



**NURSING GUIDELINES ON THE
CARE OF INFANTS WITH THERMOREGULATION INSTABILITY
3RD EDITION**


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1.0 Thermoregulation Overview

Introduction

Thermoregulation is a critical function which is closely linked to the survival of preterm infants, sick neonates and infants. Hypothermia has a direct relationship with mortality and morbidity, and is also an independent predictor of mortality i.e. 28% increase in mortality for each 1° C drop in temperature (Costello *et al.* 2000, Morehouse 2014). Heat loss will occur at between 0.1°C to 0.3°C, up to 1°C per minute in the newborn nursed in an inappropriate environment. Consequently, the nurse has a crucial role in limiting heat loss and providing the correct thermal environment. There is a responsibility to ensure that heat loss is minimised and that thermal conditions are stable for the infant, resulting in reduction in energy burnt, improved growth and lower oxygen requirements (Allen 2011). Monitoring accurate core and skin temperatures are vital. It is fundamental to understand the mechanisms of heat production and heat loss pertaining to the preterm infant. The nurse must also have a thorough knowledge of the equipment available and how to use it safely and appropriately (Fellows 2010, Turnbull and Petty 2013).


Definition of Thermoregulation

Neutral thermal environment has been defined as when the infants' temperature does not change, with a stable metabolic state and where minimal rates of oxygen consumption or energy expenditure occur (Knobel *et al.* 2007, Brown and Landers 2011). The recommended neutral thermal environment is best achieved when infants can maintain a core temperature at rest of between 36.5° and 37.5 °C (WHO 1997, Brown and Landers 2011, Altimier, 2012).

Indications for Assisted Thermoregulation

Normal body temperature symbolises the optimum thermal condition required to maintain internal body function. Thermoregulation provides a balance between heat generation and heat loss therefore maintaining normal body temperature. Thermoregulation is a vital body function, which is reflective of physiological maturity. The neonate (0-28 days old) has to instigate thermoregulation at birth. However, if born prematurely the physiological pathways have not yet fully developed to initiate this action. Furthermore sufficient reserves are not present in the premature infant to maintain thermal stability without compromising other body systems (Fellows 2010). Neonates are more prone to poor thermoregulation due to:

- Intrauterine temperature has been constant unlike the external environment
- High metabolic rate
- Large surface to body mass ratio
- Big head (25% heat loss)
- Reduced/poor insulation with lack of subcutaneous fat
- Permeable skin
- Immature hypothalamus, central nervous system, vasomotor control
- Limited shivering (neonates) and non-shivering response (preterm infants). Sick neonate and preterm infants are not well developed to produce heat.
- Reduced energy stores
- Dependent /communication difficulties
- Poor muscle tone and inability to position own body
- Inefficient sweat glands (van der Spek *et al.* 2009, TSCUH 2011).

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Infants Most at Risk

- Low Gestational Age (LGA)
- Extremely Low Birth Weight (ELBW) infants
- Cardio-respiratory, neurological and endocrine disease
- Congenital abnormalities, e.g. gastroschisis, exomphalos
- Sedation, muscle relaxation
- Hypoglycaemia
- LSCS delivery (in the immediate postnatal period)

Complications Associated with Thermo-Instability

Heat production takes place through oxidation of metabolic substrates (metabolism), non-shivering thermogenesis, muscle activity and vasoconstriction.

Excessive Heat Gain can lead to:

- Increased fluid loss
- Hyponatraemia
- Increased jaundice
- Recurrent apnoea / tachypnoea
- Tachycardia
- Increased neonatal mortality
- Flushed red skin / sweating / weak absent cry
- Irritability / lethargy (Brand and Boyd 2010).


Heat Loss takes place through conduction, convection, radiation and evaporation.

- **Conduction** accounts for **10-15%** of heat loss and occurs when objects are placed in contact with each other, e.g. a warm infant is placed on a cool surface. Heat is then transferred from one to the other i.e. cold x-ray plate, stethoscope or weighing scales.
- **Convection** involves heat loss due to the movement of air at the skin surface i.e. draughts, cool environmental temperature and open incubator ports. It is the second most common mode of heat loss in the preterm and term infant.
- **Radiation** is the transfer of heat energy from the exposed surface of the infant to the surrounding surfaces i.e. cold incubator walls. In the term infant it accounts for **60%** of heat loss.
- **Evaporation** is the insensible water loss from the skin surface and the respiratory mucosa. It accounts for **60%** of heat loss in the preterm infant (EOENBG, 2011, GOSH, 2014).

Excessive Heat Loss contributes in particular to:

- **Acidosis** due to metabolism of fatty acids and increased lactic acid accumulation.
- **Increased oxygen consumption** causing hypoxemia / hypoxia, desaturation due to anaerobic metabolism from pulmonary hypertension, also vasoconstriction and decreased delivery of oxygen to tissues.
- **Hypoglycaemia** due to increased metabolic rate, glucose utilization and depletion of glycogen stores (Knobel and Holditch-Davis 2007, Karlsen 2014).

REMEMBER allowing the infant to get cold and stay cold, even mild hypothermia / cold stress increases neonatal mortality and morbidity (Fellows 2010).

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“Preventing hypothermia is much easier than overcoming the detrimental effects of hypothermia, once they have occurred” (Karslen 2014: p. 73).

