NEST-ED

Clinical Modules

June 2020

Newborn Essential Solutions and Technologies-Education (NEST-ED) Clinical Modules provide educational support for each of the technologies included in the NEST360° bundle for newborn care. These materials are intended to strengthen locally developed neonatal and technical trainings in pre-and in-service settings and are not intended to be comprehensive clinical guidelines or targeted towards intensive care of the newborn.

FACILITATING THE CLINICAL USE OF TECHNOLOGIES FOR NEWBORN CARE IN LOW-RESOURCE SETTINGS

DISCLAIMER

Newborn Essential Solutions and Technologies-Education
Clinical Modules: Radiant Warmer

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PREFACE

This series has been designed with the intent of supporting the clinical use of technologies in newborn care units.

Newborn Essential Solutions and Technologies-Education (**NEST-ED**) Clinical Modules provide educational support for each of the technologies included in the NEST360° bundle for newborn care. These materials are intended to strengthen locally developed neonatal and technical trainings in pre- and in-service settings. Of note, these materials are not intended to be comprehensive clinical guidelines or targeted towards intensive care of the newborn. They are to be used to facilitate the implementation of comprehensive newborn care, including bubble CPAP, in a resource limited setting.

The NEST-ED Clinical Modules were developed through a combination of international standard review, international expert feedback, and multinational NEST360° expert consensus opinion. NEST-ED Modules form the backbone of all lectures, power points, job aids, and other supportive education materials supplied by NEST360°.

ABBREVIATIONS

ABC	Airway, Breathing, Circulation
bCPAP	Bubble continuous positive airway pressure
dL	Decilitre
FiO_2	Increased Fractional Concentration of Oxygen
Fr	French size
HAI	Hospital acquired infections
HCWs	Healthcare workers
HFNC	High flow nasal cannula
IV	Intravenous
KMC	Kangaroo mother care
LBW	Low birth weight
LCD	Liquid crystal display
LED	Light emitting diode
mm Hg	Millimeters of mercury
NEST360°	Newborn Essential Solutions and Technologies
NEST-ED	Newborn Essential Solutions and Technologies-Education
NGT	Nasogastric tube
nm	Nanometer
O_2	Oxygen
OGT	Orogastric tube
ppm	Parts per million
ROP	Retinopathy of Prematurity
SpO_2	Peripheral blood oxygen saturation
UPS	Uninterruptible power supply
WASH	Water, sanitation and hygiene
WHO	World Health Organization
wks	Weeks

NOMENCLATURE

bCPAP prongs	bCPAP patient interface
Cot	Bassinet, infant crib
Christmas tree nozzle	Barbed oxygen fitting, nipple and nut adapter
Flow splitter	Oxygen splitter, flow meter stand
Glucometer	Glucose meter
Hospital Acquired Infection	Iatrogenic infection, nosocomial infection
Nasal prongs	Oxygen catheter, oxygen cannula, oxygen prongs
Positive Pressure	Positive end expiratory pressure, positive airway pressure
Radiant warmer	Resuscitaire, resuscitation table
Suction pump	Suction machine

Introduction

This NEST-ED Clinical Module has been prepared to help healthcare staff & students understand when & how to use radiant warmers in newborn care. This is one module in a series of NEST-ED Clinical and Technical modules available that may be used by teaching institutions to supplement current newborn care curricula or by hospitals, clinical departments, and individuals to update their knowledge and to better facilitate the effective and safe use of newborn care equipment.

Whilst reading this series, navigate to the **Table of Contents** by clicking the NEST360° logo that appears at the bottom right corner of each page: NEST360°

Every module has a similar structure with sections and subsections. The sections have similar headings and subheadings to make it easy for the user to navigate them. However, words may have different meanings for the various cadres of staff reading them and so to reduce misinterpretation, the heading titles are explained below.

An exception to this structure is the **Infection Prevention & Control: General Infection Prevention** module. This module describes general infection prevention measures in relation to the use of equipment in the ward. There are also sections on reprocessing of single use items and a useful table of suitable disinfectants.

CLINICAL PROBLEM

This describes the situations in which a piece of equipment may be clinically useful. It does not include all the clinical background in making that decision, as this should be covered in country-specific neonatal care protocols & clinical training materials.

