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NEWBORN THERMOREGULATION: A COMPREHENSIVE REVIEW

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ABSTRACT

Introduction: Thermoregulation is a critical physiological function in newborns and is essential for survival and optimal growth during the early neonatal period. Newborns, particularly preterm and low-birth-weight infants, are highly vulnerable to temperature instability due to anatomical and physiological immaturity. Inadequate thermal control can lead to serious complications, including hypoglycaemia, respiratory distress, metabolic acidosis, and increased neonatal morbidity and mortality. ***Methods:*** This study was conducted as a narrative review of the literature focusing on neonatal thermoregulation. Relevant studies were identified through electronic databases, including PubMed, Google Scholar, Scopus, and publications from international health organizations. Research articles, randomized controlled trials, systematic reviews, and guidelines addressing neonatal thermal regulation and thermal care practices were included. ***Results:*** The findings indicate that neonatal hypothermia remains a common and significant problem worldwide, particularly in resource-limited settings. Evidence consistently demonstrates that simple, evidence-based interventions such as immediate drying after birth, early and continuous skin-to-skin contact, delayed bathing, maintenance of warm environmental temperatures, and appropriate use of warming devices are effective in maintaining thermal stability. Kangaroo Mother Care was identified as a highly effective and practical intervention for preventing hypothermia and improving neonatal outcomes. ***Conclusion:*** Effective thermoregulation is a cornerstone of essential newborn care. Strengthening adherence to evidence-based thermal protection practices, including routine temperature monitoring and promotion of Kangaroo Mother Care, can substantially reduce preventable neonatal morbidity and mortality.

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INTRODUCTION

Thermoregulation is a critical physiological function in newborns and is essential for survival and optimal growth during the early neonatal period. Unlike adults, newborns—particularly preterm and low-birth-weight (LBW) infants have a limited capacity to maintain body temperature due to immature thermoregulatory mechanisms (Knobel, R. B., *et al* 2007; Blackburn, S. T. 2018). Several anatomical and physiological factors contribute to this vulnerability, including a high body surface area–to–weight ratio, thin skin, limited subcutaneous fat, an underdeveloped skin barrier, reduced vasomotor control, and an inability to shiver effectively. Consequently, newborns depend primarily on non-shivering thermogenesis, mainly through the metabolism of brown adipose tissue, to generate heat (Hull, D. 1966; Symonds, M. E., *et al.* 2015). At birth, the neonate experiences a sudden transition from the warm intrauterine environment, maintained at approximately 37 °C, to a comparatively cooler external environment. This abrupt exposure places the newborn at immediate risk of cold stress and hypothermia. Heat loss occurs rapidly through four primary mechanisms—evaporation, conduction, convection, and radiation with evaporative heat loss being particularly significant immediately after birth due to wet skin (WHO, 1997; Cloherty, J. P., *et al* 2023). Because newborns have limited physiological reserves, even minor heat losses can result in increased oxygen consumption and glucose utilization, leading to metabolic acidosis, hypoglycaemia, respiratory distress, and increased morbidity and mortality. Thermoregulatory immaturity is especially pronounced in preterm and LBW infants. These infants possess thinner skin, minimal subcutaneous fat, reduced brown adipose tissue, and inadequate metabolic reserves, all of which compromise their ability to maintain thermal stability. Impaired central nervous system regulation and immature vasomotor responses further reduce their capacity to conserve or generate heat, making them highly susceptible to both hypothermia and hyperthermia during the early neonatal period. Neonatal thermal stability is defined as the maintenance of a core body temperature between 36.5 °C and 37.4 °C (World Health Organization [WHO], 1997, 2013). Stability within this range supports optimal physiological functioning, energy conservation, and reduced risk of complications. Globally, an estimated 20 million infants are born each year weighing less than 2500 g, placing a substantial proportion of newborns at increased risk of temperature instability (Blencowe, H. *et al*. 2019; World Health Organization 2014). Hypothermia alone has been shown to contribute significantly to neonatal mortality, with studies indicating a marked increase in

