Office of Evidence Based Practice (EBP) – Critically Appraised Topic (CAT): Non-Contact Infrared Thermometers (NCIT)

Specific Care Question In pediatric patients, are non-contact infrared thermometers (NCIT) equivalent to other thermometers (Oral, Rectal, Tympanic, and Axillary) for measuring temperatures?

Recommendations Based on Current Literature (Best Evidence) Only

Based on a review of current literature by the Department of EBP, a strong recommendation is made against the routine use of NCIT in individual patient care without having another proven method of fever verification used. If the NCIT identifies an elevated temperature, then the measurement should be repeated (with a more reliable thermometer) to validate the temperature.

The overall certainty in the evidence is very low[a]. Mean difference of NCIT compared to other thermometers varied as much as 1ºC. Overall sensitivity of the studies varied greatly, from 4%-97%, and specificity varied from 60% to 99%. Positive predictive value (PPV) varied from 1% to 76% and negative predictive value (NPV) varied from 86% to 99%. While NCIT may be appropriate for screening large numbers of people, more reliable methods should be used when assessing individual patients. When there is a lack of scientific evidence, standard work should be developed, implemented, and monitored.

Literature Summary

Background. Fever is an atypical rise in body temperature that occurs as part of a particular biologic response (Ward, 2020). Children's Mercy's policy on Vital Signs recommends using the method to measure temperature that is most appropriate for age, development, and cognitive level of the patient (Vital Signs, 2018). The gold standard for measuring body temperature is core body temperature measurement (Sims, Patton, Williamson, & RyanWenger, 2018). The sites for core body temperature include the pulmonary artery, bladder, esophagus, or nasopharyngeal sites (Batra, Saha, & Faridi, 2012). It is difficult to get an actual core body temperature as these procedures are invasive. Because measuring core temperature is invasive and not conducive to screening, non-core temperature techniques are used in hospital and ambulatory environments (Sim et al., 2018).

While non-contact infrared thermometers (NCIT) have been shown to be fast, convenient, and safe; they have also been shown to be inaccurate (Canadian Agency for Drugs and Technologies in Health (CADTH), 2014). A guideline developed by the (CADTH) (2014), found that the evidence does not support the use of infrared thermometers for the use in individual patient care without verification of a more proven method. Also, based on a previous review of non-core thermometers (Dusin, 2018), oral and rectal electronic thermometer devices were shown to be the only non-core thermometers that met accuracy criterion of remaining within ±0.5 °C of the core temperature 95% of the time. Dusin (2018) did not include non-contact infrared thermometers (NCIT) in this previous review of the literature.

Study characteristics. The current review is an update from March 2016. An updated search for suitable studies was completed in May 2020. K. Mroczka RN reviewed the 119 titles and/or abstracts found in the search and identified[b] 12 single studies believed to answer the question. After an in-depth review of the single studies[c], seven answered the question (Abraham et al., 2018; Apa et al., 2016; Berksoy et al., 2018; Chatproedprai et al., 2016; Dante et al., 2019; Franconi et al., 2018; Sollai et al., 2016). These new studies are combined with the studies from the previous review on the topic, which had included Bitar et al. (2009) systematic review (SR)and five single articles on the topic (Chiappini et al., 2011; Fortuna et al., 2010; Rubia-Rubia et al., 2011; Selent et al., 2013; Teran et al., 2012). This current review was unable to create a meta-analysis due to the heterogeneity of the studies.

Summary by Outcome

Detecting Fever. See Table 1 for complete results of included studies. One systematic review (Bitar et al., 2009) and twelve cohort studies (Abraham et al., 2018; Apa et al., 2016; Berksoy et al., 2018; Chatproedprai et al., 2016; Chiappini et al., 2011; Dante et al., 2019; Fortuna et al., 2010; Franconi et al., 2018; Rubia-Rubia et al., 2011; Selent et al., 2013; Sollai et al., 2016; Teran et al., 2012) measured temperatures using NCIT (N = 80,951). Nine of the studies used an axillary thermometer as the comparator (Abraham et al., 2018; Apa et al., 2016; Berksoy et al., 2018; Bitar et al., 2009; Chiappini et al., 2011; Dante et al., 2019; Franconi et al., 2018; Selent et al., 2013; Sollai et al., 2016), four studies used rectal temperatures as the comparator (Chatproedprai et al., 2016; Fortuna et al., 2010; Selent et al., 2013; Teran et al., 2012), and one study used the pulmonary artery as the comparator (Rubia-Rubia et al., 2011) The results indicated that the intervention of using NCIT was unfavorable to other thermometers.