Hypothermia can also lead to:


- Impaired surfactant synthesis and efficiency
 - Tachypnoea resulting from an increased need for oxygen due to increased metabolism
 - Bradycardia due to hypoxia
 - Pale mottled skin due to poor perfusion and hypoxia
 - Cold extremities with poor perfusion from peripheral vasoconstriction which occurs as the infant tries to conserve heat
 - Poor feeding, with gastric distention or large aspirates / vomiting
 - Failure to gain weight or weight loss due to increased metabolism, non-shivering heat production and increase in consumption of calories.
 - Altered blood coagulopathy and risk of bleeding and thrombocytopenia
 - Increased risk of infection
 - Neurological damage due to hypoglycaemia
 - Restlessness, irritability, hypotonia and lethargy
 - Altered cerebral blood flow which may predispose to intraventricular haemorrhage
 - Hyperbilirubinemia and kernicterus
 - Acute renal failure as GFR declines due to poor perfusion
 - Necrotising enterocolitis
 - Increased metabolic rate
- (Hackman 2001, Sherman *et al.* 2006, Waldron and MacKinnon 2007, Brand and Boyd 2010, Morehouse *et al.* 2014).

Equipment Required for Thermoregulation

- Incubator / Radiant Warmers / Giraffe Omnibed
- Humidity
- Temperature monitoring device (Skin and Core)
- Clean linen

Scope of the Guidelines

Applies to all infants up to and < one year of life including preterms, neonates and all LBW infants <2.5kgs
For the purpose of this guideline a preterm is defined as an infant < 37/40 weeks gestation.
A neonate or term infant is an infant of 37/40 gestation until 28 days of life.

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2.0 Thermoregulation within Incubators

The neonatology consultants in OLCCH recommend that all infants < 2 kgs are nursed in an incubator in PICUs / ward areas.

Specific Equipment: Incubator +/- humidity depending on gestational age. Hat mittens, booties as indicated.

NB: Never turn off an incubator with the infant still inside. Always reduce incubator temperature. Opening portholes to cool incubator is ineffective as incubator only works harder to produce set heat.

ACTION	RATIONALE EVIDENCE and REFERENCE
<p>Incubator All preterm infants, low birth weight, or sick term neonates transferred to PICU are admitted into a pre-warmed incubator.</p> <p>It is preferable to keep preterm infants and low birth weight term/sick neonates in incubators whilst in the PICU environment and if < 2kgs within the ward areas.</p> <p>Provide explanation and give continued ongoing support to parents / guardians. Promote maternal and parental bonding.</p> <p>Prepare the incubator and preheat, in preparation for the infant</p> <p>Close all windows and doors and ensure privacy.</p> <p>Position incubator out of direct sunlight and away from radiator and ensure wheels are locked in position.</p> <p>Ensure the incubator is safely situated without obstruction from furniture / equipment and away from</p>	<p>Sick term infants and premature infants have difficulty in self-regulation of temperature. Incubators help reduce heat loss by conduction, radiation and secure heat gain. Incubators also help prevent cross infection, promote minimal handling, aid with noise reduction and enable close observation of the sick neonate (Fellows 2010).</p> <p>(O'Connor and Kelleher 2016)</p> <p>To increase parental confidence, autonomy and allow bonding to take place (Fellows, 2010; Trigg and Mohammed 2010).</p> <p>To prepare for the infants admission (Trigg and Mohammed 2010).</p> <p>To ensure the infant is placed in a warm environment and to prevent draughts and cold stress. Also to prevent heat loss due to convection (Trigg and Mohammed 2010, Dougherty and Lister 2015).</p> <p>To ensure the incubator / infant isn't subjected to temperature flux from the environment and to ensure health and safety issues are incorporated (Trigg and Mohammed 2010).</p> <p>To allow access to the infant from both sides of the Incubator in case of an emergency eg. resuscitation.</p>

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the walls so that both side doors can be freely let down to allow access to the infant by staff members.

The air temperature mode should be used to set the incubator pre-warmed to:

- **37°C- Preterm Infant**
- **35°C - Term Infant**

All probes to be attached should also be warming in the incubator.

Once the infant is placed in the incubator, the air temperature should then be reduced and set accordingly to maintain infant's temperature within a neutral thermal temperature, i.e. 36.5° - 37.5 °C. (Appendix 3).

The initial set incubator temperature is reduced in preparation for transfer to a cot.

Monitor core and peripheral temperatures continuously and document same i.e:

- PICU's in the preterm or LBW infant < 1.8kgs
- Intubated, unstable, inotrope dependent
- Until the infant no longer needs to be in an incubator and has successfully transferred to a cot. Infant is considered clinically stable with expected weight gain and on full feeds.

In exceptionally rare cases within ward areas, some sick neonate may require skin and core temperature and ECG monitoring, as per medical team.

As infant matures and becomes more stable 4 hourly clinical observation, assessment and documentation of core and peripheral temperature is acceptable within the PICU and ward areas. Core temperatures can be monitored age appropriately i.e. tempadot (single use).

Incubator temperature > infant temperature will secure heat gain and help to reduce heat loss by conduction and radiation. It will also ensure the incubator infant isn't subjected to temperature fluctuations from the environment and to ensure health and safety issues are incorporated. The term infant has a lower temperature set to avoid overheating the infant (St Mary's Hospital 2008, Trigg and Mohammed 2010, EOENBG 2011).


(EOENBG 2011)

Infants nursed in "air control mode" have a more stable thermo-regulated environment and less variance between core and peripheral temperatures (Boyd and Lenhart 1996).

To maintain the infant in a neutral thermal environment.

The infant becomes more mature, condition improves, is maintaining own temperature and ready to be dressed in preparation for transfer to cot.

To ensure early detection and timely intervention for temperature fluctuations (Fellows 2010). A temperature gradient >2 °C between skin (peripheral) and core may be an early indication of cold stress as the infant tries to minimise heat loss and should be investigated. Core temperatures which are measured from abdomen, or axilla whilst mainly accurate, may be subject to heat fluctuations from surrounding environment (Brand and Boyd 2010, Fellows 2010, Turnbull and Petty 2013).

