# Temperature Measurement in the Preterm and Term Neonate: A Review of the Literature

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**Abstract**

The maintenance of a constant body temperature is important to all humans but even more so for newborn babies (neonates), especially those born pre-term. Because accurate measurement of body temperature is an important component of thermoregulation management in the neonate, a review of the literature was undertaken to determine the most appropriate method and site of temperature measurement in both the preterm and term neonate. The available evidence indicates that the axilla remains the most common place for temperature measurement.

The maintenance of constant body temperature is important to all humans but even more so for newborn babies (neonates), especially those born preterm. Environmental regulation is essential for the neonates because, unlike adults and older children, they have limited ability to regulate their own temperature. Furthermore, neonates are extremely sensitive to temperature changes associated with illnesses.[1] Detection of temperature change enables early intervention because changes in body temperature may indicate the presence of infection and can impact physiologic responses that can include metabolic reactions, hypoglycemia, and hypoxia. Accurate measurement of body temperature is an important component of maintaining normal temperature in the neonate.[2]

This review examines the literature associated with temperature measurement in the neonate. It aims to establish the most appropriate method and site of temperature measurement in both the preterm and term neonate.

## BACKGROUND

For the purpose of this review, hyperthermia was defined as any temperature >37.5°C.[3]

Measuring temperature in the neonate should be simple and as noninvasive as possible.[2] In the past, temperature in neonates was measured via the axilla or rectum using mercury in glass or digital thermometers. The rectal method using mercury glass thermometers or digital thermometers was generally considered the "gold standard."[4,5] Historically, several issues were raised about the use of glass thermometers, which resulted in their replacement with newer devices.[6–8]

Digital devices, which are placed in the axilla, remain a common option for use in neonatal units.[9–16] The main disadvantage of these devices is the time it takes to obtain an accurate reading: up to three minutes, depending on the device.[9,17] More recently, the thermistor device has been used for both axilla and tympanic measurement. It has been found to be a quick (within ten seconds) and accurate way of measuring temperature in both the adult and pediatric population.[18–20] However, despite the introduction and use of electronic, thermistor, and infrared (IR) thermometers, their efficacy in preterm and term neonates has not been clearly established.

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## METHODS OF LITERATURE REVIEW

### Search Strategy

The databases used for the review were CINAHL, MEDLINE, The Cochrane Library, PubMed, and Ovid. The search spanned 26 years beginning with the 1984 report by Mayfield and colleagues. These authors compared axillary temperature measurement with core (deep rectal) temperature in 99 term infants and 24 preterm infants; this was considered a pivotal study regarding this review.

### Keywords

The key search words used were infant, neonate, axillary temperature, tympanic temperature, neonatal nursing, neonatal temperature, neonatal thermoregulation, electronic thermometer, digital thermometer, tympanic thermometer, and preterm temperature.

### Inclusion/Exclusion Criteria

Papers were selected for the review that met the following criteria:

1. Research papers in peer-reviewed journals, which included the neonatal population
2. Papers published in English
3. Papers published between 1984 and 2011

Papers that did not meet the aforementioned criteria were excluded from the review.

## RESULTS

Fifty-two studies were identified. Twenty-one of these studies were not included in the review because they focused only on the pediatric population. Of the thirty-two studies eligible for review, all included the axilla and/or tympanic body sites (Table 1). Although the axillary method is currently preferred in the neonate because of its safety and accuracy, there are other approaches in use as well as a variety of devices being used to measure temperature in the neonate.[4,9,15,17,19,21–25] Therefore, it was deemed necessary to review the current research related to the efficacy of approaches and devices for temperature measurement in neonates.