The systematic review of adults by Bitar (2009) (N = 77024) found, sensitivity varied from 4.0 to 89.6% and specificity varied from 75.4 to 99.6%. While, the PPV varied from 0.9 to 76.0% and the NPV from 86.1 to 99.7%. When prevalence was fixed at 1% in all studies, the derived PPV varied from 3.5% to 65.4% and NPV was 99%. Only one study (Rubia-Rubia et al., 2010) compared NICT to core temperature. This study used pulmonary artery temperatures as the core temperature and found the NPV for NCIT? to range from 98-99% but the PPV ranged 33-44% based on different cut-off temperatures. Five studies (Abraham et al., 2018; Apa et al., 2016; Dante et al., 2019; Franconi et al., 2018; Teran et al., 2012) reported mean difference of NCIT with results that varied from -0.32 to +0.94ºC compared to other temperature routes (axillary, oral, rectal). Four studies (Apa et al., 2016; Fortuna et al., 2010; Selent et al., 2013; Teran et al., 2012) reported the correlation coefficient of NCIT with r^2 ranging from 0.48 to 0.950. The lowest r^2 of 0.48 was from only study that compared NCIT to rectal temperatures (Fortuna et al., 2010). Six studies (Apa et al., 2016; Berksoy et al., 2018; Chatproedprai et al., 2016; Chiappini et al., 2011; Selent et al., 2013) reported sensitivity and specificity for NCIT compared to other thermometers (axillary, oral, rectal). Sensitivity ranged from 48.3-97% and specificity ranged from 60% to 97%.

Certainty of the evidence for detecting fever. The certainty of the body of evidence was very low based on four factors[a]: *within-study risk of bias*, *consistency among studies, directness of evidence*, and *precision of effect estimates*. The body of evidence was assessed to have very serious risk of bias, very serious inconsistency, serious indirectness and not serious imprecision. The risk of bias was very serious as the included studies were non-blinded, employed convenience samples, and only one study (Rubia-Rubia et al., 2010) used core temperatures as the comparator. The indirectness was serious as over 90% were adults that came from one study. Inconsistency was very serious due to the heterogeneity between he studies as different populations with different fever prevalence were studied, different brands of NCIT were used, and different protocols to measure temperatures were employed.

Identification of Studies

Search Strategy and Results (see Figure 1)

(("infrared"[tiab] OR "forehead"[tiab]) AND ("Thermometry"[Mesh] OR "Thermometers"[Mesh] OR "Fever/diagnosis"[Mesh])) OR ("infrared thermometry"[All Fields] OR "forehead thermometer"[All Fields] OR "infrared thermometer"[All Fields]) AND ("Infant, Premature"[Mesh] OR "Infant, Extremely Premature"[Mesh] OR "Intensive Care, Neonatal"[Mesh] OR "Intensive Care Units, Neonatal"[Mesh] OR "Intensive Care Units, Pediatric"[Mesh] OR "infant"[MeSH Terms] OR "child"[MeSH Terms] OR "adolescent"[MeSH Terms]) AND ("2005/08/13"[PDat] : "2015/08/10"[PDat])

(("infrared"[tiab] OR "forehead"[tiab]) AND ("Body Temperature Changes"[Majr] OR "Body Temperature"[Majr] OR "Thermometry"[Mesh] OR "Thermometers"[Mesh] OR "Fever/diagnosis"[Mesh])) OR ("infrared thermometry"[All Fields] OR "forehead thermometer"[All Fields] OR "infrared thermometer"[All Fields]) AND (children OR child OR infant OR adolescence OR pediatr* OR paediatr*) AND ("2015/07/01"[PDat] : "2020/12/31"[PDat])

Records identified through database searching *n* = 119

Studies Included in this Review

Citation	Study Type
Abraham et al. (2018)	Cohort
Apa et al. (2016)	Cohort
Ataş Berksoy et al. (2018)	Cohort
Bitar et al. (2009)	Systematic Review
Chiappini et al. (2011)	Cohort
Chatproedprai et al. (2016)	Cohort

Dante et al. (2019)	Cohort
Fortuna et al. (2010)	Cohort
Franconi et al. (2018)	Cohort
Rubia-Rubia et al. (2011)	Cohort
Selent et al. (2013)	Cohort
Sollai et al. (2016)	Cohort
Teran et al. (2012)	Cohort

Studies Not Included in this Review with Exclusion Rationale

Citation	Reason for exclusion
Antabak et al. (2016)	Non-English
Hurwitz et al. (2015)	Non infrared study
Mogensen et al. (2018)	Non infrared study
Smith et al. (2018)	Non infrared study
Syrkin-Nikolau et al. (2017)	Non infrared study

Methods Used for Appraisal and Synthesis

[a]The GRADEpro Guideline Development Tool (GDT) is the tool used for this analysis.