ASSESSMENT

This section explains how a piece of equipment works, as well as how it may be useful in certain patient care settings (e.g., why an overhead radiant heater is useful for short term warming in the labour ward while resuscitating a newborn).

MANAGEMENT

Step by step preparation for setting up, checking, and using the equipment is described. This is followed by explanations of how to remove the equipment from a baby when it is no longer needed, how to clean it, and how to store it safely until further need.

INFECTION PREVENTION

In this section infection prevention measures are described for the equipment when in use, followed by instructions on how to disinfect the equipment both during and after use.

COMPLICATIONS

The complications described in this section are those relating to the use of the equipment and do not include all clinical complications that may arise from underlying medical problems. These are beyond the scope of the modules and should be covered in clinical training materials.

CARE & MAINTENANCE

Advice is given on where to place equipment for use, how to safely handle such devices and their consumables, and how to keep them functioning well by using preventive maintenance measures.

TROUBLESHOOTING & REPAIR

This section provides helpful advice on what to check if equipment is malfunctioning on the ward. It is intended to help healthcare staff deal with minor technical difficulties for which there are simple remedies. Detailed machine maintenance is beyond the scope of these modules and is covered in the technical modules that accompany these clinical ones.

ASSESSMENT QUESTIONS

A few questions are attached based on module content. These may be used, for example, during mentoring visits or to emphasise some of the points raised in teaching with the module.

REFERENCES & ALERTS

References and alert boxes are included within each module to provide clarity on areas where recommendations are governed by published standards, evidence, and/or expert opinion. This is included for the dual purpose of facilitating (1) feedback and continuous improvement of NEST-ED Education Modules and (2) implementer review of content for incorporation in local trainings.

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ALERT 0.0 Subject

QUERY ALERT BOXES appear where there may be controversy or disagreement. In these cases, alert boxes provide background to the recommendations that are made in the body of the document. Relevant documents are cited and brief explanation of reasoning for current module content provided.

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ALERT 0.0

RECOMMENDATION ALERT BOXES appear where there are recommendations based largely on expert opinion or consensus, or to emphasize an important element of care. Relevant documents are cited and brief explanation of reasoning for current module content provided.

Thermal Management

Radiant Warmer

1 Clinical Problem

Temperature less than 36°C at birth has been recognised as an independent risk factor for death in preterm infants.[1,2]

Radiant warmers may be used on any neonatal patient admitted to the nursery ward, but especially for:

- Initial assessment of a sick or premature baby
- Hypothermia
- Undertaking invasive procedures
- Resuscitation
- When stabilising a sick baby

OBSTETRIC & LABOUR NOTE

In stable newborns priority should always be given to skin-to-skin and KMC over artificial warming devices. Unstable babies and any requiring resuscitation need an area post-delivery to prevent hypothermia. Using pre-warmed towels, neonatal patients should immediately be dried, with one towel that is then discarded and replaced by another dry one, wrapped and placed under a radiant warmer following delivery. Newborn babies can drop their body temperature very quickly, even within minutes. They must be kept warm from the moment of birth, during their time in the labour ward and when transferred to the nursery. **Even small drops in temperature increase the likelihood of mortality.**[2–4]

Extremely premature babies can be placed in a clean plastic bag immediately after birth, without prior drying and ensuring the head is kept free from the plastic.[4] **(1.1)** The head is covered with a hat. This assists prevention of heat loss. A baby in a plastic bag must be monitored very frequently to prevent overheating.

1.1 A neonatal patient may be wrapped in plastic, with head free, to prevent heat loss.

Regardless of location, it is preferential to start patients on Kangaroo Mother Care if it is clinically appropriate and the patient is stable.

2 Assessment

However warm a room may feel to an adult, a neonate can lose heat. This heat loss in neonatal patients is rapid, with hypothermia directly contributing to mortality.[2–4] Radiant warmers (2.1) use overhead heating elements to provide radiating heat ensuring maintenance of normothermia.

