

Safe and Effective Thermal Protection for Inpatient Care of Newborns

DO NO HARM TECHNICAL BRIEF

Neonatal thermal stability, defined as the maintenance of a constant body temperature within the physiologically acceptable range of 36.5–37.4°C is essential for newborns to survive and thrive.

Why is Thermal Protection Important?

Each year more than 20 million infants are born less than 2500 g at birth.¹ These low birth weight (LBW) infants comprise both small infants born near term as well as premature infants born less than 37 weeks gestational age. These babies have impaired abilities to regulate temperature and are especially vulnerable to both hypo- or hyperthermia both in facilities and in the household setting. Early temperature support is an important aspect of newborn care as hypothermia and hyperthermia are associated with increased mortality and poor outcomes.

What is hypo- and hyperthermia and how frequently do they occur?

Neonatal hypothermia is defined as a temperature less than 36.5°C. All newborns are vulnerable to hypothermia, particularly in the first hours after birth. Although limited, data from low resource settings suggests hypothermia occurs in up to 85% of newborns admitted to medical facilities and as many as 92% of home births, even in tropical settings.²

Hypothermia is strongly correlated with an increased risk of mortality, contributing to an estimated 40% of neonatal deaths.³ The odds of mortality have been estimated to increase 28% for every 1°C decrease in admission temperature among infants weighing between 500 g and 1500 g at birth.⁴ Studies from Africa and Asia report between 5-fold and 10-fold increases in mortality among hypothermic neonates.^{5,6} Hypothermia has also been associated with impaired growth and infections.⁷

Neonatal hypothermia may delay the transition from intrauterine to extra-uterine life, and is associated with complications including a need for respiratory support, hypoglycemia, hypotension, intraventricular hemorrhage, and late onset sepsis. Cold stress lowers arterial oxygen tension and increases metabolic acidosis. Subsequent attempts at heat production leads to increased oxygen and glucose demands for infants with already impaired oxygen delivery and limited glucose stores. The exceedingly high prevalence of hypothermia is understood in the context of usual practices after birth that can lead to massive heat loss of the newborn, such as not drying the infant, leaving the infant without appropriate cover, shortening the duration of or not initiating skin-to-skin contact (SSC), and delaying or not initiating breastfeeding. Sick and small babies require continuous contact with a heat source such as SSC or radiant heater and temperature monitoring.

Neonatal hyperthermia is defined as a body temperature greater than 37.5°C in a newborn. Newborns experiencing a cardiac arrest in the first 48 hours of life are particularly prone to hyperthermia and poor outcomes.⁹ The prevalence of hyperthermia is largely unknown as it is infrequently reported in the literature. One Nigerian study reported 35% of infants hospitalized in special care baby units experienced a hyperthermic event and were more likely to be associated with mortality.⁸

Elevated temperature may arise from intrinsic causes (infection, inflammation, dehydration, etc.) or extrinsic causes (environmental). Among newborns presenting with hyperthermia, less than 10% have culture-proven sepsis.¹⁰ Dehydration is a common cause of elevated body temperature in the newborn. Neonatal hyperthermia increases the metabolic rate and the rate of water loss through evaporation, which may lead to dehydration. Animal studies report that hyperthermia can be associated with a progression of cerebral injury.¹¹

External causes of hyperthermia in the newborn include an environment that is too warm, such as if the baby is exposed to excessive heat from the sun or radiant heater, or if the baby is wrapped in too many layers. Poorly regulated or managed equipment (i.e. incubators, radiant warmers) are additional risk factors for hyperthermia. Elevated maternal temperature during labor from maternal infection or epidural response can lead to hyperthermia in a newborn at time of birth. Infants born to febrile mothers have a higher incidence of respiratory depression, neonatal seizures, cerebral palsy and early mortality.

What are the clinical principles of thermal stability?

While all newborns require some level of intervention to help them maintain a normal temperature range of 36.5–37.4°C, known as the thermo-neutral zone, preterm and LBW newborns require more specialized care and monitoring to maintain this same temperature range.

The first 12-72 hours of life affords the highest likelihood of developing hypothermia or hyperthermia. The risk of falling out of the thermal safe zone is highest for LBW and preterm newborns.