[b]Rayyan is a web-based software used for the initial screening of titles and / or abstracts for this analysis (Ouzzani, Hammady, Fedorowicz & Elmagarmid, 2017).

[c]Review Manager (Higgins & Green, 2011) is a Cochrane Collaborative computer program used to assess the study characteristics as well as the risk of bias and create the forest plots found in this analysis.

[d]The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram depicts the process in which literature is searched, screened, and eligibility criteria is applied (Moher, Liberati, Tetzlaff, & Altman, 2009).

[a]GRADEpro GDT: GRADEpro Guideline Development Tool (2015). McMaster University, (developed by Evidence Prime, Inc.). [Software]. Available from gradepro.org.

[b]Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan-a web and mobile app for systematic reviews. *Systematic Reviews, 5*(1), 210. doi:10.1186/s13643-016-0384-4

[c]Higgins, J. P. T., & Green, S. e. (2011). *Cochrane Handbook for Systematic Reviews of Interventions [updated March 2011]* (Version 5.1.0 ed.): The Cochrane Collaboration, 2011.

[d]Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097 **For more information, visit www.prisma-statement.org.**

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Acronyms Used in this Document

Acronym	Explanation
AGREE II	Appraisal of Guidelines Research and Evaluation II
Axillary	AXL
CAT	Critically Appraised Topic
CADTH	Canadian Agency for Drugs and Technologies in Health
DAT	Digital Axillary Thermometers
FHD	Forehead
FST	Forehead Skin Thermometer
EBP	Evidence Based Practice
IFR	Infrared thermometer
ITT	Ear temperature
NCIT	Non-contact Infrared Thermometers
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SR	Systematic Review
TYM	Tympanic

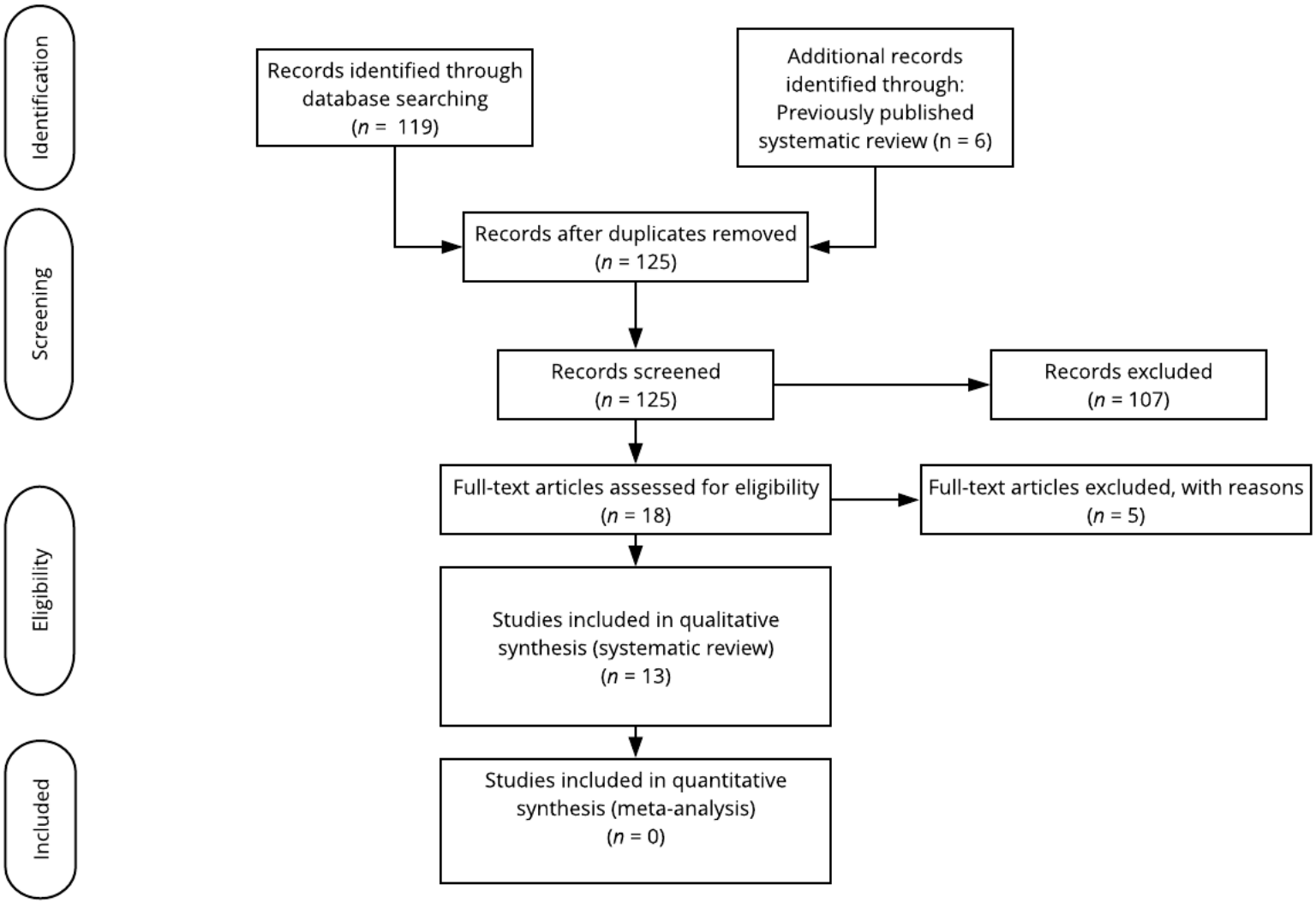
Identification
Screening
Eligibility
Included
Records identified through database searching (n = 119)
Additional records identified through: Previously published systematic review (n = 6)
Records after duplicates removed (n = 125)
Records screened (n = 125)
Records excluded (n = 107)
Full-text articles assessed for eligibility (n = 18)
Full-text articles excluded, with reasons (n = 5)
Studies included in qualitative synthesis (systematic review) (n = 13)
Studies included in quantitative synthesis (meta-analysis) (n = 0)