Newborn babies lose heat through four main mechanisms.[5]

- **Evaporation:** water loss through the skin.
- **Radiation:** heat radiating from the warmer patient towards cooler surfaces (e.g., windows or walls).
- **Conduction:** direct heat travel from warmer surface of the skin to the cooler mat or cot on which the patient rests.
- **Convection:** air currents move heat away from the skin/body.

Radiant warmers provide radiating heat to minimise metabolic requirements for heat production, decreasing the risks of hypoglycaemia and respiratory distress associated with hypothermia. Radiant warmers provide an area where resuscitations, procedures, and short-term observation can take place while keeping the baby warm. Warmers may vary in complexity, including only heating functionality or heating functionality with resuscitation and oxygen equipment. All warmers include a temperature probe that provides information on the patient's temperature. **(2.2)**

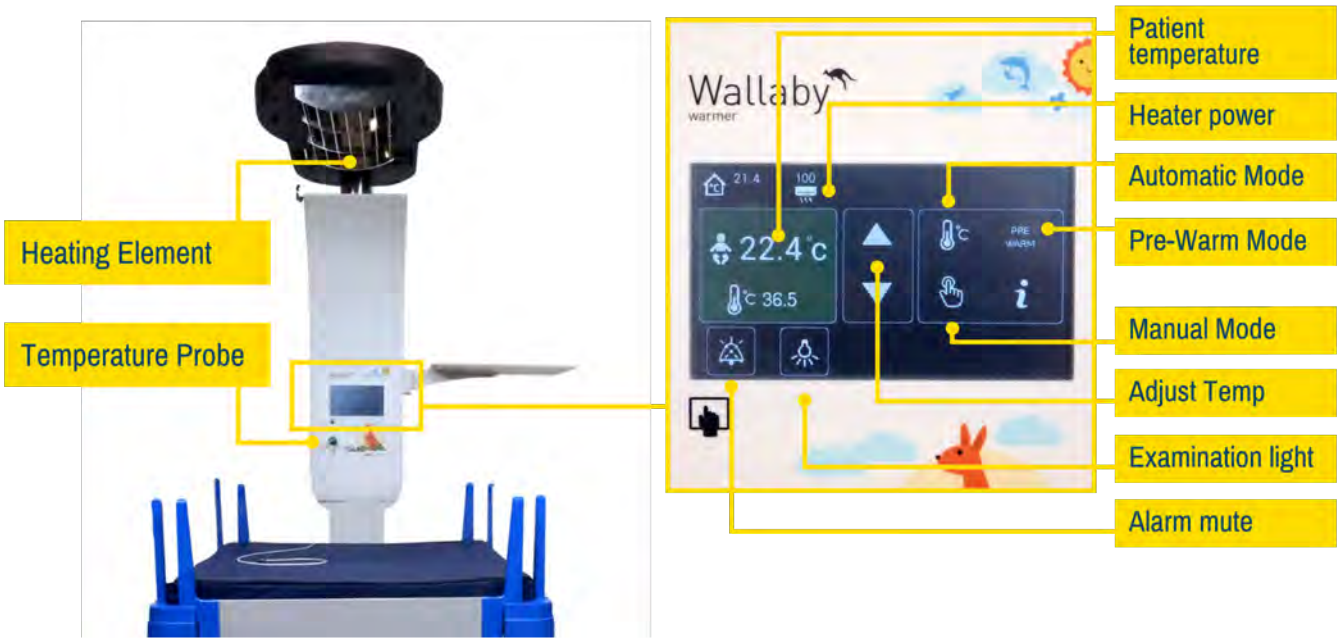
2.1 A typical radiant warmer.

2.2 A typical temperature probe.

Radiant warmers heat in various modes, the names of which may vary based on device: **(2.3)**

- **Prewarm:** provides constant low heat for a short amount of time (typically 10 minutes or less) to prepare the cot underneath the warmer to receive a patient.

- **Automatic:** also called servo or baby mode; uses a temperature probe on the baby to automatically adjust heat provided to maintain the patient's temperature within an acceptable range.
- **Manual:** provides a constant, unadjusting heat that is set by the user. Patients should never be left unattended if being treated in manual mode.



