Specific Care Question:
Non-Contact Thermometers

Question Originator:
Lacey Bergerhofer, MSN, RN-BC

Plain Language Summary from The Office of Evidence Based Practice: Summary:

Only one guideline was identified on this topic. The 2014 guideline was developed by the Canadian Agency for Drugs and Technologies in Health (CADTH) (2014). AGREE II was used to grade and evaluate this guideline. Based on the AGREE II, the guideline was recommended for use and the overall quality, of the guideline, was rated as high. The CADTH (2014) guideline included literature on Non-Contact Thermometers from January 1, 2009 to October 15, 2014. A further literature search was conducted to identify other research articles or guidelines after the publication of the CADTH Guideline in 2014. No additional literature or guidelines were identified. The guideline used sixteen non-randomized studies and four systematic reviews (Table 1). The guideline reported serious limitations of identified studies due to a large amount of heterogeneity. (Heterogeneity arises in a meta-analysis when the included studies are not undertaken in the same way.)

The research questions addressed in the CADTH (2014) guideline are:
1. What is the accuracy of tympanic infrared thermometers for detecting febrile individuals?
2. What is the accuracy of handheld infrared non-contact thermometers for detecting febrile individuals?
3. What is the accuracy of thermal scanners for detecting febrile individuals?
4. What is the comparative effectiveness of tympanic thermometers, handheld infrared thermometers, and thermal scanners for detecting febrile individuals?

The CADTH (2014) guideline supports the accuracy of tympanic thermometers. The use of thermal scanners should be used with caution (Bitar, Goubar, &Desenclos, 2009; Cho & Yoon, 2014; Chan, Kumana, & Cheung, 2013; Priest, Duncan, Jennings, & Baker, 2011; Selent, Molinari, Baxter, Nguyen, Siegelson, & Brown, 2013; Nguyen Cohen, Lipman, Brown, Molinar, & Jackson, 2010). On infrared thermometers, the guideline questions the generalizability of the evidence and recommends more research due to the ambiguity of the evidence.

Based on the findings of the CADTH (2014) guideline, the evidence does not support the purchase of infrared thermometers at this time. If the infrared thermometers are purchased an algorithm should be developed to provide nursing staff with needed actions in the event a patient has a temperature. If the infrared thermometer identifies an elevated temperature then the measurement should be repeated with more reliable thermometer to validate the findings.

EBP team member responsible for reviewing, synthesizing, and developing this literature:
Jarrod Dusin, MS, RD, LD, CNSC, EBP Program Manager

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Studies included in this review:

Method Used for Appraisal and Synthesis:
AGREE II
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<table>
<thead>
<tr>
<th>First Author, Publication Year, Country</th>
<th>Study Design</th>
<th>Patients Characteristics, Sample Size (n)</th>
<th>Intervention</th>
<th>Comparator</th>
<th>Outcomes</th>
<th>Strengths</th>
<th>Limitations</th>
<th>Main Study Findings</th>
</tr>
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<tbody>
<tr>
<td><strong>Systematic Reviews</strong></td>
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<tr>
<td>Zhen 2014, China</td>
<td>SR/MA of studies 29/31 prospective) on the diagnosis of pediatric fever.</td>
<td>31 studies (25 articles), 5749 pediatric patients. Sample size range from 40 to 964 patients. Age: &lt;18 years.</td>
<td>Infrared tympanic thermometry</td>
<td>Rectal thermometry (electronic or mercury)</td>
<td>A priori-designed SR with MAs.</td>
<td>Literature search (including grey literature) strategy described and duplicate study selection. The characteristics of the studies are provided along with their quality scores. Heterogeneity and publication bias have been assessed.</td>
<td>A list of excluded studies is not provided, only included studies are reported. Contradictory conclusions were presented in the text. Conflicts of interest were not assessed in the included studies.</td>
<td>• Pooled sensitivity was 0.70 (95% CI 0.68 – 0.72) and pooled specificity was 0.86 (95% CI 0.85-0.88). There was high heterogeneity in the pooled results. • The pooled positive likelihood ratio was 9.14 (95% CI 6.37-13.11) and the negative likelihood ratio was 0.24 (95% CI 0.17-0.34). There was high heterogeneity in the pooled results. • The pooled diagnostic odds ratio was 47.3 (95% CI 29.79-75.18). The area under the summary receiver operating characteristic (ROC) curve was 0.94 and the Q* value was 0.87. There was high heterogeneity in the pooled results.</td>
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<tr>
<td>Zhen 2014, China</td>
<td>SR/MA of cross-sectional, prospective studies investigating thermometry in pediatric patients.</td>
<td>28 studies (33 comparisons) 5448 pediatric patients. Sample size range from 36 to 623 patients. Age: &lt;16 years.</td>
<td>Infrared ear thermometry</td>
<td>Rectal thermometry (electronic or mercury)</td>
<td>Mean Difference from comparator Upper and lower 95% limits of agreement</td>
<td>A priori-designed SR with MAs. Literature search strategy described and duplicate study selection. A description of included studies with reported. Heterogeneity of the data have been assessed.</td>
<td>Excluded studies are not disclosed. Individual quality of studies was assessed, but no reported. Inclusion criteria in some studies were subjective. Publication bias was not properly assessed. Conflicts of interest were not assessed in the included studies.</td>
<td>• The overall pooled mean difference between tympanic and rectal temperature (mercury and electronic) was 0.22°C (95% limits of agreements -0.44°C to 1.30°C). There was significant heterogeneity in the data. • The mean differences between tympanic and subgrouped rectal temperature were: Mercury 0.21°C (95% LOA -0.44°C to 1.27°C) and electronic 0.24°C (95% LOA -0.46°C to 1.34°C). There was significant heterogeneity.</td>
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</table>
In febrile children (subgroup), the pooled mean difference between tympanic and rectal temperature was 0.15°C (95% LOA -0.32°C to 1.10°C). There was significant heterogeneity in the data.