EVERY
PREEMIE
SCALE



USAID
FROM THE AMERICAN PEOPLE



 **gapps**
GLOBAL ALLIANCE TO PREVENT
PREMATURITY AND STILLBIRTH


**AMERICAN COLLEGE
of NURSE-MIDWIVES**
With women, for a lifetime®

The high surface-area-to-body-mass ratio of LBW newborns makes them especially susceptible to heat loss (see Box 1).⁷ Additionally, LBW and premature infants lack adequate brown fat supply which serves as a major source of heat production for newborns and develops in the last weeks of pregnancy. The lack of brown fat, combined with a reduced ability to generate heat through mechanisms such as shivering or altering body position to maintain heat, as well as a poor ability to feed, result in LBW infants requiring additional support for thermoregulation.

These thermoregulatory vulnerabilities have triggered the introduction of thermal protection devices to maintain a neonatal thermo-neutral environment during inpatient care of LBW and sick infants. Poor understanding of the importance of thermal stability among health care providers, combined with an inadequate capacity to operate thermal protection devices safely and improper monitoring of newborn temperature within health care facilities may lead to harm via iatrogenic hypo- or hyperthermia in newborns. Adequate thermal protection is a critical component of newborn care to promote weight gain and growth in the newborn.

Despite the profound impact that thermal stability has on improving newborn health indicators, safe and effective thermal control measures are relatively neglected interventions during inpatient newborn care in many low resource settings. Fortunately, these are relatively simple, low cost interventions.

What are the current WHO recommendations for thermal stability?

The 2015 WHO recommendations on interventions to improve preterm birth outcomes for thermal care of newborns are focused on the use of SSC/kangaroo mother care (KMC) for the routine care of newborns weighing 2000 g or less at birth. These newborns should receive as close to continuous SSC/KMC as possible, and use of intermittent SSC/KMC when continuous care is not feasible.¹² Unstable newborns should be cared for in a thermo-neutral environment utilizing radiant warmers or incubators.¹²

The WHO has created a practical guide on thermal protection of the newborn centered on utilization of a warm chain (discussed in the best practices section) at birth and in the first days of life.⁷ WHO recommends a sequence of routine care practices immediately after birth for all newborns to prevent hypothermia and hyperthermia: drying the baby thoroughly, removing any wet cloths, SSC, early and exclusive breastfeeding, and monitoring of temperature in the first 24 hours.¹³ Bathing should be delayed to after 24 hours of birth. If this is not possible due to cultural reasons, bathing should be delayed for at least 6 hours.¹⁴ In addition, the WHO offers guidance on keeping the healthy newborn warm with clothing appropriate for ambient temperature, generally 1-2 layers more than for adults and a hat.¹⁴

What is the evidence for thermal protection interventions?

The majority of evidence on hypothermia prevention is based on a common intervention of SSC. Use of SSC among preterm and LBW infants has been associated with a 23% to 33% reduction in mortality.^{15,16} SSC was also associated with significant reductions in hypothermia, nosocomial infections, neonatal sepsis, hypoglycemia, length of hospital stay, as well as increases in breastfeeding, oxygen saturation, attachment, and infant growth.

Immediate drying of infants following birth is essential care of

all newborns [WHO Essential Newborn Care]. A study from Nepal reported 85% of infants cared for without drying had temperatures < 36°C at 2 hours after birth, and 50% were hypothermic at 24 hours following birth. Following immediate drying and wrapping, the number of hypothermic infants dropped dramatically to 38% at 2 hours and 18% at 24 hours.¹⁷

Delaying the first bath at least 24 hours is also recommended by WHO.¹⁴ A randomized, controlled trial in Uganda found babies who were bathed within an hour of birth were nearly three times more likely to have hypothermia at 70 minutes of age and nearly four times more likely to have hypothermia at 90 minutes of age compared to newborns who were not bathed within an hour of life.¹⁸

Finally, the use of plastic bags and wraps has been studied for hypothermia prevention immediately following birth, usually in combination with radiant warmers or chemical warming mattresses for the care of extremely preterm infants. There is insufficient evidence on the effectiveness of plastic bags/wraps in providing thermal care for preterm newborns immediately after birth.^{12,14} The WHO does support the use of plastic wraps in limited circumstances such as during stabilization and transport of preterm newborns if alternative methods are unavailable.