### Routes Used in Temperature Measurement in the Neonate

In general, any site near a major artery is suitable for assessing body temperature.[26] Invasive techniques such as pulmonary artery temperature measurement are impractical for use in neonates.[27] In clinical practice, the most convenient sites for measuring temperature are sublingual, rectum, axilla, and ear canal. Of course, the mouth is not used in the neonate or pediatric patient because of factors such as poor compliance, intubation, continuous positive airway pressure (CPAP), and the use of nasal oxygen; both the axilla and rectum are used for measuring temperature. The most commonly used site for monitoring temperature in the neonate is the skin. Incubators and radiant warmers are designed to work using a set skin temperature. Continuous monitoring of the abdominal skin temperature is a noninvasive method that has shown good correlation with rectal temperatures.[28]

The axillary method of temperature measurement has been shown to correlate closely with rectal temperature.[4,15,24–26] It has also shown to be accurate, easy to access, causes fewer disturbances to the neonate when compared with rectal, and is considered a relatively safe option.[25,29] However, axillary temperature measurements still require some manipulation and can cause stress-related events in neonates such as desaturations or bradycardia as a result of overhandling. Roll and colleagues evaluated 21 infants and assessed whether infants tolerate axillary temperature measurement better than rectal.[30] They found that mean heart rate increased and oxygen saturations decreased in 20 percent of infants. These investigators also assessed cerebral oxygenation and documented a decrease in cerebral oxygenation.

The length of time it takes to obtain an accurate temperature reading via digital thermometer is not clearly defined in the literature, especially when so many different thermometers are now being used in the neonatal population. However, rapid-response thermometers can now give a temperature reading in less than ten seconds.

**Infant Discomfort Between Axillary and Temporal**. Two recent studies, Lee and colleagues and Duran and colleagues, measured infant discomfort associated with temperature measurement by using a pain scale adapted for neonates.[31,32] Both studies confirmed that temperature measurement via the axillary method increases discomfort levels. Lee and colleagues studied a total of 34 infants and showed discomfort using the temporal artery was 3 (9 percent) compared with 14 (41 percent) after axillary temperature measurement.[31] Duran and colleagues, using the premature infant pain profile (PIPP), concluded that the mean PIPP score of axillary temperature measurements were significantly higher than midforehead and temporal artery measurements.[32] Therefore, temperature measurement via the axilla site needs to be quick yet accurate.

**Comparison Between Axillary and Rectal Temperatures**. In a seminal study on temperature measurement routes in the neonate, Mayfield and colleagues studied premature and term neonates to determine the relationship between the accuracy of axillary temperatures and deep rectal temperature.[33] They concluded that axillary temperature was as reliable as the rectal temperature when using glass/mercury thermometers. Interestingly, studies by Khan and colleagues and Haddock and colleagues identified rectal temperatures to be significantly different from axillary temperatures.[9,34] They also reported that infants took from 2 to 11 minutes to reach their maximum axillary temperature, whereas rectal temperatures took from 1 to 5 minutes when taken with a mercury in glass thermometer (electronic thermometers can produce an axillary temperature in less than ten seconds, whereas others,