| Jefferies 2011, New Zealand | SR of prospective studies investigating thermometry in critically ill patients. | 3 studies, 110 critically ill adult patients with fever. Sample size ranging from 9 to 72 patients. | Infrared tympanic thermometer. Studies compared different Devices/mode/core temperature ranges | Pulmonary artery catheter core thermometry | + Mean difference from core temp. | A priori-designed SR. Literature search strategy was described. The characteristics of the studies and their quality were reported. Conclusions were in line with the results. | Study selection was not duplicated. The authors did not mention if grey literature was included. Excluded studies were not disclosed. Publication bias was not assessed. Conflict of interest were not assessed for included studies. Included studies were heterogeneous, lacked some information on the study or patient characteristics and the statistical methods either failed to account for repeated measures on the same participants or did not report appropriate measures of variation (meta-analysis could not be conducted). | + Five of seven different tympanic thermometer/mode/core temperature range combinations were clinically accurate with a mean difference within ±0.2°C of core febrile temperatures. + The two tympanic thermometer/mode/core temperature ranges combinations that exceeded this limit had a mean difference of -0.22°C (Thermoscan Pro-1/unadjusted mode/ temp. 37.6-38.0°C) and 0.24°C (Thermoscan HM-1/oral mode) from core temperature. |
| Bitar 2009, France | SR of studies on fever screening under mass screening conditions. | 6 studies, 77,024 participants (including healthy visitors, hospitalized patients or patients presenting for emergency or | Non-contact thermometry: infrared skin thermometers and thermal infrared cameras (tympanic was | Tympanic thermometry | + Sensitivity • Specificity • Positive/Negative predictive values | The characteristics of the included studies were reported. | A priori design has not been mentioned. Study selection was not duplicated. Literature search strategy was not comprehensive, | + Sensitivity varied from 4.0 to 89.6%. + Specificity varied from 75.4 to 99.6%. + The positive predictive values
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<table>
<thead>
<tr>
<th>Sample size ranging from 176 to 72,327</th>
<th>considered contact</th>
<th>inclusion of grey literature is uncertain. Excluded studies were not properly reported. Quality assessment of included studies was not documented. Publication bias was not assessed. Conflict of interest was not disclosed.</th>
<th>(PPV) varied from 0.9 to 76.0% and the negative predictive value (NPV) from 86.1 to 99.7%.</th>
</tr>
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#### Non-randomized studies