2.3 Major components & modes of a radiant warmer.

Normothermic axillary temperature in neonates ranges from 36.5°C to 37.5°C.[4,5] **Every effort must be made to keep a baby's temperature within the normal range as temperature below 36°C is an independent risk factor for death in newborns.**[1,2]

3 Management

Management covers how to use the radiant warmer, including set up for a patient, patient preparation & commencement, care whilst on the device & removal of the patient from the device.

SETTING UP FOR A PATIENT

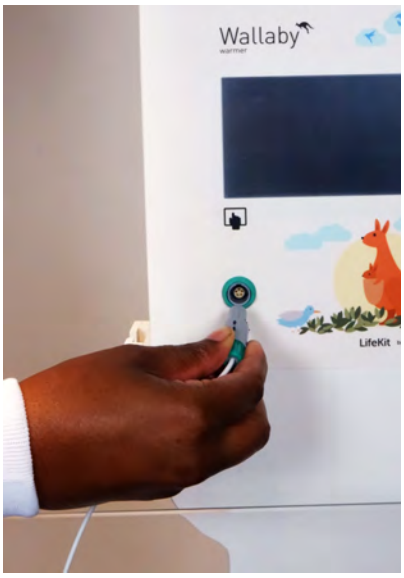
1. Plug power cable into the radiant warmer. **(3.1)** Plug power cable into a wall socket & surge protector if available and switch on the power. **(3.2)**
2. Select manual setting at 25% or **Prewarm** setting (if available on model). **(3.3)**

3.1 Plug in the radiant warmer.

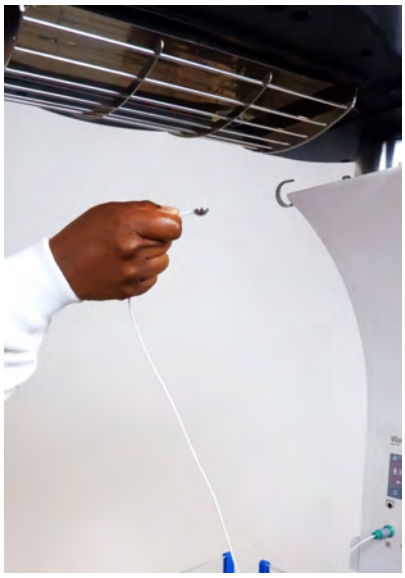
3.2 Switch on the power.

3.3 Select Pre-Warm setting to warm bedding.

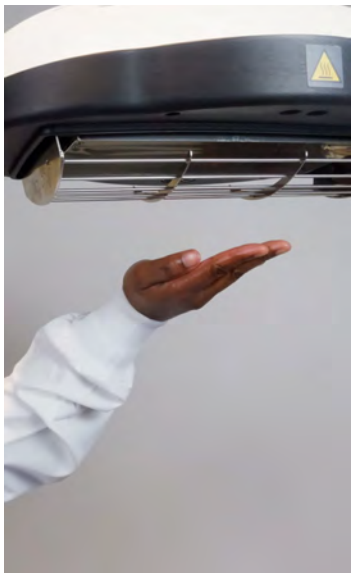
3 Plug temperature probe into the infant temperature probe port. **(3.4)** Hold temperature probe in hand and move hand directly under overhead heating elements to check for heat. **(3.5)** You should be able to feel heat emitting from the heating elements. **(3.6)** Allow bedding to grow warm while waiting for the baby to arrive in the nursery, be transferred to the radiant warmer, or be delivered in the labour ward.



3.4 Plug in the temperature probe.



3.5 Pass the temperature probe underneath the heating elements.



3.6 Feel heat emitted from elements.

PREPARING A PATIENT

1 Collect:

- Tape or elastic bandage
- Gauze
- 70% alcohol

2 Always explain the purpose, risks, and benefits of a procedure to guardians BEFORE performing the procedure.

3 Follow handwashing protocol.

4 Ensure patient is dry from any birth fluids or bodily secretions and is wearing a hat to prevent excess heat loss from the head.

STARTING A PATIENT

1 Ensure radiant heater has been prewarmed. If the radiant warmer has not been prewarmed, then take steps to do so. Prewarming is essential in order to prevent infant from losing heat to the mattress when initially placed on the warmer.