**TABLE 1 ■ Studies: Temperature Taking in the Term and Preterm Infant**

| Study | Site | Apparatus | Key Findings | Limitations |
|---|---|---|---|---|
| Eoff et al. (1974)[66] | Axilla<br>Rectal | Mercury in glass telethermometer | Significant difference between axillary and rectal temperatures ($p < .1$). Axillary temperature is recommended. | Healthy infants<br>Small sample size (N = 30)<br>Open cot |
| Mayfield et al. (1984)[33] | Rectal<br>Axilla<br>Skin | Glass mercury thermometer | Close agreement between rectal and axillary temperatures. | Wide gestational age and weight |
| Moen et al. (1987)[68] | Axilla<br>Rectal | Glass mercury thermometer | Axillary measurement can be substituted for rectal measurement. | Small sample size (N = 25)<br>Preterm infants |
| Haddock et al. (1988)[9] | Axilla<br>Rectal | Glass mercury thermometer | 99% of preterm infants reached their optimum axillary temperature in 3 min. The difference between rectal and axilla showed a wider range than in Mayfield et al. | Small sample size (N = 30)<br>Preterm infants |
| Bliss-Holtz (1989)[71] | Rectal<br>Axilla<br>Inguinal | Glass mercury thermometer | At least 99% of the subjects reached temperature stabilization by 5.5 min. It was found that the inguinal site temperatures are more reflective of rectal temperatures and may be less sensitive to the effects of BAT heat generation. | Term infants |
| Johnson et al. (1991)[67] | Axilla<br>Rectal<br>Tympanic | FirsTemp<br>Glass mercury | No difference in temperature in the protected and unprotected ear.<br>No significant differences in axillary readings between tympanic and mercury in glass. | Tympanic thermometer underestimated in two modes and overestimated in one<br>Wide gestational age and weight<br>Healthy infants<br>Small sample size (N = 31) |
| Weiss (1991)[62] | Axilla<br>Rectal<br>Tympanic | Thermoscan<br>IVAC electronic | No significant difference between tympanic and axillary. Correlations between left and right ear were moderate. | May be variations in technique and/or ambient temperature<br>Small sample size (N = 34) |
| Yetman et al. (1993)[22] | Rectal<br>Axilla<br>Oral | Glass mercury<br>Aural tympanic | Temperatures—axillary and rectal—were similar.<br>Tympanic thermometer in oral and rectal mode did not reflect rectal or axillary temperature. | Wide gestational age and weight<br>Study conducted on healthy infants<br>Open cots only |
| Rekha et al. (1993)[10] | Rectal<br>Axilla | Not stated | Difference between rectal and axillary temperature was 0.3°F.<br>Correlation was good.<br>Axillary temperature can be used as an alternative. | Wide gestational age and weight<br>Small sample size (N = 55) |
| Weiss (1994)[23] | Axilla<br>Rectal<br>Tympanic | IVAC electronic | No significant differences between tympanic and axillary temperatures.<br>Right ear (exposed) best approximation of axillary measurement. Protected ear (nearest the mattress) is best approximation of rectal temperature. | Term infants<br>Small sample size (N = 34) |
| Weiss et al. (1994)[63] | Axilla | IVAC electronic in P and M modes | Support axillary temperature measurement via the P mode. | |
| Hicks (1996)[12] | Axilla<br>Tympanic | FirsTemp<br>Glass mercury | There was a difference of 1.2°C between axillary and tympanic for the overall sample. | Wide gestational age and weight<br>Small sample size (N = 40) |
| Cusson et al. (1997)[36] | Tympanic<br>Inguinal<br>Axillary | IVAC electronic<br>FirsTemp | No significant differences between right and left ear. Correlations between tympanic and rectal were weak. Significant interaction was found between site and environment.<br>Tympanic should be used with caution in newborns. | Healthy term infants |