Thermal protection practices during facility newborn care



Harmful Practices Best Practices

Room temperature too warm or too cool
Maintain a warm delivery room (~25°C)

Leaving the infant wet following delivery or leaving a wet cloth in contact with the infant

Dry the newborn immediately upon delivery with a clean, dry cloth and remove the wet cloth

Unnecessary exposure of the infant to being weighed, immunized, etc. until better thermoregulation is established

Maintain skin-to-skin contact with the mother

Delayed initiation of breastfeeding

Initiate breastfeeding within an hour of birth

Early bathing shortly after delivery

Wait to bathe the infant until more than 24 hours following birth, dry immediately

Inappropriate wrapping – too few or too many layers

Dress and wrap infants appropriately

Placing newborn in direct sun exposure or placing near windows with cool draft

If a warm room is not available, use appropriate locations where ambient temperatures are less extreme

Newborn alone or under a radiant warmer

Maintain as close to continuous SSC as possible

Newborn unmonitored under a radiant warmer or in an isolette, warming mattress, etc.

Monitor temperature frequently when using warming technologies

Use of cool IV fluids

Use of room temperature IV fluids

Unheated/non-humidified oxygen and air

Use heated/humidified oxygen and air

Newborn under phototherapy undressed and without appropriate heat source or with unmonitored heat source

During medical intervention (i.e. phototherapy) use appropriate technologies to keep infant normothermic

Thermally unprotected transportation

Provide warmth during transportation including SSC/KMC

What are the current evidence-based best practices?

Avoidance of hypothermia during inpatient newborn care

Thermal protection of the newborn can be achieved with a 'warm chain', a set of 10 interlinked procedures implemented at the time of birth and during the subsequent hours and days to keep infants in the safe temperature range (36.5–37.4°C).⁷ (Box 1)

Box 1: Steps to Avoid Hypothermia - the Newborn Warm Chain

- 1 Warm delivery room** with a temperature of at least 25°C.
- 2 Immediate drying** of the newborn upon delivery while the cord is still attached.
- 3 Skin-to-skin contact.** The newborn should be placed on the mother's chest immediately following delivery and covered by a dry warmed cloth. Continuous SSC should be practiced for low birth weight and premature infants.
- 4 Support early initiation of breastfeeding** within an hour of birth. The baby should be allowed to feed as frequently and for as long as she or he desires throughout the neonatal period. Careful attention should be paid to the newborn's ability to breastfeed and where necessary, alternative support should be provided to ensure adequate human milk feeding.
- 5 Bathing and weighing** should be postponed for at least several hours. Keep the newborn wrapped during weighing and subtract the weight of the covers. For bathing wait a minimum of 24 hours following birth. Bathe the newborn in a warm room using warm water, followed by rapid drying.
- 6 Appropriate clothing/bedding.** This should always include a cap because as much as 25% of heat loss in the newborn occurs from an uncovered head. Clothing can be warmed in front of a heat source, or warmed by being tucked inside garments of caregivers if there or no other exogenous heat sources.
- 7 Keep the mother and baby together** promoting continuous SSC as much as possible.
- 8 Warm transportation.** If the newborn needs to be transferred to a different location, do so using SSC.
- 9 Warm resuscitation.** If the newborn requires resuscitation, dry thoroughly first, cover the head, and ensure the baby is wrapped in a warm blanket as soon as possible after successful resuscitation. Use a radiant heater with caution if resuscitation is prolonged.
- 10 Raise awareness of and train** all levels of health care providers on each step of the Newborn Warm Chain.

Avoidance of hyperthermia

Prevention of hypothermia during clinical care has overshadowed that of prevention of hyperthermia and application of heat sources could contribute to the incidence of hyperthermia. Inappropriate use of incubators

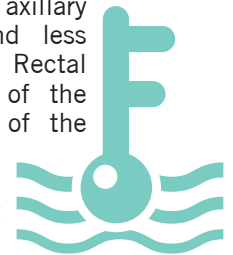
and radiant warmers are common causes of neonatal hyperthermia. Makeshift apparatuses such as light bulbs, hot stones, and hot water bottles for thermal protection should be discouraged in favor of SSC. The following practices may decrease the occurrence of hyperthermia. (Box 2)

Box 2: Steps to Avoid Hyperthermia

- 1** Monitoring for autoregulation signals by the baby such as flushed red skin or fast breathing.
- 2** Periodic temperature monitoring for seriously ill infants (every hour), small infants < 2500 g (2 to 4 times/day), and stable infants who are progressing well (daily).
- 3** SSC provides a thermal protective environment and promotes breastfeeding on demand that maximizes the opportunity for the newborn to remain hydrated.
- 4** Careful use of external heat sources (radiant warmers, incubators, heated water bottles, etc.) that often lack a mechanism for temperature monitoring.
- 5** Maintain only one newborn per cot. Multiple newborns placed together on the same cot to share one radiant warmer result in some infants getting too much heat and others not enough.