2 Change the radiant warmer from **Pre-Warm** to select **Servo/Automatic** mode. **(3.7)**

3 Position infant in middle of radiant warmer cot, maintaining additional treatment tubing (e.g., CPAP tubing, IV lines) in place. **(3.8)**

4 Use gauze and 70% alcohol to clean temperature probe.

5 Place temperature probe directly above infant's liver and secure with tape or elastic bandage. **(3.9)** If a child with myelomeningocele needs to be cared for prone, then place the probe over the infant's flank. The probe should be secured firmly enough that it will not fall off the patient, but not so firmly that it is pressing into the infant's skin.

3.7 Switch to servo mode.

3.8 Place the patient in the centre of the cot.

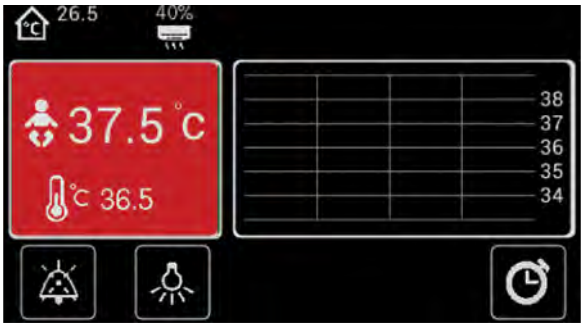
3.9 Place & secure temperature probe.

6 If used in servo mode, the **goal temperature** for the baby is usually set to a default 36.5°C. The user may change the goal temperature depending on patient's clinical status.

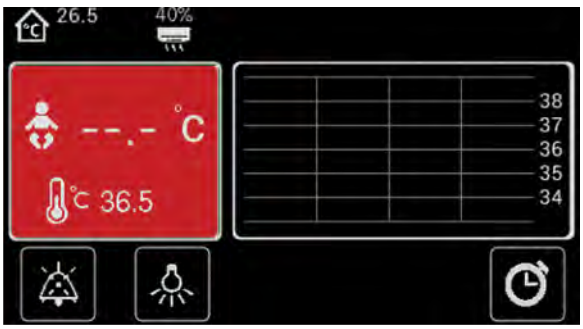
7 Ideally, each radiant warmer should be used for one baby with a temperature probe dedicated for that patient. Sharing of a radiant warmer and temperature probe poses a risk for temperature regulation and infection control. If multiple patients are sharing one warmer, regular temperature monitoring must be conducted using a temperature probe or thermometer. If the radiant heater is used in manual mode, the baby must be constantly attended as there is a real danger of overheating.

1. Monitor the patient's temperature 5 minutes after starting on radiant warmer, and then 4 hourly (if in **servo** mode) or every 30 minutes (if in **manual** mode).
2. Pay close attention to any alarms:
   - **Temperature:** the infant temperature probe has recorded temperatures below **(3.10)** or above **(3.11)** the safe range for the patient. Assess if the patient is too hot or cold and change the radiant warmer settings accordingly. Check probe is not dislodged from the baby.
   - **Probe:** the temperature probe is not secured in the radiant warmer appropriately or the probe has malfunctioned. **(3.12)** Make sure the probe is plugged in; if the alarm continues, replace the probe or contact your maintenance department.
   - **Power:** the mains power has failed. **(3.13)** Turn off the power button on the radiant warmer control and move the patient to a working warmer.
   - **System:** the radiant warmer has recorded a problem with its system. **(3.14)** This may result in the radiant warmer no longer providing heat or no longer monitoring the patient. Move the patient to a working warmer and contact your maintenance department.

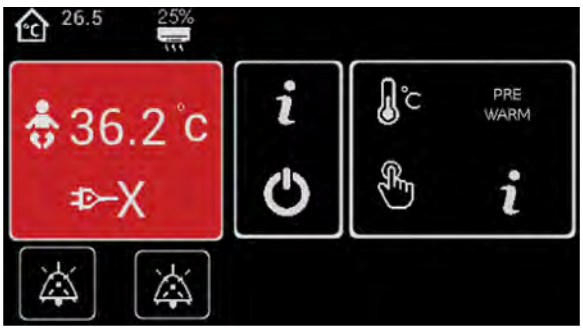
3.10 Low Patient Temperature alarm.