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Peripheral temperatures can now be monitored via touch / feel i.e. 'warm to toes' and, 'warm to finger tips' method. The infant should have more frequent monitoring/ recording of core / peripheral temperatures if their condition becomes unstable / deteriorates as clinically indicated.

Close monitoring of central / peripheral temperature and incubator temperature is necessary when undertaking care of preterm infant and to interrupt if the neutral thermal environment is compromised.

Core temperature (while in PICU) should be monitored using:

- Skin temperature probe between mattress – skin (extrascapular) attached to a cardiac monitor
- Rectal temperatures should be avoided where possible, however they may be indicated (PICU ONLY), i.e.
 - Post cardiac surgery, meningococcal septicaemia, sepsis, cooling of infant to protect brain i.e. asphyxia. Where used, rectal temperature monitoring should be of short duration (< 24hrs) unless best practice indicates otherwise.

Peripheral temperature monitoring (while in PICU):

- Peripheral skin probe attached to sole of foot
- Used routinely for all premature infants and sick neonates.

Preterm infant's the core temperature should be maintained between 36.5 - 37.5 °C

Monitor and document incubator temperature hourly (PICU).

Incubator temperatures fall during care when portholes or incubator doors are open with subsequent drop in the preterm infant's / sick neonates central and peripheral temperature subjecting them to the risk of cold stress (Brand and Boyd 2010).

Probe between scapular and non-conducting mattress is very accurate (EOENBG 2011).

Rectal temperatures are extremely invasive and may be unreliable. A rectal temperature probe predisposes to rectal polyps and perforation (Fellows, 2010; Macqueen *et al.* 2012, Smith *et al.* 2013).

In the 1st 2-3 days of life the pre-term infant is poikilothermic i.e. adopts the temperature of the environment. He then develops the ability to peripherally vasoconstrict, shunting blood to the core when challenged thermally. Decreased peripheral temperature is also an early indication of cold stress and also poor perfusion (EOENBG, 2011; Brown and Launders 2011, Altimier 2012).

To help maintain temperature of the infant and reduce heat loss (British Columbia, 2003; EOENBG, 2011).

To observe the frequency of changes to the incubator temperature which may indicate that extra energy is being expended by the infant (GOSH 2008, EOENBG 2011, Macqueen *et al.* 2012).

2-4 hourly if the infant is clinically stable at ward level.

Hat, mittens and booties should be used for infants.

WHO Classification

Temperature	
36-36.4 °C	COLD STRESS Mild Hypothermia Cause for concern.
< 36.0 °C	Moderate Hypothermia Dangerous requires immediate warming of the infant.
< 32.0 °C	Severe Hypothermia Outlook grave, requires urgent skilled care.

Within the PICUs the temperature alarm limits on cardiac monitor should be tightly set, i.e. 0.2 °C above and below accepted parameters.

Oxygen/air gases should always be humidified and warmed.

The ventilator temperature probe sits inside the incubator and must be shielded from environmental flux by the use of heat reflective shield.

When infant has stabilised, dressing the infant fully is encouraged as clinically indicated.

The infants head has a large surface area in proportion to size and is vulnerable to heat loss (Knobel *et al.* 2009).

The core temperature of preterm infants may be allowed to rise to 37.5°C to maintain this difference (Knobel *et al.* 2009, Brown and Landers 2011).


This allows for early notification of fluctuations and rectifying of the problem. (WHO 1997, Brown and Landers 2011).

To assist in the early detection of temperature variations and potential complications of same (Blissinger and Annibale 2010, Trigg and Mohammed 2010).

This decreases insensible water and heat loss from respiratory tract. Endotracheal tubes bypass the natural humidification and filtering systems. Infant temp can ↓1°C when ventilator heater temp <34°C. Inadequate humidification of the preterm airway leads to changes in lung function, even after short periods (Doyle and Bradshaw 2012)

The gases may cool before reaching the infant, if the extension tubing is used as the heating wire only goes as far as the temperature probe.

Clothed infants feel more comfortable and require lower air temp (Bosque and Haverman 2009). The sick and/premature infant is less at risk of cold stress once stabilised but is still at risk (Fellows 2010). Insulating effect of dressing the infant can prevent heat loss. Infant when naked can drop their temperature, up to 3°C central and peripherally with handling and recovery can take up to 2 hours (Bosque and Haverman 2009).

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<p>Temperature monitoring should be continuous:</p> <ul style="list-style-type: none"> • PICU's • First few days after transfer to a cot if the infant is unfit for transfer to the ward. <p>Care should be taken when placing covers over incubators. .</p> <p>Items or electrical equipment should not be placed on the top or in the incubator</p> <p>Incubators should be changed weekly, and more frequently if soiled or if the infant is septic. Document any changes.</p>	<p>To ensure early detection and timely intervention for temperature fluctuations.</p> <p>Whilst this may minimise light to the infant it may also reduce visibility and mimic the day / night effect (Fielder and Moseley 2000, Lee <i>et al.</i> 2005). The nurse must be able to assess the infant's condition at all times.</p> <p>Placing the item (i.e. feeding bottles) on top of the incubator can be very noisy and cause undue stress for the infant (Reid and Freer 2003). NB: Noise created outside the incubator is amplified greatly inside the incubator.</p> <p>To minimise the risk of infection (OLCHC 2008). Evidence of practice and continuity of care (Macqueen, 2012, NMBI 2015).</p>
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3.0 Thermoregulation in Giraffe Omnibed (PICU and Children's Heart Center Only)

Giraffe OmniBed has two modes:


- Radiant Warmer
- Incubator

Specific Equipment Required: Giraffe Omnibed


Patient indicators

- Preterm <32wks <1.5kg priority
- Recommend <35wks < 2kgs


ACTION	RATIONALE EVIDENCE and REFERENCE
All preterm infants <1500grams should be admitted to a pre-warmed Giraffe OmniBed (where possible).	The Giraffe OmniBed is a radiant warmer that can be converted to an incubator, once the infant has been stabilised. This eliminates the stress of moving critically-ill infants from bed to bed. The mattress in the giraffe rotates facilitating proper positioning of the infant for all types of procedure without having to physically move the infant (GE Healthcare 2010).