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRIMSA)[d]

Table 1

First Author, Publication Year, Country	Study Design	Patients Characteristics, Sample Size (n)	Intervention	Comparator	Outcomes	Limitations	Main Study Findings
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 consultation). Sample size ranging from 176 to 72,327	Non-contact thermometry: infrared skin thermometers and thermal infrared cameras (tympanic was considered contact)	Tympanic thermometry	•Sensitivity •Specificity •Positive/Negative predictive values	A priori design was not mentioned. Study selection was not duplicated. Literature search strategy was not comprehensive, 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.	• Sensitivity varied from 4.0 to 89.6%. • Specificity varied from 75.4 to 99.6%. • The positive predictive values (PPV) varied from 0.9 to 76.0% and the negative predictive value (NPV) from 86.1 to 99.7%. • In 3 studies, reported values of the area under the curves of ROC were of 0.96, 0.92 and 0.86. • Correlation coefficients with the reference (forehead vs tympanic) were of 0.25, 0.51 and 0.71 in 3 studies. • Sensitivity was higher with external auricular meatus vs forehead (compared in 2 studies): 82.7% vs 17.3% and 67.0 vs 4.0%. Specificity remained high: 98.7% and 96.0%. • When fever prevalence was fixed to 1% in all studies, the derived PPV (forehead area) varied from 3.5 to 65.4% and the derived NPV was ≥99%.
Abraham 2018, India	Non-blinded prospective study. Hospital setting.	30 Infants, 211 sets of temperature readings, Newborn Care Unit	Non-contact infrared thermometer (Multifunctional Infrared thermometer PC808)	Digital axillary temperature (DAT) Omron Digital Thermometer (Model MC-246)	Agreement of DAT and NCIT	Not peer reviewed, as it is a letter. No true measure of the core body temperature to compare	DAT vs NCIT • Abdomen, *MD* = 0.22, 95% CI [0.17, 0.27] • Chest, *MD* = 0.13, 95% CI [0.08, 0.18] • Forehead, *MD* = -0.32, 95% CI [-0.38, -0.25] • Chest NCIT had the narrowest mean difference