*(continued)*

**TABLE 1 ■ Studies: Temperature Taking in the Term and Preterm Infant** *(continued)*

| Study | Site | Apparatus | Key Findings | Limitations |
|---|---|---|---|---|
| Leick-Rude & Bloom (1998)[13] | Axilla<br>Tympanic<br>Tempa-Dot<br>Digital | IVAC electronic<br>BD Digital<br>Tempa.Dot<br>Glass mercury | The BD thermometer has the highest correlation with the mercury in glass.<br>Skin temperatures were influenced by swaddling.<br>Tympanic was inappropriate for hospitalized neonates. | Tympanic thermometer was awkward to handle and position.<br>Infants objected to ear tug.<br>Study conducted on infants only <1,500 g. |
| Fallis & Christiani (1999)[14] | Axilla | IVAC Temp Plus in M and P modes | The P mode is reliable for axillary measurement. | Healthy term infants |
| Seguin & Terry (1999)[37] | Axilla<br>Rectal | LighTouch<br>Thermistor 400 | Axillary temperatures via IR approximate rectal temperatures. | Healthy term infants<br>Small sample size (N = 28) |
| Browne et al. (2000)[25] | Axilla<br>Tympanic | Glass mercury<br>LighTouch<br>Genius | Glass mercury axilla correlated well with standard rectal glass mercury.<br>The use of IR axillary thermometer is recommended. | Study conducted on healthy term infants. |
| Jirapaet & Jirapaet (2000)[15] | Tympanic<br>Skin<br>Axilla<br>Rectal | FirsTemp<br>Glass mercury<br>Electronic | Mean axillary temperatures were the least different from the rectal.<br>Tympanic temperatures in the rectal mode showed significantly higher mean temperatures than rectal temperatures.<br>The protected ear has a significantly higher temperature than the exposed ear. | |
| Sganga et al. (2000)[72] | Axilla<br>Tympanic | Digital disposable<br>Electronic<br>Glass mercury | Tympanic were the most "cost worthy," but lack of correlation with the glass mercury makes them a poor choice for newborns. | Term newborns |
| Bailey & Rose (2001)[4] | Tympanic<br>Axillary | Glass mercury<br>FirsTemp | Statistically significant difference between tympanic and axilla; however, the mean temperature differences are only small and not clinically significant.<br>Temperature from the protected ear is higher in 82% of cases. | Difficulty placing the probe in the ear<br>Preterm infants<br>Small sample size (N = 22) |
| Bergstrom et al. (2004)[70] | Tympanic<br>Rectal | Braun ThermoScan<br>Digital | Correlation between tympanic and rectal is satisfactory. | Healthy term infants |
| Smith (2004)[16] | Groin<br>Axilla<br>Rectal | DataTherm<br>Glass mercury | Axilla site performed better than the groin skin site. | Healthy term infants<br>Small sample size (N = 44)<br>Open cots only |
| Rosenthal & Leslie (2006)[19] | Axilla | SureTemp<br>Glass mercury<br>LighTouch IR | 93% of readings by the SureTemp and 96% by the LighTouch thermometers were within 0.5°C of the paired glass mercury readings demonstrating good positive correlation. | |
| WelchAllyn, Inc. (2003)[20] | Axilla | SureTemp<br>Axilla in P and M modes | Excellent correlation and not clinically significant<br>Difference between 5 min. monitor mode and predicted axillary temperatures (average error was 0.044°C) | Term newborns<br>Small sample size (N = 20) |
| Hissink Muller et al. (2008)[2] | Axilla<br>Rectal | Digital thermometer | Axillary temperatures significantly lower than rectal temperatures. Mean difference of 0.27°C, 95% limits of agreement, ranged from 0.13° to 0.67°C. | Small sample size (N = 33) |
| De Curtis et al. (2008)[47] | Rectal<br>IR skin | Glass mercury<br>IR skin | The IR device provided lower readings than the mercury rectal thermometer, with the difference being negative in 61%. | |
| Hutton et al. (2009)[60] | Axilla<br>Rectal | Alaris Temp Plus<br>SureTemp<br>Tempa.Dot | Statistically significant temperature difference between axillary and rectal temperatures | Term infants<br>Small sample size (N = 36) |

*(continued)*

**TABLE 1 ■ Studies: Temperature Taking in the Term and Preterm Infant** *(continued)*

| Study | Site | Apparatus | Key Findings | Limitations |
|---|---|---|---|---|
| Duran et al. (2009)[32] | Temporal artery<br>Axilla<br>IR skin | Glass mercury<br>Plus Med IR | No statistically significant difference was noted between the means of the midforehead and axilla.<br>Temporal artery thermometer was statistically higher than the forehead and axilla. | Preterm infants <1,500 g<br>Small sample size (N = 34) |
| Lee et al. (2011)[31] | Temporal artery<br>Axilla<br>Rectal | Rectal probe<br>IR TAT-5000<br>SureTemp | Significant difference between temporal artery and axilla when compared with rectal temperatures ($p > .01$). | Small sample size (N = 34) |
| Uslu et al. (2011)[59] | Digital<br>Rectal<br>Tympanic<br>Forehead | Digital<br>Mercury<br>IR | Tympanic, good correlation with mercury thermometer | |
| Duru et al. (2012)[61] | Rectal<br>Tympanic | Mercury<br>Braun | Good correlation between rectal and tympanic, but sensitivity in the tympanic method was relatively low. | Term infants<br>Different wards |

*Abbreviations:* BAT = brown adipose tissue; P mode = prediction mode; M mode = monitor mode; IR = infrared.

such as the digital thermometer, can take up to three minutes if used in monitor mode).

The difference between rectal and axillary temperatures in the newborn may be influenced by the presence or absence of brown adipose tissue (BAT). The BAT is found within the neck, back, mediastinum, abdomen, and axillae. Mayfield and colleagues noted that premature infants took a shorter time to reach their axillary temperature when compared with the term infant.[33] This could be attributed to the brown fat, which is in the axillary area, whereby it can generate heat. Dodman concluded that the close proximity of the BAT could give a false high axillary temperature recording.[35] The difference in a premature neonate's temperature could also be attributed to the environment in which he or she is cared for, mainly incubator care, which can sometimes involve up to 90 percent humidity (depending on the gestational age of the infant), where a constant temperature is set according to gestational age.[13,36,37]

There is considerable variability in the sensitivity of axillary temperatures reported in the literature. In some trials, the sensitivity of the axillary method is reported to be between 27.8 and 33.0 percent.[38,39] On the other hand, a study done by Morley and colleagues found that the axillary method has a sensitivity of 73 percent, with a postpredictive value of 69 percent and a false-negative rate of 27 percent.[40] This variability may be related to the device studied and highlights the differences between different devices.