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<p>Keep parents / guardians informed and explain all equipment as clinically indicated.</p> <p>On admission, infants should be nursed under the radiant warmer in servo mode.</p> <p>Servo mode should be utilised when used as radiant warmer instead of an incubator.</p> <p>Keep the sides of the warmer up where possible</p> <p>The Giraffe Omnibed can be used in radiant warmer for surgical procedures.</p> <p>The Giraffe OmniBed should be converted from radiant warmer to incubator mode once the infants' temperature has been stable for an hour and nursing cares / procedural interventions have been completed.</p> <p>Servo Mode Should be used for all critically ill infants who are nursed naked (nappy only) in an incubator.</p> <p>Once changed to incubator mode, humidity should be commenced as clinically indicated (Section 5).</p> <p>Air Mode Should only be used for the stable dressed infant nursed in an incubator as clinically indicated.</p>	<p>To reduce parental stress and provide support though the use of information (Trigg and Mohammed 2010).</p> <p>This mode allows stabilisation of the infant's temperature and facilitates examination and procedural interventions.</p> <p>To maintain the infants' temperature constant and prevent cold stress (Lyon 2004).</p> <p>To prevent the infant from falling from the Giraffe and maintain a warm environment by preventing unnecessary draughts (Trigg and Mohammed 2010)</p> <p>It is not necessary to move the infant into a radiant warmer for surgery, i.e. PDA ligation, laparotomy etc. Surgery can be performed in radiant warmer mode and then the giraffe omnibed can be converted back to an incubator once the procedure is complete and the patient is stable.</p> <p>Incubators provide a more stable temperature (thermal neutral environment) in comparison to radiant warmers and reduces the incidence of trans-epidermal water loss (TEWL). In newborn very extremely low birth weight (ELBW) preterm infants, evaporation of water from the skin is an important mode of fluid loss (Lyon 2004).</p> <p>This is to allow maintenance of a thermal neutral environment and easy conversion between radiant warmer and incubator in emergency situations without having to adjust settings thus preventing the infant from developing cold stress.</p> <p>Humidified warm air reduces TEWL and may decrease the infant's air temperature requirements. TEWL are high in the immature baby. The 26 week infant, on day 1 of life, can lose over 50 kilocalories / kg via evaporation compared with less than 5 kilocalories / kg in the term infant (Lyon 2004).</p> <p>Air mode can be adjusted by the nurse to maintain a stable body temperature in infants in accordance with the amount of clothing applied.</p>
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<p>During nursing care or procedural interventions the 'Boost Air Curtain' should be used (Appendix I).</p>	<p>This creates a strong blanket of air to serve as a barrier against cool air entry when a porthole or door is opened.</p>
<p>The infant should be placed directly on the linen covered mattress and surrounded by boundaries (nesting).</p>	<p>In accordance with recommended positioning for infants (Sweeney and Gutierrez 2002, Nair <i>et al.</i> 2003). The mattress in the Giraffe is a layered Pressure-Diffusing Mattress designed to help relieve pressure points and preserve skin integrity in the critically ill infant (GE Healthcare 2007a, 2007b).</p>
<p>All temperature probes should be checked at the start of every shift and an axilla temperature taken to check correlation of core temperature probe. -If the infant's core temperature changes > 0.5°C, an axilla temperature should be taken and the position of the servo probe checked.</p>	<p>Temperature probes can become detached from the infant secondary to environmental humidity in the incubator, skin moisture, nursing care or movement of the infant. Correlation of core temperature probe to axilla temperature is to ensure that the infant is not overheating due to incorrect temperature probe placement.</p>
<p>The Servo temperature probe should be positioned either on the infants:</p> <ul style="list-style-type: none"> • Middle of abdomen, if nursed supine • The flank of the back, if nursed prone. 	<p>If the probe is positioned on the abdomen when the infant is prone, a falsely high temperature may be recorded (Hockenberry <i>et al.</i> 2017).</p>
<p>Monitor core and peripheral temperatures continuously and document same i.e.:</p> <ul style="list-style-type: none"> • PICU's. in the preterm or LBW infant < 1.8kgs • Intubated, unstable, inotrope dependent • Until the infant no longer needs to be in an incubator and has successfully transferred to a cot. Infant is considered clinically stable with expected weight gain. 	<p>To ensure early detection and timely intervention for temperature fluctuations (Fellows 2010). A temperature gradient >2 °C between skin (peripheral) and core may be an early indication of cold stress as the infant tries to minimise heat loss and should be investigated. Core temperatures which are measured from abdomen, or axilla whilst mainly accurate, may be subject to heat fluctuations from surrounding environment (Fellows 2010).</p>
<p>Close monitoring of central / peripheral temperature and incubator temperature is necessary when undertaking care to preterm infant and to interrupt if the neutral thermal environment is compromised.</p>	<p>It has been reported that incubator temperatures fall during care when portholes or incubator doors are open with subsequent drop in the preterm infants / sick neonates central and peripheral temperature subjecting them to the risk of cold stress.</p>
<p>Monitor and document incubator temperature hourly.</p>	<p>To observe the frequency of changes to the incubator temperature which may indicate that extra energy is being expended by the infant (British Columbia 2003, EOENBG 2011, GOSH 2014).</p>