APA 2016, Turkey	Non-blinded prospective study. Hospital setting.	100 pediatric patients, hospitalized patients to the infectious disease. Age: mean 56.3 ± 50.2 months. Gender not reported	Non-contact infrared thermometer (ThermoFlash LX-26, Visiomed SAS France, Paris/France) •Mid-forehea •Umbilicus	Axillary fossae with axillary digital thermometer (Microlife MT 3001, Microlife AG Swiss Corporation Windnau/ Switzerland)	Agreement of DAT and NCIT	No true measure of the core body temperature to compare No true measure of the core body temperature to compare	• Positive correlation between axillary and umbilical temperatures with a correlation coefficient of 0.78. • Average difference between the mean of both axillary and umbilical temperatures was –0.47 ± 0.65°C • 2.5 % of the readings falling outside the 95% level of confidence. • Umbilical measurements showed sensitivity of 71.7% and specificity of 95.8%. • Area under the ROC curve was 0.93.
Berksoy 2018, Turkey	Non-blinded prospective study. Hospital setting. Emergency Department	184 Febrile and 135 Afebrile Children Age: Median 30 months, range from 1 month to 18 years. 55% male, 45% female	Non-contact infrared thermometer •Forehead • Neck (carot artery) • Nape of nec	Digital axillary thermometer	Agreement of DAT and NCIT	No true measure of the core body temperature to compare	• A Bland–Altman plot of the differences suggested that all agreements between IFR and axillary measures were poor • The forehead measurements had a sensitivity of 88.6% and a specificity of 60% in patients with temperatures ≥36.75°C • The sensitivities of the neck measurement at cut-offs of ≥37.35°C and ≥36.95 were 95.5% and 78.8% • 11.4% of febrile subjects were missed when forehead measurements were performed
Chiappini 2011, Italy	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 thermometers	•Variability of repeated measures •Concordance between forehead and axillary measures • Discomfort assessment •Sensitivity •Specificity •PPV •NPV	Investigators were not blinded. The percentage of participation was not disclosed. No true measure of the core body temperature to compare	• 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 mercury-in-glass 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.
Chatproedprai 2016, Thailand	Non-blinded prospective observational study. Outpatient Clinic	312 pediatric patients, 109 afebrile, 103 low-grade fever, 100 high-grade fever, Age 9.9 ± 5.9 months, 184 male.	Forehead skin thermometer (FST) (Coolkids®, NanoMed, Thailand) Ear temperature by ITT (Microlife IR1DE1-1®, Microlife AG, Switzerland)	Rectal temperature measurement	Mean values of FST and ITT were compared with rectal temperature	the brands of thermometers used (both FST and ITT) may not represent all brands available in the market. No true measure of the core body temperature to compare	Agreement between RMT and other sites*: • FST: Mean difference = 1.04°C 95% CI [-0.25, -2.32] • ITT: Mean difference = 1.03°C 95% CI [0.06, 1.99] • FST: • >38.9°C Sensitivity 48.3%, Specificity 100% • 37°C Sensitivity 90.1%, Specificity 56% *lack of agreement between rectal temperature and FST and ITT Mean difference of RMT compared to other sites when categorized by fever level were all statistically significantly different (p < 0.001) for all levels of fever.
Dante 2020, Italy	Non-blinded prospective observational study. Multiple Hospital setting.	Consecutively admitted patients, 433 pediatric patients, 5.9 median age (0-14), Male 57.5%	Infrared Chicco® Easy Touch thermometer forehead (FHD)	Axillary (AXL and Tympanic (TYM)	Agreement between FHD, AXL, TYM.	Inability to detect the environmental temperature The diagnostic accuracy of the investigated thermometers was not calculated. No true measure of the core body temperature to compare	• FHD versus AXL: +1.79 °C to -1.67 °C • Bland Altman analysis FHD: 95% LoA (+0.94 °C to -1.02°C)

Fortuna 2010, USA	Non-blinded prospective observational study. Hospital setting.	Convenience sample of 200 children from 1 month to 4 years of age presenting to tertiary pediatric emergency department.	Non-contact infrared thermometer (Thermofocus) (mid-forehead)	Rectal thermometer (Welch Allen Sure Temp)	• Agreement in measurement between two techniques • Bias of techniques	Investigators were not blinded. The percentage of participation was not reported. Power calculation has not been presented. No true measure of the core body temperature to compare	• Average rectal temperature of all participants was 99.6°F (98.7°F to 100.5°). • 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, r2 = 0.48, *P* <0.01). • Infrared thermometry overestimated rectal temperature in patients with lower temperatures. • Infrared thermometry underestimated rectal temperatures in patients with fever (r2 = 0.149, *P* <0.01).
Franconi 2016, Italy	Non-blinded prospective study. Emergency department	Consecutively admitted pediatric emergency department patients 422 pediatric patients	Infrared thermometer- Hartmann Thermoval Duo Scan (Model 925082; Hartmann, Germany) was placed 5-6 cm from the center of the forehead	Axillary thermometer- Smart Care Digital Thermometer (Model HA3030424, Pic, Italy) placed in contact with a clean dry armpit	Agreement of axillary and infrared thermometer assessments	Inability to the control environ-mental temperature No true measure of the core body temperature to compare	• Axillary vs. infrared thermometer assessment, MD = 0.41 (0.81), p = .000 • Bland Altman analysis showed agreement. The mean value of differences for 95% of measures were between -1.18 and +1.99º C