**Rectal Temperature**. Many clinicians continue to consider rectal temperature measurement as the gold standard because it closely approximates the neonate's core temperature and is not influenced by ambient temperature or age.[41–43] Problems with the rectal approach include trauma to the rectum as well as the potential for infection secondary to perforation with subsequent sepsis and hemorrhage, and rectal temperature measurement is contraindicated if there is bowel disease, especially necrotizing enterocolitis and trauma to the rectum.[44–47] It has also been suggested that, in a hypotensive state such as that which occurs in overwhelming sepsis, perfusion of the rectum can be impaired, which may cause a lag in changes of core body temperature.[45,48,49] It is also contraindicated in conditions such as thrombocytopenia because of the risk of perianal bleeding.[48] Frank and Brown discussed two cases where infants suffered rectal perforation, which was probably caused by a thermometer.[46] A further 26 cases of neonatal rectal perforation caused by thermometers were reported by Horwitz and Bennett, Lynch and colleagues, and Tan and colleagues.[8,50,51]

Dodman questions the accuracy of rectal thermometry, arguing that the core temperature decreases after the skin temperature drops, but Schuman claims that there is a good correlation between rectal and axillary temperature in neonates.[35,52] As a result, it has been argued that rectal temperatures can be lower or higher than the core temperature. A more recent study conducted to determine the efficacy of the axillary and rectal method in neonates found a wide variation between the two methods, with rectal temperature being the most reliable indicator of core body temperature.[2] This study evaluated the difference between axillary temperature and rectal temperature measurement in neonates using a single brand of digital thermometer. This study enrolled 33 neonates with gestational age between 25 and 42 weeks. They concluded that axillary temperature was significantly lower than rectal temperature (mean ± standard deviation [*SD*] 0.27 ± 0.20°C, $p < .5$). Variations in temperature could be attributed to several factors, including operator technique;

positioning of the thermometer in the axilla; measurements taken after a clinical procedure such as a chest x-ray; environment; and skin maturity.

Rectal temperature monitoring is not used regularly in the neonate; however, in infants suffering from hypoxic ischemic encephalopathy (HIE), whole body cooling and head cooling is administered. The core body temperature needs to be reduced to 34°C, and it is necessary to reduce systemic temperature to that degree to achieve deep brain cooling.[53] A target core temperature of 33.5°–34.5°C is maintained for 72 hours. The goal during this phase is to avoid large fluctuations in the core temperature. To achieve this, the use of the rectal core thermistor temperature probe or an esophageal probe is used with a skin temperature probe fixed to the abdomen (dual temperature measurement). The core temperature is then measured continuously and avoids fluctuations.[54]

**Skin**. Continuous monitoring of the abdominal skin temperature is a widely used and accepted practice in neonatal units. It is a noninvasive method, and research has shown that it correlates well with rectal temperatures.[28] However, more research is needed because skin and core temperatures are different, and servo-controlled incubators act on changes in skin temperature, not on core temperature.[55] The incubator is set to the desired skin temperature, and an insulated patch is placed over the thermistor, which then gives a continuous temperature readout. The incubator will adjust accordingly in response to signals from the thermistor attached to the skin.[56]

**Esophageal**. Esophageal temperatures are considered central temperatures because of the large central vasculature and close proximity to the heart. Esophageal temperatures are not routinely used in the neonatal population and are mainly used in anesthesia or in therapeutic hypothermia.[55] When esophageal temperatures are monitored, they will measure the core temperature when placed in the lower third of the esophagus.[57] It has been noted that neonates have minimal thermal insulation between the esophagus and the tracheobronchial tree; therefore, temperature measurements may not be accurate when measured from this site (Table 2).[48,58]