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<p>If the infant is stable and doesn't require humidity it should be dressed and nursed in air mode.</p> <p>Weigh infants using the in-bed scales when nursed in the Giraffe Omnibed.</p> <p>Phototherapy for infants nursed in the Giraffe Omnibed</p> <p>Hood Cover Used with preterm infants</p> <p>NB: The hood can be raised quickly should the infant's condition deteriorate / become unstable as clinically indicated.</p> <p>Remove Giraffe hood at the start of every shift as clinically indicated.</p> <p>Do not use the Giraffe hood initially during an acute admission until stable.</p> <p>Frequency of use should be reduced as the pre-term infant approaches term.</p> <p>Use at night and quiet time only once infants reaches term.</p> <p>Giraffe Omnibed should be changed weekly or more frequently if soiled or if the infant is septic.</p>	<p>Clothed infants feel more comfortable and require lower air temp (Bosque and Haverman 2009). The sick and/premature infant is less at risk of cold stress once stabilised but is still at risk (Fellows 2010). Insulating effect of dressing the infant can prevent heat loss. If naked can drop temp up to 3°C central and peripherally with handling, with recovery taking up to 2hrs (Bosque and Haverman 2009).</p> <p>This allows for weights to be taken and trended without removing the infant thus promoting minimal handling and preventing additional stress to the infant whilst allowing the nurse to evaluate weight gain/loss (GE Healthcare 2007c).</p> <p>Phototherapy can be administered using a bili blanket, overhead lights or the Spot PT Lite (Appendix 1).</p> <p>A hood cover may be used to minimise light stimulation for pre-term infants which increases infant's stability, respiratory instability, reduces heart rate, blood pressure, respiration rate, and motor activity (Fielder and Moseley 2000).</p> <p>To ensure timely access to the infant in an emergency.</p> <p>To allow a thorough examination of the infant.</p> <p>Hood covers can impede the close observation and visual monitoring of infants. The colour of the fabric can reflect off infants making it difficult to recognise a change in colour (Lee <i>et al.</i> 2005).</p> <p>To accustom them to light (Fielder and Mosely 2000).</p> <p>To allow infants distinguish between night and day (Fielder and Mosely 2000).</p> <p>To minimise infection risk (OLCHC 2008).</p>
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4.0 Thermoregulation in a Radiant Warmer (PICU only)

Specific Equipment Required: Radiant Warmer

ACTION	RATIONALE EVIDENCE and REFERENCE
<p>Nursing staff should familiarise themselves with the radiant heaters used within OLCHC by consulting the operator manual and taking direction from the technical support team within the PICUs. Bleep: 8465</p> <p>Explanation to parents/guardians as clinically indicated.</p> <p>Prepare the radiant warmer, in preparation for the infant on manual mode.</p> <p>Close all windows and doors.</p> <p>Ensure the radiant warmer is safely situated without obstruction from furniture / equipment etc. and that both side doors are free to open completely and allow access by staff members.</p> <p>Position Radiant warmer out of direct sunlight and away from radiator and ensure wheels are locked in position.</p> <p>When infants are admitted to PICU it is always preferable to nurse the infant in an incubator. However this may create challenges i.e.</p> <ul style="list-style-type: none"> • Ventilation: High Frequency Oscillation Ventilation (HFOV) • Gastroschisis silo bag (unrepaired gastroschisis) (Appendix 1). 	<p>To reduce anxiety and stress caused by hospitalisation (Trigg and Mohammed 2010).</p> <p>To ensure the infant is placed in a warm environment and to prevent cold stress.</p> <p>To keep the environment warm, draught free and also to prevent heat loss due to convection (Trigg and Mohammed 2010).</p> <p>To allow access to the infant in case of an emergency.</p> <p>To ensure the incubator/infant isn't subjected to temperature flux from the environment and to ensure health and safety issues are incorporated (Trigg and Mohammed 2010).</p> <p>Radiant warmers provide easier access to the critically ill infant. When procedures / investigations / surgery are required it can be prudent to nurse the infant in a radiant warmer. This, however, should be short term and the baby should be placed in a closed incubator as soon as possible.</p> <p>The Giraffe Incubator with radiant warmer option should be used in the preterm especially < 32 weeks gestation.</p> <p>Radiant heaters can subject neonates to increased trans epidermal water loss (TEWL) and possible electrolyte imbalance, variances in thermal stability,</p>