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	The authors did not describe the devices used. The percentage of participation was not reported. Investigators were not blinded. No true measure of the core body temperature to compare	• Validity for cut-off point pulmonary artery core temperatures 38.5°C, 38.7°C, and 38.9°C o Infrared in right ear (core equivalency) • 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% o Infrared in right ear (oral 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%
Selent 2013, USA	Non-blinded, prospective study. Hospital setting.	855 pediatric patients who presented at emergency department. 469 boys/386 girls. Age: 6 months to 17 years. 218 rectal, 422 oral and 215 axillary temperature.	3 ITDS: two thermal cameras (OptoTherm Thermoscreen and FLIR) and one handheld infrared skin Thermometer (Thermofocus)	Oral, rectal or axillary thermometry following age.	• Sensitivity • Specificity • Correlation with reference • Receiver operating characteristic curve	Investigators and patients were not blinded. The timing of measurements was not reported. No true measure of the core body temperature to compare	• 306 (35.8%) children had confirmed fever. Parents reported fever in 400 (46.8%) children. • At optimal fever threshold, sensitivities for Opto Therm, FLIR and Thermofocus were of 83.0%, 83.7% and 76.8%, respectively. Similar to patient report (83.9%). • 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.
Sollai 2015, Italy	Non-blinded prospective study. Hospital setting	Newborns nursed in incubators, 189 with 1134 actual temperature measurements	Non-contact infrared thermometer (NCIT)	Bilateral digital axillary (DAT) and bilateral infrared tympanic temperature (ITT) measurements were performed in every newborn.	Agreement of NCIT, DAT, and ITT assessments* measured by clinical reproducibility between two source temperatures, mean of difference (the authors identify this as bias) and outliers (defined as a differentce ≥ 1°C)	The majority of the participants were healthy; no child presented febrile infection and critically ill newborns were excluded. No true measure of the core body temperature to compare	NCIT reproducibility was 0.0794°C (0.0455°C for infants in incubator and 0.0861°C for infants outside the incubator). • Bias was 0.047°C (0.029°C for infants in incubator and <0.0001°C for infants outside the incubator). • Zero outliers were recorded.

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	Outcomes were not clearly described. The percentage of participation was not reported. Investigators and patients were not blinded. Power calculation has not been done. No true measure of the core body temperature to compare	• 167 children were identified with fever. • Mean temperature was 37.9 ± 0.9ºC for the rectal mercury thermometer, 37.6 ± 0.8ºC for the temporal artery thermometer and 37.9 ± 0.9ºC for the non-contact infrared thermometer. • The mean difference vs rectal thermometry was of 0.029 ± 0.01ºC for the non-contact infrared and – 0.2 ± 0.277ºC 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 were of 99.3% and 94.6%, respectively.

Characteristics of Intervention Studies

Bitar et al., 2009

Design	Diagnostic Quantitative Synthesis and Meta-analysis
Objective	Review available literature on the sensitivity, specificity and predictive values of NCIT used with the objective of fever screening, in airports or other gathering areas.
Methods	**Types of studies.** • Diagnostic **Participants.** • The studies varied from adults, children, or not reported • Hospital patients • Hospital visitors • Outpatient consultations • Sports club • Inpatient setting • Emergency department **Index tests.** • Non-contact Infrared Thermometers **Target Condition (s).** • Fever from influenza • Fever from SARS **Reference Standards.** • Tympanic thermometers **Information sources.** • MEDLINE **Search.** • 1975 to August 2008. • Key words: fever; screening; non-contact, infrared thermography or thermometers; thermal imagers or scanners or pyrometers; thermal screening. **Study Slection.** • Not reported **Data collection process.** • Not reported **Methodological quality (Risk of Bias)**. • Not reported **Synthesis of results.** • Sensivity, Specificty, Positive Predictive Value (PPV), Negative Predicitive Value (NPV)
Results	**Study Selection.** **Number of articles identified:** *N* = Not reported **Full-text articles assessed for eligibility:** *n* = Not reported

