caesarean section rate was close to those delivered by spontaneous vaginal delivery, probably because our center is a referral center taking in all kinds of complicated cases from other hospitals in the town and allied states.

### *Prevalence of hypothermia*

There was a high prevalence of hypothermia in this study (51.7%) and this corroborates the findings of a systematic review of the global burden of neonatal hypothermia.[2] It is also consistent with the pooled prevalence reported by Ruan et al in a recent systematic review and meta-analysis of 18 studies involving 44,532 neonates across 13 countries.[6] However, the figure in the present study is lower than reported prevalence by Ogunlesi et al from Sagamu, Nigeria, a tertiary hospital in Gondar, Ethiopia, and the pooled East African prevalence documented by Beletew et al.[7-9] Conversely, the prevalence is higher than the reported one from a tertiary hospital in Jos, Nigeria.[10] The variation in prevalence across these studies likely reflects differences in gestational age distribution, facility-level thermal care practices, local climatic conditions, and the specific definitions and time points used to ascertain hypothermia. In the present study, the incidence of mild hypothermia was significantly higher among term babies while moderate hypothermia was significantly higher among the preterm babies. The proportion of babies who had normal temperature was also significantly higher among the term neonates however; there were no cases of severe hypothermia in either group of neonates.

The high prevalence of hypothermia recorded in this study, despite the setting being a well-equipped level III NICU in a university teaching hospital, reinforces the longstanding observation that neonatal hypothermia in sub-Saharan Africa remains prevalent even in facilities with modern infrastructure, and continues to be under-recognized and inadequately prevented.[11] Brambilla Pisoni et al further corroborated this, noting that in sub-Saharan Africa, a combination of inadequate awareness among health workers and a shortage of appropriate thermal devices continues to drive high hypothermia rates, even in hospital settings.[12]

### *Risk factors for hypothermia*

#### *Gestational age*

Preterm neonates had a significantly higher prevalence of hypothermia compared to term neonates. This finding is consistent with the well-established physiological vulnerability of preterm neonates to heat loss, arising from their higher surface area-to-volume ratio, reduced subcutaneous fat, and immature brown adipose tissue thermogenic capacity.[1,3] Sanni et al in a multicentre prospective cohort study of preterm infants admitted to four tertiary hospitals in Northern Nigeria, similarly demonstrated that prematurity was among the strongest predictors of hypothermia at admission.[13] Bayih et al reported that preterm neonates were more likely to be hypothermic than term neonates, a finding in line with the present results.[14]

Among neonates with hypothermia, moderate hypothermia was more common among preterm neonates compared to term neonates, while mild hypothermia was more frequent among term neonates. This observation reflects the more severe thermoregulatory impairment seen with increasing prematurity, as previously noted by Ogunlesi et al who observed that low birth weight and extreme prematurity were independently associated with deeper degrees of hypothermia.[7] There were no cases of severe hypothermia in both term and preterm in this study, which may reflect the benefit of NICU based care with radiant warmers as well as early admission of neonates to the unit.

#### *Care at birth*

Radiant warmer use was significantly the most common form of thermal care provided at birth. However, only a small percentage of neonates received skin-to-skin care (SSC). This low rate of SSC utilization is of concern, as there is substantial evidence that SSC is an effective, low-cost intervention for maintaining normal body temperature, particularly in resource-limited settings. Bayih et al found that neonates not placed in skin-to-skin

contact after delivery were more likely to be hypothermic.[14] Similarly, Ruan et al identified absence of skin-to-skin contact as one of the key independent risk factors for neonatal hypothermia across multiple studies.[6]

For clinically unstable neonates, skin-to-skin care may not always be feasible. In such cases, the WHO recommends the use of radiant warmers or incubators as the primary alternative.[15] Kyokan et al in a rapid review of warming devices for low-resource settings, confirmed that radiant warmers provide effective thermal protection in the delivery room and NICU, particularly for neonates of borderline stability.[16] The predominant use of radiant warmers in the present NICU is therefore appropriate for the clinical severity of the admitted population. However, the very low uptake of SSC, even among clinically stable neonates, suggests an opportunity to increase its utilization. A randomized controlled trial by Lode-Kolz et al. demonstrated that immediate SSC in very preterm neonates (28-32 weeks) was associated with stable thermoregulation and a reduced risk of hyperthermia compared to incubator care.[17]

*Time of delivery*

The majority of deliveries in this study occurred in the morning, with the remainder distributed between afternoon and night. The time of delivery was a statistically significant risk factor for hypothermia. Hypothermia occurring during afternoon and night deliveries may partly reflect reduced nursing vigilance, lower staffing levels, and cooler ambient temperatures in the unit during those periods, as has been observed in other low-resource NICU settings.[1,8] A study in Addis Ababa identified night-time delivery as an independent predictor of hypothermia, stating this to reduced preparedness and fewer available staff to implement thermal care measures promptly.[18] The finding in this study reinforces the need for consistent thermal care protocols regardless of time of delivery, with particular attention to staffing adequacy and delivery room preparation during night shifts.