Temperature monitoring in the newborn

Newborn temperature monitoring using the axillary temperature is reasonably accurate and less invasive than rectal temperatures. Rectal temperatures are discouraged because of the associated discomfort and disturbance of the newborn, but also because of the rare but serious risks of rectal perforation and vaginal stimulation with resulting arrhythmias, bradycardia and apnea.



The WHO recommends frequent temperature monitoring among the following populations: seriously ill infants (every hour), small infants < 2500 g (2 to 4 times/day), and stable infants who are progressing well (daily).

Thermal protection for unstable newborns after delivery, stabilization and extended care

Newborns less than 32 weeks gestation may require a combination of interventions to maintain temperature: SSC, radiant warmer or incubator, increased room temperature of 25°C, polyethylene wrapping without drying, cap, thermal mattress, and warmed humidified oxygen or room air.

What are the health system requirements for thermal stability?

National health policies along with an implementation strategy to promote thermal stability are essential. Within health facilities, the infrastructure to provide reliable power supply, clean and running water, and appropriate space and staffing levels are fundamental to ensuring safe and effective newborn care. Procurement decisions regarding medical devices impact a facility's ability to provide quality newborn care.

What program actions can be taken to improve thermal stability and health outcomes?

National standards for thermal control should be developed and supported with training materials. Incorporating the principles of thermal protection into the curricula of medical, nursing, and midwifery schools will aid in routine standardized thermal protection practices. Utilizing the participation of existing staff to develop and implement thermal protection policies at individual institutions will likely improve compliance. Involving the parent(s) directly in inpatient care, including extensive promotion of SSC, allows for essential training of basic skills and demonstrated competency in thermal protective measures that will continue at home.

Relevant health indicators for thermal care of newborns include the prevalence of hypothermia, hyperthermia and normothermia (e.g. having a temperature 36.5°C to 37.5°C). The admission temperature should be recorded as a predictor of outcomes as well as a quality indicator. One useful facility target would be to have over 90% of newborns be normothermic 2 hours after birth.

Actions at many levels within the health system are needed to assure thermal protection.

Policy Makers

- Regionalization of care with referral and transport to higher-level special newborn care
- Clinical guidelines for thermal stability
- Development of standards for thermal stability for various levels of the health system
- Development of staffing norms and requirements
- Development of strategies to ensure capital investments and ongoing financing
- Development of relevant health indicators for thermal care of newborns

Program Planners/Implementers

- Matching infrastructure needs to level of care provided
- Procurement planning that ensures a sustainable supply of diagnostics and related consumables
- Development of a supply chain management plan for thermoprotection devices, with potential plans for manufacturing capacity
- Provide written Operation and Maintenance Standard Procedures, including procurement plan for spare parts
- Incorporating the principles of thermal protection into the curricula of medical, nursing, and midwifery schools
- Capacity building plan for health care workers including pre-service and in-service needs

Facility Managers/Administrators

- Infrastructure and maintenance support for thermostability
- Procurement of equipment and supplies specific for thermoprotection of neonates (radiant warmers, temperature monitors, oxygen heaters/humidifiers)
- Adequate human resources to provide care and monitoring
- Utilizing the participation of existing staff to develop and implement policies

Health Care Providers (Physicians, Nurses, Midwives, Ancillary Staff)

- Increasing awareness of the extreme vulnerability of newborns to both hypo- and hyperthermia that requires vigilance about the environment and monitoring
- Providing excellent neonatal care that continually incorporates thermal protection measures
- Involving the parent(s) directly in inpatient care, including extensive promotion of skin-to-skin contact, that allows for essential training of basic skills and demonstrated competency in thermal protective measures that will continue at home

Acknowledgements

The Do No Harm Technical Series was prepared by a team led by James A. Litch (Every Preemie—SCALE/Global Alliance to Prevent Prematurity and Stillbirth), Judith Robb-McCord (Every Preemie—SCALE/Project Concern International) and Lily Kak (USAID). We would like to acknowledge the development of the draft by James A. Litch and Laura Sangare (Every Preemie/Global Alliance to Prevent Prematurity and Stillbirth) and Krystle Perez (Univ. of Washington). Expert reviews were provided by Carole Kenner (Council of International Neonatal Nurses), Judith Robb-McCord (Every Preemie/Project Concern International), Nils Bergman (Karolinska Institute), Bina Valsangkar (Save the Children), Sufang Guo (Unicef), Lily Kak, Smita Kumar, Susan Niermeyer, and Pavani Ram (USAID), and Ornella Lincetto (WHO).