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<p>Admit the infant to a pre-warmed radiant warmer using the manual mode heated to 25% power.</p> <p>The manual mode, alarms every 12 minutes to alert the nurse to check the infant.</p> <p>All preterm infants and sick neonates nursed in PICU should be nursed in the Servo mode.</p> <p>When the infant has been transferred to the radiant warmer the infants should be nursed on:</p> <ul style="list-style-type: none"> • Air mattress • Radiant warmer mattress • Infants less than 30wks gestation gamgee may be used if thought appropriate on an individualised basis. Use of gamgee should be discontinued at 30 weeks unless otherwise indicated by consultant or neurodevelopment physiotherapist / individualised clinical indication. <p>The preterm infant < 31 weeks gestation will require humidity. Therefore, it is a priority that the infant is moved to a Giraffe incubator preferably or to a closed incubator as soon as possible.</p> <p>Ensure that the bedside panels are locked in position when the infant is in the warmer.</p> <p>Radiant warmers increase the infants' insensible water losses especially in the low birth weight infant compared to incubators. This water loss needs to be taken into account when daily fluid requirements are calculated i.e. increased by 10 -20 % as discussed with neonatologist/ medical team.</p>	<p>increased oxygen consumption and handling. Also oxygen consumption increases by 8.8% under radiant warmers (Sequin and Vieth 1996, Birmingham Children's Hospital 2003)</p> <p>This reduces heat loss through conduction and radiation (Ohmeda Medical 1994).</p> <p>To prevent overheating and evaluation of preheating of the radiant warmer thereby ensuring the safety of the patient.</p> <p>To maintain the infants temperature in a neutral thermal environment and prevent cold stress (Brown and Landers 2011).</p> <p>A firm mattress is needed to facilitate development. (Reid and Freer 2003).</p> <p>Evaporation and insensible water losses are higher under radiant heaters compared to incubators i.e. 40-50% more. The use of humidity can help reduce transthermal epithelial water loss (TEWL) and maintain the infant's body temperature (Flenady and Woodgate 2009, GE Healthcare 2010, Brown and Lauanders 2011).</p> <p>To prevent the infant from falling from the radiant warmer and maintain a warm environment by preventing unnecessary draughts (Trigg and Mohammed 2010).</p> <p>Radiant warmers may also increase the infant's insensible water losses (Flenady and Woodgate 2009; Fellows 2010).</p>
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<p>Urinary output should be monitored closely.</p> <p>Servo Temperature Probe <i>NB: Please note that the temperature probe alarm is only active in servo mode</i> In servo mode the servo skin temperature probe should be in situ.</p> <p>Place the servo skin temperature probe midway centrally above the umbilicus in the direct path of radiant heat with the metal side in contact with the skin and the heat reflective foil patch facing up.</p> <p><i>NB: Do not cover servo skin probe with bedding and avoid any bony areas</i></p> <p>Place the skin probe on infant's back, with foil facing uppermost when the infant is nursed prone</p> <p>Change servo probe site a minimum of every shift. Care must be taken when removing or resiting adhesive pads.</p> <p>Temperature probe-skin contact should be checked every 30 minutes to hour.</p> <p>The servo temperature should not be relied on. Peripheral and core temperatures must always be checked separately and continuously</p> <p>The infant should be placed in a warmed incubator as soon as possible</p> <p>The radiant warmer should be changed weekly as clinically indicated.</p>	<p>This will determine accurate fluid and electrolyte balance (Fellows 2010).</p> <p>(Ohmeda Medical 1994).</p> <p>Brown adipose tissue (BAT) deposits are located around the neck, between the scapulae, across the clavicle line and down the sternum. It also pads the kidneys and the thoracic vessels. BAT deposits can absorb heat giving inaccurate temperature readings. The skin is very thin over bony areas and bone is not a good conductor of heat.</p> <p>To prevent skin damage to delicate and immature skin. Incidents of skin blister development have been reported in the literature (Fellows 2010).</p> <p>To ensure satisfactory skin contact and early detection of servo probe lifting resulting in over heating of the infant.</p> <p>A 2-3 °C gap between skin and core can give an early indication of cold stress, hypovolaemia, shock, infection. In cold stress the peripheral temperature will fall before the central (Brown and Landers 2011).</p> <p>Incubators assist in preventing cross infection, promote minimal handling, aid with noise reduction and enable close observation of the sick neonate (Fellows 2010).</p> <p>To minimise infection risk (OLCHC 2008).</p>
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5.0 Thermoregulation and Humidity

Specific Equipment Required: Sterile Humidity container and sterile water


Scope of Guideline

- <31 week gestation infant
- Infants with some skin condition i.e. scalded skin condition.
- Humidity level and length will be determined by Neonatologist/Dermatologist

ACTION			RATIONALE EVIDENCE and REFERENCE									
<p>Offer explanation to parents / guardians.</p> <p>Infants' < 31 weeks gestation should be nursed in a warmed and humidified environment.</p> <table border="1"> <thead> <tr> <th>Gestation of Delivery</th> <th>Humidity Percentage</th> <th>When to Discontinue</th> </tr> </thead> <tbody> <tr> <td>28-31 weeks</td> <td>85% humidity decreasing gradually from day 7 of life</td> <td>Discontinue at 14 days of life</td> </tr> <tr> <td><28 weeks</td> <td>85% humidity decreasing gradually from day 7 of life</td> <td>Discontinue 21-28 days of life, depending on prematurity</td> </tr> </tbody> </table> <p>Table 1: Percentage of Humidity Treatment for Preterm Infants Nursed in Incubators.</p> <p>The above criteria are dependent on the clinical condition of the infant and must be in consultation with the neonatal consultant.</p>			Gestation of Delivery	Humidity Percentage	When to Discontinue	28-31 weeks	85% humidity decreasing gradually from day 7 of life	Discontinue at 14 days of life	<28 weeks	85% humidity decreasing gradually from day 7 of life	Discontinue 21-28 days of life, depending on prematurity	<p>Providing parents/guardians with appropriate information reduces anxiety and stress caused by hospitalisation (Trigg and Mohammed 2010).</p> <p>Premature infants, due to their large surface area in relation to body weight are poorly developed and have thin skin due to lack of keratin. They may lose large amounts of heat by evaporation, which is known as trans-epidermal water loss (TEWL). The preterm infant has only a thickness of 2-3 cell layers of stratum corneum (outer most area of epidermis) especially over the abdomen, compared to the term infant who has 10-20 layers. TEWL can be up to 18 times higher in the 25/40 infant than in full term infant (Blissinger and Annibale 2010). Each 1ml that evaporates from skin is equal to 560 kcal heat loss. TEWL is dependent on the epidermal barrier, the temperature, air speed and humidity. The use of humidity will reduce TEWL and when 100% humidity is added TEWL is stopped. It will also improve fluid and electrolyte balance, enhance skin integrity and achieve thermal stability (Rutter 2000, St. Mary's Hospital 2008, Heuchen <i>et al.</i> 2009, Queen Mothers Hospital 2009, Coombe Hospital 2010, Fellows 2010, Xifan 2014a, 2014b, Slade 2016) The 26 week gestation infant has developed a very thin keratinized stratum corneum. Birth accelerates this maturation of the skin and the process can take between 2-4 weeks, depending on prematurity. The stratum corneum doesn't become functionally mature until the infant is 32 – 34 weeks gestation. Humidity is considered ineffective after this time (Blissinger and Annibale, 2010). High ambient relative humidity levels also cause more rapid skin barrier formation compared to lower levels in the first days of life in this population (Argen <i>et al.</i> 2006, Slade 2017).</p>
Gestation of Delivery	Humidity Percentage	When to Discontinue										
28-31 weeks	85% humidity decreasing gradually from day 7 of life	Discontinue at 14 days of life										
<28 weeks	85% humidity decreasing gradually from day 7 of life	Discontinue 21-28 days of life, depending on prematurity										