*Mode of delivery*

The caesarean section rate in this study was higher than the national rate but consistent with the expected case-mix of a tertiary referral centre. Neonates born by caesarean section are at particular risk of developing hypothermia compared to those born vaginally, primarily because operating theatre environments tend to be cooler, spinal or general anaesthesia impairs maternal thermoregulation with consequent neonatal effects, and skin-to-skin contact is less readily initiated in the theatre setting.[19,20] A study from a tertiary hospital in South Africa, found that neonates born by caesarean section were hypothermic at birth, with most accounted for by mild cases and few by moderate hypothermia.[20] The high caesarean section rate in the present study, combined with the high hypothermia prevalence, is consistent with these observations and warrants attention to temperature management protocols in the operative delivery setting.

*Perinatal asphyxia and Apgar score*

Apgar score was a statistically significant risk factor for hypothermia in this study. Seventeen neonates had a 1-minute Apgar score of ≤3, indicating severe asphyxia, and 26 had scores of 4-5, indicating moderate asphyxia. Perinatal asphyxia predisposes to hypothermia through several mechanisms: the need for prolonged resuscitation exposes the neonate to the ambient environment, muscular hypotonia reduces heat generation, and altered skin blood flow impairs peripheral thermoregulation.[1,3] In the systematic review by Ruan et al low Apgar score and asphyxiation requiring resuscitation were among the most consistently identified risk factors for neonatal hypothermia across the included studies.[6] Furthermore, a meta-analysis by an Ethiopian group found that neonates with a 5-minute Apgar score of less than 7 were more likely to be hypothermic than those with a score of ≥7.[18] The co-occurrence of asphyxia and hypothermia is clinically significant, as both conditions exacerbate tissue hypoxia, metabolic acidosis, and the risk of late-onset sepsis, as detailed in the pathophysiology section of this paper.[1]

***Outcomes***

The mortality rate in this study was less than five percent. This is lower than the mortality reported among hypothermic neonates at a Kenyan referral hospital, and substantially lower than the hypothermia-associated mortality rates described in community-based studies conducted among hospitalized populations in sub-Saharan Africa.[9,21] The relatively low mortality in this study may reflect the positive effect of NICU-level thermal management with radiant warmers, early admission in the majority of neonates, and the availability of supportive care within a tertiary institution. It may also reflect the absence of severe hypothermia cases in this cohort, as the severity of hypothermia is strongly correlated with mortality risk. Previous studies have reported that each 1°C decrement in body temperature increases mortality risk by a significant percentage.[9] Conversely, Nyandiko et al found that absence of admission hypothermia increased the likelihood of neonatal survival more than twentyfold.[21]

## CONCLUSION

Neonatal hypothermia was prevalent in more than half of the admitted neonates. Strengthening thermal care practices, particularly skin-to-skin care utilization and consistent delivery room protocols would help to reduce prevalence of hypothermia related neonatal morbidity and mortality in this setting.

The high prevalence of neonatal hypothermia in this study, despite being a tertiary setting, calls for urgent

action at multiple levels. A thermoregulatory care package aimed at pre-warming of resuscitation surfaces, routine temperature monitoring at birth and NICU admission, and a clear management protocol for hypothermia should be implemented across all delivery points, with particular attention to the operating theatre. This package should be implemented across all shifts given the significant association between timing of deliveries and hypothermia. The critically low uptake of SSC must be addressed through active promotion among clinically stable neonates. Regular staff training on thermal care should be institutionalized, and temperature monitoring should be adopted as a routine quality indicator reviewed at clinical meetings. A multi-centre study across the region is recommended to generate broader evidence and drive a coordinated response to this preventable cause of neonatal morbidity and mortality.

*Funding: No funding sources*
*Conflict of interest: None declared*
*Ethical approval: The study was approved by the Institutional Ethics Committee*

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**Cite this article as:** Oluwafemi RO, Ray EO, Adeleye OJ, Oluwafemi TM. Neonatal hypothermia in a tertiary health facility in Ondo state: prevalence, outcomes and way forward. Int J Contemp Pediatr 2026;13:1049-56.