<table>
<thead>
<tr>
<th>Cho 2014, Korea</th>
<th>Non-blinded, retrospective, cross-sectional study, Airport setting.</th>
<th>608 symptomatic arrivals (runny/stuffed nose, sore throat, cough, fever) were analyzed. 313 F/294 M. Age: mean 25.1 years, range 1 to 86. Participants were travelers at an international airport</th>
<th>Thermal Camera temperature (Thermovision A20M, Thermo Tracer TH7800, ThermoGraphy R300)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tympamic (or ear) thermometry (ThermoScan IRT-3020 and IRT – 4020)</td>
<td>• Fever prevalence</td>
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<tr>
<td>• Association between self-reported fever and tympanic temperature</td>
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<tr>
<td>• Difference between thermal camera and tympanic thermometry</td>
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<tr>
<td>Description of objective, outcomes, subject characteristics, interventions, findings (with actual P value). Participants were representative of the study population and in a realistic context. Comparison of interventions is made on a single group. Outcome measure was objective.</td>
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<td>Investigators were not blinded. Retrospective study. Variability of measurements were not correctly reported.</td>
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<tr>
<td>• Fever prevalence was of 0.002% among the total arrivals screened and of 1% among the symptomatic arrivals.</td>
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<td>• Among self-reported fever arrivals (31 cases), 2 cases (6.5%) were confirmed as febrile. Of all non-self-reported febrile arrivals (577 cases), 4 cases (0.7%) were identified as febrile. The association with the declaration was statistically significant (P &lt; 0.001).</td>
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<td>• The average temperature from thermal camera scanning (36.83°C) and average tympanic temperature (38.14°C) were not statistically significant.</td>
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<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Population</th>
<th>Methods</th>
<th>Findings</th>
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</thead>
<tbody>
<tr>
<td>Chan 2013, China</td>
<td>Non-blinded, prospective study, Hospital setting.</td>
<td>1517 patients with or without fever, who presented to an accident and emergency department. Mean age: 45.8 years (747 M/770 F)</td>
<td>Remote sensing infrared camera (maximal frontal, lateral views and forehead temperatures) (FLIR ThermaCam S40) Oral or ear thermometry</td>
<td>• Proportion of feverish subjects detected • Correlation with reference • Sensitivity • Specificity • PPV/NPV • Positive/negative likelihoods</td>
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<td>Description of objective, outcomes, subject characteristics, findings (with actual P value and CI). Participants were representative of a population in hospital. Comparison of interventions is made on a single group. Outcome measure was objective. Oral and ear thermometers were not described. The percentage of participation was not disclosed. Investigators were not blinded. No power calculation. No description of statistical analyses. The timing of measurements was not reported.</td>
</tr>
<tr>
<td>Selent 2013, USA</td>
<td>Non-blinded, prospective study, Hospital setting.</td>
<td>855 pediatric patients who presented at emergency department. 469 boys/386 girls. Age: 6 months to 3 ITDS: two thermal cameras (OptoTherm Thermoscreen and FLIR) and one handheld</td>
<td>Oral, rectal or axillary thermometry following age.</td>
<td>• Sensitivity • Specificity • Correlation with reference • Receiver operating characteristic</td>
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<td></td>
<td>Description of objective, outcomes, subject characteristics, interventions, findings (with actual P value and CI).</td>
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<td>Investigators and patients were not blinded. The timing of measurements was not reported.</td>
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<td>• 113 (7.4%) of patients had fever. • IRT temperatures were lower (-3.10ºC) and more variable than reference. The correlation between the two was significant (P &lt; 0.001), albeit generally under 0.5. The maximal forehead (FOREMAX) had the lowest correlation. This correlation was dependent on age, gender and core temperature, i.e. optimal in ≤ 20 years old febrile males. • To detect a core temperature ≥38ºC, the area under the curves of ROC were of 0.812 (95% CI, 0.761-0.863), 0.780 (95% CI, 0.723-0.837), and 0.815 (95% CI, 0.763-0.867) for maximal frontal (AREAMAX), FOREMAX and lateral views (LATMAX) temperatures. No difference when subgrouped in regard to sex. • At a low cut-off temperature (35ºC IRT, i.e. ≈38ºC core temp) for AREAMAX and LATMAX, the maximum sensitivity was 0.87, specificity was 0.34-0.43, PPV was 0.10-0.11, NPV was 0.97-0.98, positive likelihood 1.33-1.53 and negative likelihood 0.29-0.37.</td>
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| Chue 2012, Thailand | Non-blinded, prospective study. Screening at border with high ambient temperature. | 201 persons who presented at a border. Age: mean 27 years, range 5 to 70. 40.8% M/59.2 F. 26.9% pregnant women. | Tympanic thermometry (Braun ThermoScan IRT 4520) | Oral mercury in glass thermometry | • Temperature difference from oral thermometry | Description of objective, participants characteristics, interventions, findings (with actual P value and CI). A fair percentage (72.6%) of eligible children participated to the study. Comparison of interventions is made on a single curve | Outcomes were not clearly stated. Very ill patients were excluded from the study. Investigators and patients were not blinded. | 38.3% of participants were defined as febrile (i.e. ≥37.5°C with oral). | • For each of the three investigators, the mean difference from oral temperature was 0.05 (95% CI, 0.01-0.08°C), 0.11 (95% CI, 0.07-0.16°C), 0.12 (95% CI, 0.07-0.17°C), respectively. | • Most (92.0%) differences between tympanic temperature and Thermofocus were of 83.0%, 83.7% and 76.8%, respectively. Similar to patient report (83.9%). |
|---|---|---|---|---|---|---|---|---|---|
| 17 years, 218 rectal, 422 oral and 215 axillary temperature. | infrared skin Thermometer (Thermofocus) | curve | A high percentage (80%) of eligible children participated in the study. Comparison of interventions is made on a single group. Outcome measure was objective. Power calculation has been made. | | | | | | | • Specificity for Opto Therm, FLIR and Thermofocus were of 86.3%, 85.7% and 79.4%, respectively. Higher than parent report (70.8%). |
| | | | | | | | | | | • Correlation with traditional thermometry ($P < 0.01$ vs reference) for Opto Therm, FLIR and Thermofocus were of 0.78, 0.75 and 0.66, respectively. |
| | | | | | | | | | | • The ROC curves of OptoTherm and FLIR were similar based on ROC contrast tests ($P = 0.8025$), and areas under the curves were similar, 92.2% and 92.3%, respectively. |
| | | | | | | | | | | • Thermofocus’ area under the curve was significantly lower at 85.2%, and the curve did differ significantly from both OptoTherm ($P < 0.0001$) and FLIR ($P < 0.0001$) based on ROC contrast tests. |
| | | | | | | | | | | • Age, antipyretic, use, emotional state and positioning of child with parent in ITDS field were factors affecting readings. |
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<table>
<thead>
<tr>
<th>Teran 2012, Bolivia</th>
<th>Non-blinded, prospective study. Hospital setting.</th>
<th>434 pediatric patients at emergency room or as inpatient. Age 1 to 48 months. Mean 14.6 ± 10.7 months. 208 males/226 females</th>
<th>Infrared non-contact skin (Thermofocus) thermometry and temporal artery (Exergen) thermometry</th>
<th>Rectal glass mercury thermometer</th>
<th>Measurements taken at the same time.</th>
<th>Outcomes were not clearly described. The percentage of participation was not reported. Investigators and patients were not blinded. Power calculation has not been done.</th>
<th>167 children were identified with fever. Mean temperature was 37.9 ± 0.9°C for the rectal mercury thermometer, 37.6 ± 0.8°C for the temporal artery thermometer and 37.9 ± 0.9°C for the non-contact infrared thermometer. The mean difference vs rectal thermometry was of 0.029 ± 0.01°C for the non-contact infrared and –0.2 ± 0.277°C for the temporal artery. A significant (P &lt; 0.001) and strong (0.952 for non-contact infrared and 0.950 for temporal artery) correlation was shown vs rectal temperature. The sensitivity and specificity of the non-contact infrared thermometer were of 97%. The PPV and NPV were of 95.2% and 98.1%, respectively. The sensitivity and specificity of the temporal artery thermometer were of 91% and 99.6%, respectively. The PPV and NPV measurements on the same participant were within the manufacturers reported accuracy of ±0.2°C, and 98.4% within ±0.5°C. • Ambient temperature affected the difference only slightly (P = 0.002), the difference between the two methods of temperature measurement being 0.09 (95% CI, 0.04-0.15)°C at an ambient temperature of 30°C and 0.04 (95% CI, -0.01-0.09) at an ambient temperature of 40°C.</th>
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**Teran 2012, Bolivia**