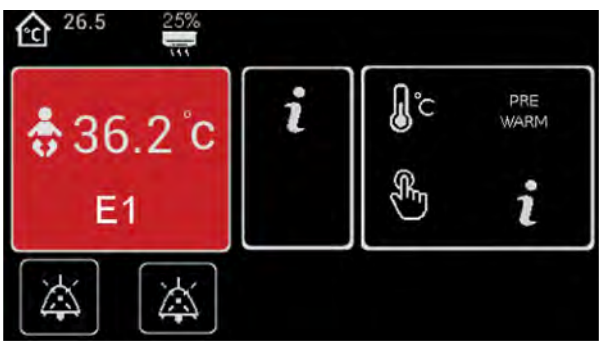
3.11 High Patient Temperature alarm.



3.12 Probe Failure alarm.



3.13 Power Failure alarm.



3.14 System Failure alarm.

REMOVING A PATIENT

1. Collect:
    - Gauze
    - 70% alcohol
2. Gently remove tape/bandage holding temperature probe from patient. **(3.15)**

3.15 Peel off tape holding temperature probe in place.

3. Disinfect probe site on patient and temperature probe with gauze and 70% alcohol.
4. Turn off warmer using switch and unplug.
5. Check the patient's temperature after 30 minutes off the warmer, to ensure normal body temperature is maintained.
6. Disinfect the cot before reuse.

4 Infection Prevention

Routine and adequate cleaning of medical devices is critical to prevent hospital-acquired infections in newborn care units.

GENERAL INFECTION PREVENTION

1. Clean hands with soap and water or 70% alcohol before and after placing a patient in a radiant warmer or handling any consumables that will be used on a patient (e.g., temperature probe).

2. Ensure that all patient-related consumables (including probes) are new or have been cleaned thoroughly before use. Any patient-related consumables must be cleaned before they are used to assess another patient on the radiant warmer.
3. All patient-related consumables should be stored in a clean, dry location. Any cables should be loosely wrapped and secured, preventing sharp bends or kinks, which will decrease the lifetime of the cables. Do not pinch or bend the cables.
4. As mentioned in **Radiant Warmer: Management**, each radiant warmer should be used for one baby with a temperature probe dedicated for that patient. Sharing of a radiant warmer and temperature probe poses a high risk for infection transmission between patients. If the patient probe and surfaces are not cleaned thoroughly before use, infection can also be transmitted.

DISINFECTION AFTER USE

1. Turn off and unplug the radiant warmer, if not using with another patient. Allow to cool.
2. After every use, use gauze and 70% alcohol or diluted chlorine **(Alert 4.1)** to thoroughly wipe:
   - Temperature probe, including cable and plug head
   - Control panel
   - Power button
   - Mattress – cleaning both sides
   - Cot walls
3. Housing of the radiant warmer should be cleaned according to ward guidelines for disinfecting surfaces.

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ALERT 4.1

Disinfection of equipment should always comply with manufacturer guidelines. General guidance on environmental cleaning and disinfection of equipment was taken from the Infection Prevention and Control: Reference Manual for Health Care Facilities with Limited Resources, Jhpiego, Module 6[6] which lists isopropyl alcohol (70-90%), sodium hypochlorite (0.05% or >100ppm available chlorine) quaternary ammonium, and Iodophor germicidal detergent as appropriate for low level disinfection. Phenolic germicidal detergent is also listed in this category but should not be used in neonatal wards since affordable, effective alternatives are available; and, there are concerns it may cause hyperbilirubinemia and/or neurotoxicity in neonates.[7]

When utilising re-processed devices meant for single-use (like temperature probes), careful attention must always be paid to assure that devices are continuing to function properly.

5 Complications

Introduction of equipment in newborn care units poses clinical and device complications for patients. Awareness of potential complications is critical to maximise patient safety.