death risk for every degree decrease in body temperature. Although less common, hyperthermia can also be harmful and may result from dehydration, infection, environmental overheating, or inappropriate use of warming devices, leading to increased metabolic demand and potential neurological injury. Effective thermoregulation in newborns depends on a combination of intrinsic physiological adaptations and appropriate external thermal care practices. Evidence-based interventions such as immediate drying after birth, early and continuous skin-to-skin contact through Kangaroo Mother Care (KMC), delayed bathing, maintenance of warm delivery-room temperatures, appropriate clothing and bedding, and the use of incubators or radiant warmers play a vital role in maintaining normothermia. Kangaroo Mother Care, in particular,provides physiological warming through thermal synchrony, reduces all four mechanisms of heat loss, enhances non-shivering thermogenesis, and has been shown to significantly reduce the incidence of hypothermia while offering additional benefits such as improved breastfeeding, reduced infection rates, and enhanced maternal–infant bonding. Despite the availability of clear guidelines and proven interventions, gaps persist in the consistent implementation of thermal protection practices, particularly in resource-limited settings. Given the strong association between temperature instability and adverse neonatal outcomes, maintaining a neutral thermal environment remains a fundamental component of essential newborn care. Strengthening adherence to evidence-based thermoregulatory practices is therefore crucial to improving neonatal survival and reducing preventable morbidity and mortality.

MATERIALS AND METHODS

Study Design: This study was conducted as a narrative review of the literature to synthesize existing evidence on thermoregulation in newborns, including physiological mechanisms, risk factors for thermal instability, disorders of thermoregulation, preventive strategies, Kangaroo Mother Care, and current international recommendations for thermal protection.

Data Sources: A comprehensive literature search was performed using the following electronic databases:

- PubMed
- Google Scholar
- Scopus
- World Health Organization (WHO) publications and guideline repositories

In addition, reference lists of relevant articles were manually searched to identify additional pertinent studies.

Search Strategy: The literature search was carried out using combinations of the following keywords and Medical Subject Headings (MeSH):

- Newborn thermoregulation
- Neonatal hypothermia
- Neonatal hyperthermia
- Low birth weight infants
- Preterm infants
- Thermoneutral environment
- Kangaroo Mother Care
- Skin-to-skin contact
- WHO warm chain

Boolean operators (AND, OR) were applied to refine the search.

Eligibility Criteria

Inclusion criteria:

- Studies published in English
- Research articles, randomized controlled trials, observational studies, systematic reviews, and WHO guidelines
- Studies focusing on term, preterm, and low-birth-weight newborns
- Literature addressing neonatal thermoregulation, hypothermia, hyperthermia, thermal care practices, and Kangaroo Mother Care

Exclusion criteria

- Studies involving older infants or children beyond the neonatal period
- Animal studies (except where referenced for physiological explanation)
- Articles with insufficient methodological detail or relevance

Study Selection

Titles and abstracts were screened for relevance. Full texts of potentially eligible studies were reviewed to confirm inclusion. Priority was given to high-quality studies, randomized controlled trials, and internationally recognized guidelines, particularly those issued by the World Health Organization.

Data Extraction and Synthesis: Data were extracted manually and synthesized descriptively under thematic domains including mechanisms of heat loss, thermoneutral environment, Kangaroo Mother Care, monitoring techniques, and preventive strategies.

RESULTS

Overall Findings: Across national and international studies, Kangaroo Mother Care consistently demonstrated a strong protective effect against neonatal hypothermia and improved thermoregulation in both term and preterm newborns.

Comparison of Studies Within Countries

India and Other Low- and Middle-Income Countries (LMICs)

Studies conducted in India and other LMICs reported a high prevalence of neonatal hypothermia**,** particularlyduring the first hours after birth. Facility-based studies showed hypothermia rates ranging from 60% to 85**%,** while community-based and home-birth studies reported rates as high as 90–92**%,** even in tropical climates (Kumar *et al*., 2009; Lunze & Hamer, 2012; Bang *et al*., 2005). Kumar *et al*. (2009) describe high prevalence of neonatal hypothermia widely reported from warmer high-mortality regions of Africa and South Asia**,** consistent with the above prevalence ranges. Admission hypothermia was strongly associated with increased mortality, respiratory distress, Indian and African studies consistently demonstrated a dose–response relationship between body temperature and mortality. A decrease of 1 °C in admission temperature was associated with an approximate 28% increase in the risk of death**,** particularly among infants weighing between 500 g and 1500 g (Laptook, *et al*. 2007; Mullany, L. C., *et al*. 2010). Similar findings were reported from Nepal, Guinea-Bissau, Nigeria, and other sub-Saharan African countries, where hypothermia was linked to a 5- to 10-fold increase in neonatal mortality**.** Within-country studies also highlighted gaps in thermal care practices, including inadequate delivery-room temperatures, delayed drying, early bathing, separation of mother and baby, and inconsistent use of skin-to-skin contact. Kangaroo Mother Care (KMC) trials conducted in LMICs consistently showed significant reductions in hypothermia (up to 90%)**,** improved glucose stability, better cardiorespiratory parameters, and reduced infection rates compared with incubator care (Conde-Agudelo, *et al*. 2016; Charpak, N., *et al*. 2005).