Non-blinded, prospective study. Hospital setting.

434 pediatric patients at emergency room or as inpatient. Age 1 to 48 months. Mean 14.6 ± 10.7 months. 208 males/226 females

Infrared non-contact skin (Thermofocus) thermometry and temporal artery (Exergen) thermometry

Rectal glass mercury thermometer

- Temperature difference from comparators
- Correlation vs comparators
- Sensitivity
- Specificity
- Positive predictive value
- Negative predictive value

Description of objective, patient characteristics, interventions, findings (with actual P value and CI).

Comparison of interventions is made on a single group.

Outcome measure was objective.

Measurements taken within a short time period.

Outcomes were not clearly described.

The percentage of participation was not reported.

Investigators and patients were not blinded.

Power calculation has not been done.

167 children were identified with fever.

Mean temperature was 37.9 ± 0.9°C for the rectal mercury thermometer, 37.6 ± 0.8°C for the temporal artery thermometer and 37.9 ± 0.9°C for the non-contact infrared thermometer.

The mean difference vs rectal thermometry was of 0.029 ± 0.01°C for the non-contact infrared and –0.2 ± 0.277°C for the temporal artery.

A significant (P < 0.001) and strong (0.952 for non-contact infrared and 0.950 for temporal artery) correlation was shown vs rectal temperature.

The sensitivity and specificity of the non-contact infrared thermometer were of 97%. The PPV and NPV were of 95.2% and 98.1%, respectively.

The sensitivity and specificity of the temporal artery thermometer were of 91% and 99.6%, respectively. The PPV and NPV measurements on the same participant were within the manufacturers reported accuracy of ±0.2°C, and 98.4% within ±0.5°C.