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<p>Use incubators with integral humidity. Humidity unit is sterile and Sterile Water for Irrigation (1000 mls) is used in the humidity unit which is then removed for cleaning and re-sterilisation every 24hrs. Replace with a pre-sterilised humidity unit.</p> <p>Check humidity water level minimum 4 hourly. Top up as necessary.</p> <p>Although the bedding can feel wet (damp to touch), it should only require changing once –twice a day unless soiled.</p> <p>Humidity will create a thin mist on the inside of the incubator. This is acceptable and should disperse down the sides of the incubators. However if heavy rainout / excessive rainout occurs causing droplet formation which drops on the infant, the humidification system / incubator should be changed and checked by the clinical engineers, Bleep 8465.</p> <p>Infants should not be dressed when using humidity.</p> <p>Reduce and discontinue humidity as the infant matures taking cognisance of the degree of prematurity.</p> <p>Within OLCHC, a humidity table has been devised; (Appendix II) to incorporate humidity up to and including 31 weeks gestation.</p> <p>Infant's fluid balance and daily electrolytes especially serum sodium should be monitored. Liaise with medical team.</p>	<p>To reduce / prevent risk of colonisation by pseudomonas and other bacteria. (National Maternity Hospital 2008, OLCHC 2008, Royal Children's Hospital 2013)</p> <p>(Macqueen <i>et al.</i> 2012, GOSH 2014, Xifan 2014b, Slade 2017).</p> <p>There can be a lot of misting from high humidity levels causing bedding to feel wet but once the temperature is correct the infant will not be cold (Coombe Hospital 2009).</p> <p>There is no need to wipe the inside of the incubator. Wiping can cause droplets to fall on infant causing distress.</p> <p>Visibility shouldn't be a problem. The infant should be switched to another incubator in the meantime.</p> <p>Clothes create a barrier to the moisture created by humidity (TSCUH 2011, Slade 2017).</p> <p>The literature varies but between the ages of 30-32 weeks gestation the infant's skin is considered comparable to that of an adult and that humidity is ineffective after this stage (Fellows, 2010).</p> <p>(GOSH 2014, O'Connor and Kelleher 2016).</p> <p>Yifan, 2014b, Slade 2017).</p>
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6.0 Thermoregulation Control when Transferring an Infant from an Incubator to an Open Cot

ACTION	RATIONAL EVIDENCE and REFERENCE
<p>The transfer should be a gradual process.</p> <p>Assess infant for suitability:</p> <ul style="list-style-type: none"> • Desirable weight of > 2 kgs • Five days of consistent weight gain. • Clinically well, i.e. no recent history of apnoea, desaturation, bradycardia or convulsions. • No evidence of newly acquired or increasing jaundice • Ideally not dependent on TPN or other continuous maintenance intravenous fluids • Desirable to be fully established on milk feeds (oral / breast) +/- nasogastric / PEG feeds. • Infant is able to maintain their own temperature during a nappy change / essential care. • Able to maintain own temperature dressed in a single layer of clothing, i.e. babygro, hat and mittens with incubator air temperature set at 30 degree centigrade or less for at least 2 – 3 days prior to transfer. <p>Explanation to parents /guardians as clinically indicated.</p> <p>The cot should be in a draught free area.</p> <p>The infant should be placed carefully into the cot fully clothed dressed in vest, babygro, cardigan, hat, and gloves with no more than 2 single blankets to maintain temperature as clinically indicated.</p> <p>The infant should feel comfortably warm to touch all over and not be perspiring.</p> <p>Baseline observations should be recorded on transfer including both core and skin temperature, heart rate and respiratory rate.</p>	<p>An infants own thermoregulation is dependent upon skin and vasomotor maturity, improved physical health, fat and glycogen stores, increased body weight and the ability to change position. Also if the infant is unable to maintain own temperature they will require excessive layers of clothing / blankets to allow sufficient observation (St Mary's Hospital 2006, Fellows 2010).</p> <p>If prolonged TPN is in progress they may have some degree of jaundice.</p> <p>Age and maturity of infant may have to be taken into account when on TPN. The reason why they are on TPN must also be factored in as in the case of Short bowel syndrome.</p> <p>To maintain the infants' temperature constant and prevent cold stress (St Mary's Hospital 2006).</p> <p>To reduces anxiety and stress caused by hospitalization (St Mary's Hospital 2006, Trigg and Mohammed 2010).</p> <p>To reduce convective heat losses by preventing unnecessary draughts (Trigg and Mohammed 2010).</p> <p>To maintain the infants temperature constant and prevent cold stress. To reduce the incidence of over-heating as this is a contributory risk factor in Sudden Infant Death Syndrome (SIDS) (Lullaby Trust 2013).</p> <p>This may indicate overheating.</p> <p>This will alert staff to changes in temperature and help maintain the infant's temperature constant and prevent cold stress (Lyon 2004).</p>