References

- 1 WHO. Care of the preterm and/or low-birth-weight newborn. Geneva: World Health Organization. http://www.who.int/maternal_child_adolescent/topics/newborn/care_of_preterm/en/ (accessed on May 24, 2017).
- 2 Lunze K, Bloom DE, Jamison DT, Hamer DH. The global burden of neonatal hypothermia: systematic review of a major challenge for newborn survival. *BMC Med* 2013; 11:24.
- 3 Lunze K, Hamer DH. Thermal protection of the newborn in resource-limited environments. *J Perinatol* 2012; 32(5): 317-24.
- 4 Laptook AR, Salhab W, Bhaskar B. Admission temperature of low birth weight infants: predictors and associated morbidities. *Pediatrics* 2007; 119: e643-49.
- 5 Sodemann M, Nielsen J, Veirum J, Jakobsen MS, Biai S, Aaby P. Hypothermia of newborns is associated with excess mortality in the first 2 months of life in Guinea-Bissau, West Africa. *Trop Med Int Health* 2008; 13(8): 980-86
- 6 Mullany LC, Katz J, Khatry SK, LeClerq SC, Darmstadt GL, Tielsch JM. Risk of mortality associated with neonatal hypothermia in southern Nepal. *Arch Pediatr Adolesc Med* 2010; 164(7): 650-56.
- 7 WHO. Safe Motherhood. Thermal protection of the newborn: A practical guide. Geneva: World Health Organization, 1997. http://www.who.int/maternal_child_adolescent/documents/ws42097th/en/
- 8 Amadi HO, Olateju EK, Alabi P, Kawuwa MB, Ibadin MO, Osibogun AO. Neonatal hyperthermia and thermal stress in low- and middle-income countries: a hidden cause of death in extremely low-birthweight neonates. *Paediatr Int Child Health* 2015; 35(3): 273-81.
- 9 Nolan JP, Soar J, Cariou A, Cronberg T, Moulart VR, Deakin CD, et al. European Resuscitation Council and European Society of Intensive Care Medicine Guidelines for Post-resuscitation Care 2015: Section 5 of the European Resuscitation Council Guidelines for Resuscitation 2015. *Resuscitation* 2015; 95: 202-22.
- 10 Baumgart S. Iatrogenic hyperthermia and hypothermia in the neonate. *Clin Perinatol* 2008; 35: 183-97, ix-x.
- 11 Wyllie J, Bruinenberg J, Roehr CC, Rudiger M, Trivisanuto D, Urlesberger. European Resuscitation Council Guidelines for Resuscitation 2015: Section 7, Resuscitation and support of transition of babies at birth. *Resuscitation* 2015; 95: 249-63.
- 12 World Health Organization. WHO recommendations on interventions to improve preterm birth outcomes. 2015. NLM classification: WQ 330. http://apps.who.int/iris/bit-stream/10665/183037/1/9789241508988_eng.pdf
- 13 WHO. Pregnancy, childbirth, postpartum and newborn care: A guide for essential practice, 3rd edition. Geneva: World Health Organization, 2015. <http://apps.who.int/iris/bit-stream/10665/249580/1/9789241549356-eng.pdf?ua=1>
- 14 WHO recommendations on newborn health: guidelines approved by the WHO Guidelines Review Committee. Geneva: World Health Organization; 2017 (WHO/MCA/17.07). <http://apps.who.int/iris/bit-stream/handle/10665/259269/WHO-MCA-17.07-eng.pdf?sequence=1>
- 15 Boundy EO, Dastjerdi R, Spiegelman D, Fawzi WW, Missmer SA, Lieberman E, et al. Kangaroo Mother Care and Neonatal Outcomes: A Meta-analysis. *Pediatrics* 2016; 137(1).
- 16 Conde-Agudelo A, Diaz-Rossello JL. Kangaroo mother care to reduce morbidity and mortality in low birthweight infants. *Cochrane Database Syst Rev* 2014; 4: CD002771
- 17 Johanson RB, Spencer SA, Rolfe P, Jones P, Malla DS. Effect of post-delivery care on neonatal body temperature. *Acta Paediatr* 1992; 81(11): 859-63.
- 18 Bergstrom A, Byaruhanga R, Okong P. The impact of newborn bathing on the prevalence of neonatal hypothermia in Uganda: a randomized, controlled trial. *Acta Paediatr* 2005; 94(10): 1462-67.