**TABLE 2 ■ Methods of Temperature Taking**

| Mode of Measurement | Advantages | Disadvantages | Factors Influencing Measurement |
|---|---|---|---|
| Axillary | Safe<br>Easily accessible<br>Reasonably comfortable<br>As accurate as rectal temperature<br>Recommended as the standard (AAP)<br>Cost effective<br>Minimal cross-infection | Can take longer to achieve depending on thermometer used<br>Affects sweat evaporation, which can cause temperature to be lower than core temperature | Environment<br>Placement of thermometer<br>Time of placement |
| Rectal | Gold standard<br>Closely approximates core temperature<br>Not affected by ambient temperature<br>Not limited by age | Time consuming<br>Unhygienic<br>Risk of perforation<br>Risk of sepsis<br>Lags in core temperature change | Presence of feces<br>Local blood flow<br>Bowel organisms<br>Cool blood from lower extremities<br>How deep the thermometer is inserted |
| Skin | Comfortable<br>Steady and continuous<br>Easy to use<br>Automatic response to temperature changes | Fragile skin | Placement of probe<br>Humidity<br>If probe is loose<br>If probe is placed between body and mattress |
| Esophageal | For surgical patients<br>Therapeutic hypothermia<br>Central temperatures | Invasive<br>Not practical for use | Minimal thermal insulation between esophagus and tracheobronchial tree |
| Ear | Fast<br>Easy to use<br>Minimal cross-infection<br>Cost effective<br>Tympanic membrane shares blood flow with hypothalamus via carotid artery | Large probe for premature infants<br>Difficult to place the probe correctly<br>Can record surface temperature<br>Inaccuracies in the neonatal population | Different operating modes<br>Operator technique<br>Environment |

*Abbreviation:* AAP = American Academy of Pediatrics.

### Measurement Devices

Temperature measurement is a commonly used assessment tool for care of the term and preterm infant. There are many different types of measurement devices, which are appearing frequently and are being used in neonatal units. These devices include mercury in glass, digital, electronic, chemical, and IR thermometers. The introduction of the digital thermometer has helped pave the way for a more rapid response in axillary measurement in the neonate. This means that many new measurement devices are being compared with other better-known or more commonly used devices to ascertain their accuracy, reliability, and speed of use.[31,32,47,59–61]

**Mercury in Glass and Digital Thermometers**. Mercury in glass and digital thermometers have obviously been studied more frequently than other devices. Mercury in glass and digital thermometers when used in the axilla are said to be comparable.[25] Leick-Rude and Bloom confirmed that the digital thermometer used in the axilla had the highest correlation with mercury in glass.[13] However, Hissink Muller and colleagues noted that, when used in the axilla and rectal sites, the digital thermometer's axillary temperatures were significantly lower than rectal temperatures.[2] A more recent study by Uslu and colleagues demonstrated a good correlation, at the axilla site, using a digital thermometer and mercury in glass thermometer.[59] The mean difference was statistically but not clinically significant.

**Electronic Thermometer**. Electronic thermometers have also been widely used and tested in the neonatal population.[11–14,36,62–64] All authors agree that there was good correlation when compared with other devices, which included IR, mercury in glass, and digital. They supported the use of the electronic thermometers (SureTemp, FirsTemp, and IVAC) in the neonatal population. All electronic thermometers are portable thermistor thermometers. A study conducted by Rosenthal and Leslie, comparing electronic, IR, and mercury in glass thermometers, found the SureTemp thermometer to be a reliable method for temperature measurement.[19] In a sample size of 34 infants in a neonatal intensive care unit (NICU) setting, the mean difference between the reading from the SureTemp and mercury in glass thermometer is 0.1°C; on average, the SureTemp read 0.1°C higher than the mercury in glass. Data from the WelchAllyn trial, consisting of newborns from one hour old to three days old, showed that the average error was 0.044°C with an SD of 0.199°C.[20] Therefore, the SureTemp thermometer is quick (on average, an axillary temperature could be reached in 10.2 seconds), accurate, and easy to use.

**Tympanic Thermometer**. The use and accuracy of tympanic thermometry in neonates is still unclear. The main problem has been related to the size of the probe, which is thought to be too large for the small neonatal ear. If the probe is not placed in the ear canal, it is reported that it records surface temperature rather than tympanic. Davis, who studied tympanic temperature measurement in children, argued that, because of the IR signal, probe size does not affect accuracy.[21] However, other studies have found some differences when using the probe in very small ears.[4,13,22,36] In 2009, a smaller probe was designed so more research could be carried out into the efficiency, accuracy, and reliability of tympanic thermometry in small infants using the smaller probes.