Comparison of Studies at the Global Level: Globally, an estimated 20 million infants are born each year with a birth weight below 2500 g, placing a substantial proportion of newborns at risk of thermal instability. Systematic reviews and multi country analyses confirmed that neonatal hypothermia contributes to approximately 40% of

neonatal deaths worldwide, either as a direct cause or a significant contributing factor. Global evidence from randomized controlled trials, systematic reviews, and multi country studies consistently supports the effectiveness of KMC and early skin-to-skin contact in maintaining neonatal thermal stability**.** A landmark randomized trial comparing KMC with incubator care among infants weighing 1200–2199 g demonstrated that the risk of hypothermia was reduced by approximately 90% in the KMC group. Similar results were observed in studies involving extremely preterm and VLBW infants, including those requiring respiratory support.

Systematic reviews and meta-analyses conducted across Asia, Africa, and Latin America confirmed that KMC:

- Maintains core and axillary temperature within the thermoneutral range
- Reduces hypothermia-related mortality
- Lowers metabolic stress and oxygen consumption
- Provides thermal stability comparable to or better than incubators in stable infants.

Global studies also emphasized the concept of thermal synchrony**,** whereby the caregiver's chest temperature dynamically adjusts to the infant's needs, offering a physiological advantage over static heat sources such as radiant warmers (Ludington-Hoe, S. M., *et al*. 2004; Bergman, N. J., *et al* 2004). Based on this strong global evidence, international guidelines—particularly those issued by the World Health Organization—now recommend immediate and continuous KMC**,** including for small and preterm newborns, as a standard thermal protection strategy [WHO] 2019, 2022).

DISCUSSION

The findings of this review highlight that effective thermoregulation is a cornerstone of essential newborn care and a critical determinant of neonatal survival, particularly for preterm and low-birth-weight infants. Newborns are physiologically predisposed to thermal instability, and failure to maintain normothermia can result in serious metabolic, respiratory, neurological, and infectious complications. Simple, evidence-based interventions—such as immediate drying, early and continuous skin-to-skin contact, delayed bathing, appropriate clothing, and warm ambient environments—are highly effective in preventing temperature instability. Kangaroo Mother Care offers a safe, physiologically adaptive, and cost-effective strategy for maintaining thermal stability, especially in low-resource settings. Strengthening adherence to WHO-recommended thermal protection practices through education, policy support, and routine temperature monitoring can substantially reduce preventable neonatal morbidity and mortality and improve both short- and long-term health outcomes.

CONCLUSIONS

Thermoregulation is a fundamental component of essential newborn care and is critical for neonatal survival, particularly among preterm and low-birth-weight infants who have immature thermoregulatory mechanisms. This review highlights that neonatal hypothermia remains a common and preventable problem and is strongly associated with increased morbidity and mortality, especially in low- and middle-income countries. Evidence supports simple, low-cost thermal care practices such as immediate drying, early and continuous skin-to-skin contact, delayed bathing, maintenance of a warm environment, and regular temperature monitoring. Kangaroo Mother Care is a highly effective strategy for maintaining thermal stability while also improving breastfeeding, reducing infections, and strengthening maternal–infant bonding.

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Authors' Contributions

KK conceptualized the study, conducted the literature search and review, synthesized and analyzed the data, and drafted and finalized the manuscript. The author approved the final version of the manuscript and takes full responsibility for its content.

Conflict of Interest: The author declares no conflict of interest.

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