• Ambient temperature affected the difference only slightly (P = 0.002), the difference between the two methods of temperature measurement being 0.09 (95% CI, 0.04-0.15)°C at an ambient temperature of 30°C and 0.04 (95% CI, -0.01-0.09) at an ambient temperature of 40°C.

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| Chiappini | Non-blinded, prospective multicenter (hospital s) study | 251 pediatric patients with stable, non-chronic, conditions admitted for any reason. Age: median 4.5 years, range from 1 month to 18 years. 50.6% M/49.4% F | Non-contact infrared thermometer (Thermofocus, mid-forehead temperatures) | Axillary temperature measurement with mercury thermometer s | • Variability of repeated measures • Concordance between forehead and axillary measures • Discomfort assessment • Sensitivity • Specificity • PPV • NPV | Description of objective, outcomes, subject characteristics, interventions, findings (with actual P value) were described. Participants were representative of the study population and in a realistic context. Comparison of interventions is made on a single group. Outcome measure was objective. Power calculation has been made. Measurements taken with a short time period. | Investigators were not blinded. The percentage of participation was not disclosed. | were of 99.3% and 94.6%, respectively. |

- **Chiappini 2011, Italy**
  - Clinical repeatability was 0.108°C (SD 0.095) for NCIT and 0.114°C (SD 0.103) for mercury-in-glass.
  - Mean body temperature measured was 37.19°C (SD 0.96) for mercury-in-glass and 37.30°C (SD 0.92) for NCIT (P = 0.153).
  - Using linear regression analysis, a significant correlation was obtained between the two temperature values (r² = 0.837; P <0.0001).
  - Diagnostic performance of NCIT in predicting axillary temperature of >38°C by mercury in glass thermometer:
    - sensitivity = 0.89 (95% CI, 0.80 to 0.97).
    - specificity = 0.90 (95% CI, 0.86 to 0.94).
    - PPV = 0.70 (95% CI, 0.590 to 0.81).
    - NPV = 0.97 (95% CI, 0.94 to 0.99).
  - The ROC curve to determine best threshold for axillary temperature >38.0°C, for a mid-forehead temperature of 37.98°C the sensitivity was 88.7% and specificity was 89.9%.
  - Mean distress score was significantly lower for NCIT (P <0.0001).
  - Differences in children’s temperature were not significantly correlated to age or room temperature.

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<table>
<thead>
<tr>
<th>Study Location</th>
<th>Study Design, Setting</th>
<th>Population</th>
<th>Methodology</th>
<th>BMJ#</th>
<th>Thermometer(s) Used</th>
<th>Comparison</th>
<th>Outcome</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priest 2011, New Zealand</td>
<td>Non-blinded prospective observational study. Airport setting.</td>
<td>1275 airline travelers during a seasonal influenza outbreak. (1275 in temperature comparison, 1268 for influenza prediction) All symptomatic travelers were invited to have throat and nose swabs and temperature measurement. Other travelers were randomly asked to participate.</td>
<td>Infrared thermal image scanners (FLIR) to measure cutaneous temperature</td>
<td></td>
<td>Tympanic temperature measurement (ThermoScan) and respiratory sampling.</td>
<td>Objective, outcomes, interventions, and findings were well described.</td>
<td>Comparison of interventions is made on single group.</td>
<td>0.5% of travelers screened were identified as febrile (temperature ≥37.8°C) using the ITIS.</td>
<td>0.86 (95% CI, 0.75 to 0.97)</td>
<td>71%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Barnett 2011, USA</td>
<td>Non-blinded prospective study. Hospital setting.</td>
<td>457 patients in emergency department. Average age = 64 years (SD 19 years), range 18 to 96. 59% Female/41% Males.</td>
<td>Tympanic membrane (First Temp Genius II) and oral (IVAC Temp Plus II) thermometry</td>
<td></td>
<td>Rectal (IVAC Temp Plus II) thermometry</td>
<td>Objective, patients, outcomes, interventions, and findings were well described.</td>
<td>Comparison of interventions is made on a single group.</td>
<td>The area under the ROC curve for ITIS front of face measurement of tympanic temperature ≥37.8°C was 0.66 (95% CI, 0.56 to 0.75)</td>
<td>87%</td>
<td>39%</td>
<td>2.8%</td>
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Rubia-Rubia 2010, Spain

Non-blinded prospective study. Hospital setting.

201 adult patients from intensive care unit. Mean age 59 (SD 10) years. 74% M/26% F.

Infrared ear and frontal thermometers

Gallium-in-glass, reactive strip, and digital in axilla

All compared to core temperature

Core body temperature measured at the pulmonary artery

- Validity
- Reliability
- Accuracy
- External Influence
- Waste Generated
- Ease of Use
- Speed
- Durability
- Security
- Comfort

Description of objective, outcomes, subject characteristics, findings (with actual P value and CI) were described.