CLINICAL COMPLICATIONS

- **Hypothermia & cold stress:** if the device is not prepared correctly, is malfunctioning, or the baby is left exposed for a long period of time, there is a risk of hypothermia. This is associated with a significant increase in mortality and morbidity including respiratory distress syndrome, metabolic derangements, interventricular haemorrhage, and late onset sepsis.[4] Hypothermia additionally increases the risk of necrotising enterocolitis in preterm infants.[2,4] If a baby is cold, rewarming must be careful and gradual.
- **Hyperthermia & heat stress:** hyperthermia can occur in patients whilst on manual mode who are not monitored regularly or on servo mode if the temperature probe falls off as they may become overheated. Risks of hyperthermia include increased fluid loss with development of hypernatraemic dehydration, convulsions, increased metabolism, tachypnoea, tachycardia, and recurrent apnoea.[8–12] **(Alert 5.1)**
- **Pressure sores:** pressure sores may develop if the patient is incorrectly positioned, is lying on additional tubing/equipment, or the temperature probe is not positioned correctly.
- **Falls:** the cot sides of the radiant warmer must be in place to prevent the baby falling off the mattress on to the floor.
- **Infection:** if the temperature probe or infant warmer are not cleaned thoroughly before use, infection can be transmitted. Care should be taken particularly for consumables that are marked as single-use but are reused in practice (such as temperature probes).

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ALERT 5.1 Contextualising Hyperthermia

There are two ways that an infant might have an elevated core temperature: (1) infection (2) environmental.

1. **Infection:** In the case that an elevated temperature is generated by infection, there is no temperature which is considered "dangerous" and would require additional alarms. Fever, regulated by the hypothalamus, is the body's normal response to infection or inflammation which is induced by cytokine activation.

2. **Environmental overheating:**
   - **Device overheating:** A device overheating an infant can lead to a number of potentially dangerous outcomes that may result in serious harm. Environmental overheating is not a body's normal response to an illness (as seen in fever) but rather a mismatch between environmental heat and the ability of the infant's body to dissipate heat. Environmental overheating may result in serious heat related illness including damage to the central nervous system.[8,9] Compared to older individuals, babies are at particularly high risk of environmental overheating since they have higher heat production (metabolic rates), higher surface area to mass ratios (i.e., higher absorption of heat from environment), less ability to dissipate heat and no ability to independently access fluids.[10–12]
   - **Maternal heat transference:** Immediately following delivery hyperthermia can be caused by maternal fever during labour and delivery as foetal temperature is up to 1°C higher than maternal temperature.[13]

Note on special circumstances: CNS injury, in which it is critical to avoid hyperthermia in the first 72 hours following birth, may affect the newborn's temperature. However, CNS damage will typically result in temperature instability rather than hyperthermia.[13]

DEVICE COMPLICATIONS

- **Hyperthermia due to probe mismanagement:** if the device is set to automatically adjust its temperature based on the patient's temperature (servo mode) and the patient

temperature probe falls off the patient or is not well secured **(5.1)**, the radiant warmer may overheat in an attempt to compensate for what it observes as a low body temperature. This puts the patient at risk for a body temperature > 40°C and clinical harm

5.1 An unsecured temperature probe may cause the radiant warmer to overheat.

- **Alarms:** radiant warmers have in-built alarms that should sound if the patient's temperature is above or below a set normothermic range. If this range is not appropriately set, alarms may sound at incorrect situations.
- **Fire:** if linen is placed on the radiant heater head, heat and dust may build up and pose a fire hazard. Never store linen on top of the device or close to the heating elements. Although treatment devices (e.g., phototherapy units, oxygen concentrators) can be used with a radiant warmer, care should be taken to ensure that the direct line of heat to the patient from the radiant warmer heating elements is not obstructed.

6 Care & Maintenance

Users are responsible for basic first-line care and maintenance to ensure equipment lasts to their potential lifetime.

POWER SOURCE

Radiant warmers are powered with mains/socket power. Radiant warmers are typically the largest consumers of power in a nursery and should be plugged into their own socket and surge protector if available. **(6.1 & 6.2)** Radiant warmers typically draw too much power to be used with small-scale solar systems. In most cases, the cost (both financially and energetically) to run radiant warmers during a power cut prevents them from being used with backup power.