Tympanic thermometry is quick and would cause minimal disturbance. However, its use on sick and premature neonates is not yet validated. More research is needed into the use of the tympanic measuring device in preterm and term neonates.

**Infrared Thermometers**. Temporal artery thermometers, also known as IR thermometers, have been introduced over the past ten years. Noncontact IR thermometers use IR technology to quickly and conveniently measure a surface temperature. You can obtain a fast temperature reading without touching the infant. IR thermometers are able to capture the invisible IR energy (invisible heat) naturally omitted via radiation.[65] These devices reduce the need to handle the infant and therefore cause minimal disturbance. They are reputed to be quick, easy to use, and cause no discomfort to the infant.

In a comparative study of 57 neonates (term and preterm), Brown and colleagues found that IR axilla and glass/mercury thermometers correlated well.[25] They concluded that both thermometers used in the axilla site showed a good correlation when compared with the standard rectal temperature measurement using a glass mercury thermometer.

There are very few published research trials on the use of IR thermometry, especially in preterm infants and different environments. A study by De Curtis and colleagues compared rectal and IR skin temperature using the mercury in glass (rectal) and a No Touch Sensor (No Touch Sensor Diagnostic, Chicco, Italy) placed 0.5 cm from the skin on the forehead in 107 newborns, with gestational age between 25 and 41 weeks.[47] The IR device tended to provide lower readings than the mercury thermometer. These authors concluded that IR skin measurement cannot act as a substitute for rectal measurement, but the difference between the two measurements was modest. However, there is no mention of the environments the infants were nursed in and whether the temperatures were affected by environmental conditions. Two further studies, Duran and colleagues and Lee and colleagues, investigated temporal artery thermometry.[31,32] Both studies found that axillary and temporal artery temperatures were similar and advocated for the use of the thermometer in neonates. More research needs to be undertaken in larger trials in both preterm and term infants on the accuracy of axillary and IR skin temperatures in different environments.

## LIMITATIONS OF THE CURRENT LITERATURE

While reviewing the literature, it became apparent that there were several methodologic issues that need to be taken into consideration before any conclusion can be made regarding final results. Some of these limitations are the following:

- The studies reviewed included samples of infants from various settings, which showed a wide difference in gestational age and weight.[12,22,33,34]
- Research to date has been primarily conducted on healthy neonates.[4,13,14,16,17,19,22,25,36,37,66,67] Only one study investigated temperature measurement on unwell neonates.[68]
- Large differences in sample sizes—ranging from 34 to 300—and the inclusion of both preterm and term neonates, with few adequately powered studies[69,70]
- Different environmental factors such as open cots, radiant warmers, and incubators were used in studies[16,22,66]; some used all three.[4,10,11,15,25,33,37]

Future studies need to be rigorously designed with the following:

- Targeted population
- Adequate sample size
- Controlled environmental conditions
- Defined procedures for temperature recording—site duration, and so forth
- Calibration of devices
- Appropriate statistical analysis
- Inclusion of healthy and sick premature and term neonates

## DISCUSSION

At present, it seems the axillary method is the most common route to measure a neonate's temperature using digital and electronic thermometers. As new temperature-measurement devices become available, research is needed to assess the different methods of temperature taking in preterm, well term, and sick term neonates. Consideration should be given to choosing between axillary, skin, or IR temperature monitoring, and whatever is chosen must be used constantly because measurement error will be increased if the mode of temperature taking is not consistent; therefore, nurses need to be aware of the various temperature-taking methods and the factors influencing neonatal temperature readings. Consideration must also be given to the environment the infant is being nursed in, gestational age, weight, and clinical condition of the infant.

Many new temperature devices are appearing on the market, and it is evident from this review that agreement and reliability needs to be established before use in the neonatal population can be recommended.

## CONCLUSION

It is important that research continues into the comparison and contrast of both new and old devices, and methods and the choice of thermometer used in the neonatal population should be influenced by safety, accuracy, and the risk of cross-infection.


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