Comparison of interventions is made on a single group.

Outcome measures were objective.

Power calculation has been made.

Measurements taken at the same time.

The authors did not describe the devices used.

The percentage of participation was not reported.

Investigators were not blinded.

- Validity for cut-off point pulmonary artery core temperatures 38.5°C, 38.7°C, and 38.9°C
  - Area under ROC curve 0.987 ± 0.007, 0.984 ± 0.008, 0.983 ± 0.009
  - NPV 98%, 99%, 99%
  - PPV 89%, 63%, 59%
  - specificity 98%, 95%, 93%
  - Infrared in right ear (core equivalency)
    - Area under ROC curve 0.967 ± 0.013, 0.960 ± 0.015, 0.972 ± 0.0011
    - NPV 98%, 99%, 99%
    - PPV 64%, 53%, 52%
    - specificity 91%, 90%, 91%
  - Infrared frontal on right temple
    - Area under ROC curve 0.853 ± 0.051, 0.836 ± 0.063, 0.816 ± 0.072
    - NPV 96%, 96%, 97%
    - PPV 47%, 33%, 41%
    - specificity 83%, 80%, 88%
### Fortuna 2010, USA

- **Study Design:** Non-blinded prospective observational study. Hospital setting.

- **Participants:** Convenience sample of 200 children from 1 month to 4 years of age presenting to tertiary pediatric emergency department.

- **Interventions:**
  - Non-contact infrared thermometer (Thermofocus) (mid-forehead)
  - Rectal thermometer (Welch Allen Sure Temp)

- **Outcomes:**
  - Agreement in measurement between two techniques
  - Bias of techniques

- **Measurements:**
  - Description of objective, outcomes, subject characteristics, interventions, findings (with actual P value) were described.

- **Results:**
  - Comparison of interventions is made on a single group.
  - Outcome measures were objective.

  - Measurements taken within a short time period.

  - Investigators were not blinded.

  - The percentage of participation was not reported.

  - Power calculation has not been presented.

- **Key Findings:**
  - Average rectal temperature of all participants was 99.6°F (98.7°F to 100.5°F).
  - Average infrared temperature of all participants was 99.5°F (98.6°F to 100.3°F).

  - Significant monotonic linear relationship between rectal temperatures and infrared thermometry ($P < 0.01$).

  - Slope of the regression line was far from unity ($0.697 + 0.05, r^2 = 0.48, P < 0.01$).

- **Infrared Thermometry:**
  - Infrared thermometry overestimated rectal temperature in patients with lower temperatures.

  - Infrared thermometry underestimated rectal temperatures in patients with fever ($r^2 = 0.149, P < 0.01$).

### Nguyen 2010, USA

- **Study Design:** Non-blinded prospective study. Hospital setting.

- **Participants:** 2,873 adults (>18 years of age) presenting to hospital emergency departments. 52.7% M/47.3% F. Age: mean 42, range 18 to 92.

- **Interventions:**
  - 3 ITDS (cameras): OptoTherm, FLIR, and Wahl
  - Oral digital thermometry

- **Outcomes:**
  - Sensitivity
  - Specificity
  - Receiver operating characteristic curve
  - PPV/NPV
  - Accuracy compared to oral thermometry

- **Measurements:**
  - Description of objective, outcomes, subject characteristics, interventions, findings (with actual P value and CI) were described.

  - A high percentage (86%) of eligible patients were enrolled.

  - AUC for OptoTherm was 0.96 (95% CI, 0.94-0.98), FLIR was 0.92 (95% CI, 0.88-0.96), and Wahl was 0.78 (95% CI, 0.72-0.84).

  - When oral temperature was ≥100°F, OptoTherm identified 275 (11.0%) patients as febrile, sensitivity was 91.0 (95% CI, 85.0-97.0), specificity was 86.0 (95% CI, 81.0-90.0), PPV was 17.9 (95% CI, 13.6-22.2), and NPV was 99.6 (95% CI, 99.3-99.8).

  - When oral temperature was ≥100°F, FLIR identified 247 (9.8%) patients as febrile, sensitivity was...
### Office of Evidence Based Practice – Specific Care Question: Non-Contact Thermometers

If you have questions regarding this Specific Care Question – please contact jmichael@cmh.edu