6.1 Radiant warmers should be plugged into their own socket.

6.2 Radiant warmers should be plugged into a surge protector if possible.

WARD LOCATION

Radiant warmers should be placed against a wall with the power cable/stand facing the wall and control panel facing the middle of the nursery room. **(6.3)** Warmers should be away from any windows to avoid air currents disrupting heat radiation. Windows are preferably kept closed.

6.3 Appropriate placement with the power cable port facing the wall and displace LCD facing away from the wall.

USER PREVENTIVE MAINTENANCE

Preventive maintenance should be conducted weekly and should include:

1. **Test the heating elements and temperature probe:**
    - Plug in the machine. Connect the temperature probe. Turn the power switch to ON. Leave the machine on for 1 minute.

- Hold the temperature probe in the palm of your hand and hold your hand near the overhead heating elements. Slowly move it from the part of the heating element closest to the stand, moving towards the outside end of the heating element. You should feel your hand progressively heat as you move it, and see the temperature reading on the machine steadily increase.
- If you feel any sections of the heating elements are not providing heat, contact your maintenance department.

2 **Test the power loss alarm:** while the radiant warmer is plugged in and turned on, turn off the power at the wall socket. An alarm should sound. If it does not sound, contact your maintenance department.

7 Troubleshooting & Repair

Although users are not responsible for repairing their devices, there are steps that may be taken to troubleshoot first-line errors that may occur before contacting maintenance or engineering support.

1 The radiant warmer does not turn on

- ☐ Check that the power cable is firmly plugged in to the back of the device. Check that the power switch on the back of the device is turned on.
- ☐ If the power switch is turned on and the power cable is firmly plugged in but the device is still not turning on, try replacing the power cable.
- ☐ Should the radiant warmer still not turn on, contact your maintenance department.

2 The radiant warmer is turning on, but is not heating

- ☐ Check the radiant warmer settings to ensure that heating is turned on: If in manual, the heating settings may be set to 0%. **(7.1a)** Make sure that the heater output is set to a number above 0%. **(7.1b)**
- ☐ If the heating settings are turned on & the radiant warmer is still not heating, contact your maintenance department.

7.1a Manual settings set to 0% heat output.

7.1b Manual settings set to 25% heat output.

3	**The radiant warmer is turning on, but the temperature probe is not reading the patient's temperature**

- ☐ Hold the temperature probe in the palm of the hand and watch temperature reading on control panel to see if the temperature changes to a reasonable body temperature.
- ☐ If the temperature does not change or there is a "Probe alarm" displayed, replace the probe with a spare or contact your maintenance department.

Assessment Questions

1 You have started to manage a patient's temperature using a radiant warmer. When you are making your monitoring rounds, you note that the warmer display shows the alarm in **1a**. What does this alarm indicate?

The patient has a high temperature.

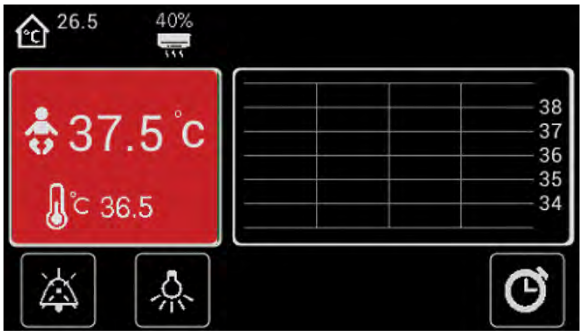
You walk over to check the patient. Whilst there, you see the patient as in **1b**.

a What is wrong with this patient's monitoring?

The patient temperature probe is not secured on the patient's core.

b Will it have an effect on the patient's temperature management? If so, what?

It will have an effect; the temperature probe is reading the temperature of the mattress, which is colder than that of the patient. If the radiant warmer is in servo/automatic mode, it may overheat the patient.



1a

1b

2 A baby is under the radiant heater which is in manual mode. What is the most important, potential complication?

The baby may become hypo- or hyperthermic if the heater output is not watched and increased or decreased as necessary.

3 How often will you monitor the baby?

Monitor the patient's temperature 5 minutes after starting on radiant warmer, and then 4 hourly (if in **servo** mode) or every 30 minutes (if in **manual** mode).

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