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<p>Core and peripheral temperatures should be record and documented for 72 hours following transfer from incubator to cot in the PICUs as clinically indicated.</p> <p>In ward areas where the infant is more stable / mature record hourly peripheral finger temperatures via touch / feel method for 1-2 days and 2-4 hourly toe and core temperature i.e. “warm to fingers, warm to toes” for 3 days / 72 hours as clinically indicated.</p> <p>In the ex PICU infant (prolonged stay) who is stable and has successfully transitioned to a cot, a minimum of 4 hourly monitoring / documenting of core and peripheral temperatures should be undertaken.</p> <p>If skin temperature drops below 36.5 °C, immediate action should be taken to increase temperature by wrapping up infant and applying more layers of clothing. Record temperature more frequently i.e. at least half hourly as clinically indicated.</p> <p>Check blood glucose.</p> <p>If skin temp remains < 36.5 °C despite warming efforts return infant to incubator.</p> <p>Attempt the whole process again 3 – 4 days later. If on repeat assessment the infant is deemed suitable for transfer to a cot i.e. temperature has stabilised and wt. gain has continued.</p> <p>Nests or pillows (under 1 year) should not be used in open cots. If the infant needs to be propped up, put pillow under mattress or tilt the cot if possible.</p> <p>Avoid bathing infant for approx. 3-4 days following transfer to the cot until weight has increased and temperature stabilized in the cot.</p> <p>Ensure that consistent weight gain is maintained by monitoring weight every 2nd day, post transfer to the cot.</p>	<p>Early detection of poor perfusion / cooling of peripheries and timely intervention.</p> <p>To ensure early and timely intervention for any deterioration in infant's condition.</p> <p>To ensure early and timely intervention for any deterioration in infant's condition.</p> <p>To reduce convective heat losses and prevent cold stress (St Mary's Hospital 2006, Fellows 2010).</p> <p>The infant is at risk of hypoglycaemia when cold stressed.</p> <p>To maintain neutral thermal environment and prevent cold stress.</p> <p>This period of time will give the infant time to recover and provides the nurse with valuable time in which to assess the infants overall condition.</p> <p>The use of pillows under the age of 1 year increases the incidents of SIDS (Lullaby Trust 2013). Use of GOI pillows(to prevent or aid plagocephaly) can be incorporated under strict guidance from Neurodevelopmental Physiotherapists</p> <p>Temperature is very unstable during this period. To ensure that energy is not being diverted away from other vital body organs towards maintaining temperature (St Mary's Hospital 2006).</p> <p>Increased energy expenditure occurs as the infant tries to maintain their body temperature which may affect their weight gain (New <i>et al.</i> 2008). It may also</p>
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8.0 Appendices

Appendix I

Features of Giraffe OmniBed

Boost Air Curtain

This increases the fan speed in order to create a strong blanket of air to serve as a barrier against cool air entry when a porthole or door is opened. It will last for 20 minutes or can be deactivated by the user once the door / porthole is closed returning to “Whisper Quiet” mode (GE Healthcare 2007b, 2010).

Phototherapy in the Giraffe: There is a Giraffe SPOT PT Lite™ (phototherapy light) attached to the Giraffe OmniBed which provides intensive phototherapy for infants (Please check the manual for appropriate distance of light from patient) (GE Healthcare 2010).

Operating the Giraffe with Two Temperature Probes


The OmniBed is equipped with two patient temperature probe jacks for co-bedding of twins, or to monitor a single baby's temperature from two anatomical sites. The OmniBed will only operate in Servo mode from temperature probe 1 (Jack 1). The second temperature probe (Jack 2) may be used in the stable dressed infant who is nursed in air mode to monitor a peripheral temperature (GE Healthcare 2007a).



Figure 1: Boost Air Curtain on Display.



Figure 2: Phototherapy Light.

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Use of Giraffe for Neonates

Requiring HFOV

Check with engineers in OLCCH re: availability of accessories (Sensormedics HFOV 45- degree fitting or accessory Plexiglas panel) to allow use of HFOV while nursing the infant in Incubator mode.

With Gastroschisis Silo Bag (Unrepaired Gastroschisis)

The Giraffe accessory support arm is available for this purpose. On each of the corners of the translation deck is a hole to mount support arms. The gastroschisis silo may be hung from a support arm mounted through these holes. If the mattress were pulled out, the support arms would move with the baby (GE Healthcare 2007c).

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Appendix III

Neutral Thermal Environmental Temperatures - Determined by Age and Weight

Age	< 1.2 kgs	1.2 – 2.5 kgs	> 2.5 kgs and > 36/40
0-24 hrs	34.0°C -35.4 °C	31.5 °C - 34.0 °C	31.0 °C - 33.8 °C
24-48 hrs	34.0 °C - 35.0 °C	31.5 °C - 34.0 °C	30.5 °C - 33.5 °C
48-96 hrs	34.9 °C -35.0 °C	31.0 °C - 34.0 °C	29.8 °C - 33.2 °C
4-14 days	32.6 °C -34.0 °C	30.0 °C - 33.0 °C	29.0 °C - 32.6.0 °C
2-6 weeks	30.6 °C - 34.0 °C	29.0 °C - 32.0 °C	29.0 °C - 33.0 °C

(Hazinski 2013, Blumer 1990)