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<th>Study</th>
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<tr>
<td>Oyakhirome 2010, Gabon</td>
<td>Non-blinded prospective study. Hospital setting.</td>
<td>1,000 children aged &lt;10 years presenting to hospital outpatient department with complaint of fever. Rectal measurements for 835.</td>
<td>Tympanic thermometry (Braun ThermoScan 6022) Rectal (&quot;gold standard&quot;) and axillary thermometry (Thermoval Basic)</td>
<td>Description of objective, outcomes, interventions were described. Comparison of interventions is made on a single group. Outcome measure was objective. Measurements taken within a short time period.</td>
<td>Sensitivity • Specificity • PPV/NPV • Spearman rank correlation coefficients for paired readings • Mean differences with limits of agreement</td>
<td>Investigators were not blinded. Inclusion and exclusion criteria not explicitly stated. Percentage of enrollment was not reported. Golden standard, rectal thermometry, was not measured for children &gt;6 years. Characteristics of participants (e.g. proportion of each gender, age range) was lacking.</td>
<td>Mean difference between rectal (&quot;gold standard&quot;) and tympanic was 0.3°C (95% CI, 0.2-0.3) and limits of agreement were -1°C to 2°C.</td>
<td>• For a tympanic temperature threshold of 37.5°C: 62% febrile, sensitivity was 81%, specificity was 86%, PPV was 94%, NPV was 65%.</td>
<td>• For a tympanic temperature threshold of 38.0°C: 42% febrile, sensitivity was 75%, specificity was 93%, PPV was 94%, NPV was 87%.</td>
<td>• For a tympanic temperature threshold of 38.3°C: 35% febrile, sensitivity was 75%, specificity was 93%, PPV was 87%, NPV was 84%.</td>
<td>• For a tympanic temperature threshold of 38.7°C: 25% febrile, sensitivity was 68%, specificity was 95%, PPV was 86%, NPV was 87%.</td>
<td>PRO4000 IRT demonstrated good agreement with the nasopharyngeal temperature.</td>
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<tr>
<td>Mangat 2010, United Kingdom</td>
<td>Non-blinded prospective study.</td>
<td>61 elective surgical patients scheduled for general</td>
<td>2 infrared tympanic thermometers Nasopharyngeal temperature</td>
<td>Correlation with reference Objective, outcomes, subject characteristics, interventions, and</td>
<td>Investigators were not blinded.</td>
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</table>
### Office of Evidence Based Practice – Specific Care Question: Non-Contact Thermometers

<table>
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<tr>
<th>Hospital setting.</th>
<th>anesthesia, 46 M/15W. Age: mean 66 years (SD 14).</th>
<th>(Genius 2 and PRO4000), 1 temporal artery thermometer (Exergen 5000)</th>
<th>probe (Thermistor 400 series 9Fr)</th>
<th>findings (with P value and CI for significant results) were clearly described.</th>
<th>The percentage of enrollment was not reported.</th>
<th>The selection of surgical patients who are presumably afebrile may limit conclusions and device accuracy at higher temperatures. All subjects were warmed by a water mattress during measurements.</th>
</tr>
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<tbody>
<tr>
<td>Outcome measure was objective.</td>
<td>Comparison of interventions was made on a single group.</td>
<td>Power calculation and description of statistical methods were provided.</td>
<td>Measurement taken within a short time period.</td>
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<tr>
<td>All subjects were warmed by a water mattress during measurements.</td>
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#### Rabbani 2010, Pakistan

Non-blinded prospective study. Outpatient hospital setting. 2000 patients presenting with or without fever to four departments. 1149 M/851 F. Age: mean 31.8 ± 19.4 years, 626 aged 5-16 years, 730 aged 17-40 years, 478 aged 41-60 years, 166 older than 60 years