	○ **Studies included in qualitative synthesis:** *n* = Six **Synthesis of results.** • Six fever screening studies in other gathering areas, mainly hospitals, were included ○ *N* = 176 to 72,327 persons ○ Fever prevalence = 1.2% to 16.9% • Sensitivity varied from 4.0% to 89.6%, • Specificity from 75.4% to 99.6%, • PPV from 0.9% to 76.0% • NPV from 86.1% to 99.7%. • When prevalence was changed to 1% in all studies to allow comparisons, the derived PPV varied from 3.5% to 65.4% and NPV was =>99% **Methodological quality of included studies (Risk of Bias)**. • Not reported
Discussion	• The low PPV suggests limited efficacy of NCIT to detect symptomatic passengers at the early stages of a pandemic influenza, when fever prevalence among passengers would be < 1% • Author reported difficulty with Interpretation and comparison of findings by the limited number of selected studies and their wide heterogeneity in terms of methods, study design and environmental conditions • Available details varied in the published papers regarding the different study populations which included either healthy or sick persons, and the different types of tested NCIT which included hand-held or remote sensors • Tympanic contact thermometers are not the gold standard for temperature
Funding	**Funding.** • The work was done as part of SARS Control : Effective and Acceptable Strategies for the Control of SARS and New Emerging Infections in China and Europe, a European Commission project funded within the Sixth Framework Programme, Thematic Priority Scientific Support to policies, Contract

Abraham et al., 2018

Methods	Cohort
Participants	Participants: Neonates Setting: Special Newborn Care Unit, India Number enrolled into study: *N* = 30 infants, 211 sets of temperature readings Gender, males (as defined by researchers): • Not reported Race / ethnicity or nationality (as defined by researchers): • The study occurred in India. The authors did not identify race or ethnicity of the participants. Age, • Not reported Inclusion Criteria: • Not reported Exclusion Criteria: • Not reported Covariates identified: • Not reported
Interventions	Temperature was taken from the forehead, chest, and abdomen within a span of 6 minutes. Temperatures were taken as infants nursed under an overhead warmer, set at 36.5º C and/or as nursed in a cot at mother's side, room temperature set between 26 - 30º C • Digital axillary temperature (DAT) Omron Digital Thermometer (Model MC-246) • Non-contact infrared temperature (NCIT) Multifunctional Infrared thermometer PC808
Outcomes	Primary outcome(s): • *Agreement of DAT and NCIT Secondary outcome(s): • Not reported Safety outcome(s): • Not reported *Outcomes of interest to the CMH CPG or CAT development team

Notes	Results:
	• DAT vs NCIT
	  ○ Abdomen, *MD* = 0.22, 95% CI [0.17, 0.27]
	  ○ Chest, *MD* = 0.13, 95% CI [0.08, 0.18]
	  ○ Forehead, *MD* = -0.32, 95% CI [-0.38, -0.25]
	Limitations:
	• Not peer reviewed, it is a letter
	• Although by analysis with Bland-Altman chart, the NCIT Chest agreed best with DAT, as you can see by the mean differences and 95% confidence intervals do not cross the line of no effect and are significantly different.

Apa et al., 2016

Methods	Cohort
Participants	**Participants:** Hospitalized pediatric patients **Setting:** Children's Training and Research Hospital (Turkey), Pediatric Infectious Disease Unit during March 2012 and October 2012 **Number enrolled into study:** *N* = 100 • **Group 1, Axillary Temps**: *n* = 2048 • **Group 2,** Non-Contact Infrared thermometer Mid-forehead, *n* = 2048 • **Group 3,** Non-Contact Infrared Thermometer Umbilicus, *n* = 2048 **Gender, males (as defined by researchers):** **Race / ethnicity or nationality (as defined by researchers):** The study occurred in Turkey. The authors did not identify race or ethnicity of the participants. **Age, mean, months (SD):** • 56.3±50.2 months (between 1 and 168 months) **Inclusion Criteria:** • Hospitalized patients to the infectious disease unit **Exclusion Criteria:** • Patients who were >95th percentile in weight for age under 2 years of age and >25 in BMI values for age for patients older than 2 years of age • Septic shock or circulatory collapse • Chronic diseases, including renal or liver failure, patients with ascites, and patients with congenital or acquired abdominal anomalies **Covariates identified:** • Not reported
Interventions	• Each patient was placed in a temperature controlled room between 24 and 26°C for 10 minutes before measurements were taken • Body temperature measurements were performed at the same time for: ○ Axillary fossae with an axillary digital thermometer (Microlife MT 3001, Microlife AG Swiss Corporation, Widnau/ Switzerland ○ Non-contact infrared thermometer Mid-forehead (ThermoFlash LX-26, Visiomed SAS France, Paris/France) ○ Non-contact infrared thermometer 1.5 cm below the umbilicus (ThermoFlash LX-26, Visiomed SAS France, Paris/France) • For each method, 2048 measurements in total were performed • Axillary temperature ≥38.0°C with digital thermometer was considered as fever
Outcomes	Primary Outcome: • Compare Axillary digital thermometer and non-contact infrared thermometers at sites from umbilicus and forehead
Notes	• Positive correlation between axillary and umbilical temperatures with a correlation coefficient of 0.78. • Average difference between the mean of both axillary and umbilical temperatures was –0.47 ± 0.65°C • 2.5 % of the readings falling outside the 95% level of confidence.