<table>
<thead>
<tr>
<th>Tympanic thermometer (Beurer FT25)</th>
<th>Oral mercury thermometer</th>
<th>Description of objective, outcomes, subject characteristics, interventions, findings (with actual P value and CI) were provided.</th>
<th>Investigators were not blinded.</th>
<th>The percentage of enrollment was not reported.</th>
<th>No Power calculation.</th>
<th>Conclusions regarding accuracy for elderly population based on small numbers of febrile cases (n=7)</th>
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<tr>
<td>Correlation with reference</td>
<td>• Febrile range</td>
<td>• Sensitivity</td>
<td>• Specificity</td>
<td>• PPV</td>
<td>• NPV</td>
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<tr>
<td>Correlation with reference</td>
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- 97 of 2000 patients (4.85%) were identified with oral mercury temperature (OMT) as febrile.
- Mean oral reading was 36.7 ºC (range 34.2 to 40.4, SD 0.66)
- Mean tympanic temperature (TT) reading was 36.6 ºC (range 34.1 to 40.0, SD 0.71)
- Significant, positive Pearson’s correlation (r; P < 0.001) between tympanic and oral for all age groups in patients with normal temperatures (overall r = 0.843)
- Significant, positive Pearson’s correlation (r; P < 0.001) between tympanic and oral in febrile patient groups except for those aged 41 and over (age 41 to 60, r = 0.394; age 60 plus, r = 0.452). Overall correlation value between tympanic and oral in febrile patients was 0.723.
<p>| Dzarr 2009, Malaysia | Comparative prospective study. Hospital setting. | 21 neutropenic cancer patients with or without fever. 10M/11W. Age: range 15 to 63 years old. | Infrared tympanic thermometry (Braun Thermoscan), mercury bulb oral and axillary thermometers | Mercury bulb rectal thermometer | • Correlation with reference • Sensitivity • Specificity • PPV • NPV | Clear descriptions of objective, outcomes, subject characteristics, interventions, findings (with 95% CIs) were provided. Investigators who recorded mercury bulb temperature readings were blinded as to their position on patient (oral, axillary, rectal). Comparison of interventions was made on a single group. Outcome measure was objective. Power calculation and description of statistical methods were provided. Measurements taken at the same time. | The percentage of enrollment was not reported. | 400 sets of temperature measurements were obtained from 21 patients. Rectal temperature in 300 randomly selected temperature sets ranged from 35.0 °C to 41.1 °C; 66 sets (22%) classified as febrile (≥ 38 °C). Intraclass correlation coefficient relative to rectal thermometry was calculated for: o right tympanic (0.810; 95% CI, 0.748 to 0.855) o left tympanic (0.770; 95% CI, 0.713 to 0.815) o mean tympanic (0.806; 95% CI, 0.749 to 0.849) Sensitivity, specificity, PPV and NPV (in brackets, respectively) of each method to detect rectal fever were as follows: o right tympanic (0.682, 0.979, 0.900, 0.916) o left tympanic (0.712, 0.957, 0.825, 0.922) o mean tympanic (0.636, 0.974, 0.875, 0.905) | • Tympanic sensitivity (all age groups) = 66.35 (95% CI, 55 to 75) • Tympanic specificity (all age groups) = 99.63 (95% CI, 99 to 99) • Tympanic PPV (all age groups) = 91.02 (95% CI, 82 to 96) • Tympanic NPV (all age groups) = 98.12 (95% CI, 97 to 98) |</p>
<table>
<thead>
<tr>
<th>Study</th>
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<th>Participants</th>
<th>Interventions</th>
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<tr>
<td>Smitz 2009, Belgium</td>
<td>Non-blinded prospective study. Inpatient hospital setting.</td>
<td>100 patients admitted to geriatric unit, with or without fever. 31M/69F. Age mean 80.9 (SD 7.5) years.</td>
<td>2 infrared ear thermometers (ThermoScan PRO 3000 and First-Temp Genius 3000A)</td>
<td>Rectal thermometer (HP 21075A probe and HP 78342A monitor)</td>
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<td></td>
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<td>• Description of objective, outcomes, subject characteristics, interventions, findings (with P values and CIs) were provided. Participants were representative of a geriatric population in hospital 67% enrollment; severely ill patients were not excluded.</td>
<td>Descriptions of objective, outcomes, subject characteristics, interventions, findings (with P values and CIs) were provided.</td>
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<td>Investigators were not blinded. No power calculation; sample size was subject to recruitment during a defined study time period.</td>
<td>Investigators were not blinded.</td>
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</table>

- Mean ear temperature measured with each infrared thermometer was significantly higher (P < 0.001) than rectal temperature.
- A significant, positive correlation with rectal temperature was shown for the ThermoScan (slope = 0.82; 95% CI, 0.75 to 0.89; P < 0.001; r = 0.91) and the Genius thermometer (slope = 0.90; 95% CI, 0.78 to 1.02; P < 0.001; r = 0.84)
- ThermoScan 95% limits of agreement with rectal temperature were –0.83 ºC and 0.42 ºC (95% CI, –0.88 to 0.48 ºC)
- Genius 95% limits of agreement with rectal temperature were –1.32 ºC and 0.20 ºC (95% CI, –1.39 to 0.27 ºC)
- Optimal ear fever thresholds were 38.0 ºC (ThermoScan) and 38.3 ºC (Genius)
- ThermoScan sensitivity, specificity, PPV and NPV, respectively were 94%, 98%, 89%, and 99%
- Genius sensitivity, specificity, PPV and NPV, respectively were 94%, 96%, 85%, and 99%

CI = confidence interval; F = Fahrenheit; F = females; IRT = infrared thermograph; ITDS = infrared thermal detection system; ITIS = infrared thermal image scanners; LOA = limits of agreement; NCIT = non-contact infrared thermometer; NPV = negative predictive value; M = males; MA = meta-analysis; OMT = oral mercury thermometer; OPD = outpatient department; P = probability value; PPV = positive predictive value; RCT = randomized controlled trial; ROC = receiver operating characteristics; SD = standard deviation; SR = systematic review; TAT = temporal artery thermometer; TT = tympanic membrane temperature; USA = United States of America

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References


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