	• Umbilical measurements showed sensitivity of 71.7% and specificity of 95.8%. • Area under the ROC curve was 0.93.

Berksoy et al., 2018

Methods	Diagnostic Accuracy Study
Participants	**Participants:** Pediatric patients presenting to the hospital ER **Setting:** Dr Behçet uz Children Teaching Hospital, Turkey, between July and September 2014 prospectively **Number enrolled into study:** *N* = 184 febrile and 135 afebrile children • **Group 1,** Axilary (AD): *n* = 319 • **Group 2,** Infrared (IFR) Forehead: *n* = 319 • **Group 3**, IFR Neck (carotid artery): *n* = 319 • **Group 4**, IFR Nape of Neck: *n* = 319 forehead, the neck (over the carotid artery), and the nape **Gender, males (as defined by researchers):** • 176 male (55%) **Race / ethnicity or nationality (as defined by researchers):** The study occurred in Turkey. The authors did not identify race or ethnicity of the participants. **Age, mean, months (SD):** • a median age of 30 (50) months (range: 1 month to 18 years) **Inclusion Criteria:** • Children >1 month of age • Presenting with or without fever to the emergency triage room during the day time were evaluated for inclusion in the study **Exclusion Criteria:** • Patients who were unwilling to be enrolled in the study • Perspiration during temperature measurement • Inappropriate temperature readings • Patients whose axillary temperature readings could not be measured at 1 time due to the incapability of their family **Covariates identified:** • Not reported
Interventions	• 2 dedicated nurses were trained on how to use the IFR and AD thermometers. • Patients who fulfilled the study criteria had their axilla and 3 different site of IFR thermometers simultaneously conducted by the same nurse
Outcomes	Primary Outcome: • Compare Axillary digital thermometer and non-contact infrared thermometers at different sites
Notes	• A Bland–Altman plot of the differences suggested that all agreements between IFR and axillary measures were poor • The forehead measurements had a sensitivity of 88.6% and a specificity of 60% in patients with temperatures ≥36.75°C • The sensitivities of the neck measurement at cut-offs of ≥37.35°C and ≥36.95 were 95.5% and 78.8% • 11.4% of febrile subjects were missed when forehead measurements were performed

Chatproedprai et al., 2016

Methods	Cohort
Participants	**Participants:** Children, aged 0-2 years **Setting:** pediatric outpatient clinic at King Chulalongkorn Memorial Hospital in Bangkok, Thailand with the chief complaint of "fever" **Number enrolled into study:** *N* = 312 • **Group 1,** afebrile (<38.0 degrees celsius (°C)): *n* = 109 (34.9%) • **Group 2,** low-grade fever (38.0-38.9°C), *n* = 103 (33%) • **Group 3,** high-grade fever (>39.0°C), *n* = 100 (32.1%) **Gender, males (as defined by researchers):** *n* = 184, the authors did not disclose the number of males:females per fever level **Race / ethnicity or nationality (as defined by researchers):** The study occurred in Bangkok, Thailand. The authors did not identify race or ethnicity of the participants. **Age, mean, months (range):** 9.9 ± 5.9 months (10 days to 24 months) the authors did not disclose the subjects ages fever level **Inclusion Criteria:** Patients with chief complaint of "fever" **Exclusion Criteria:** Children with: • unstable vital signs, • rectal/ear/other anomalies, • chief complaint of ear pain or ear discharge, • perianal infection, diarrhea, • low platelet count, • diagnosis of otitis media, • uncooperative children, and • parents not willing to provide consent **Covariates identified:** Temperature due to heat or perspiration was minimized by the study team waiting at least 10 minutes after play was stopped. **Sample size:** A sample size of 100 subjects was required for each level of fever. Level of fever was determined by rectal temperature, as follows: • afebrile (<38.0 degrees celsius (°C)), • low-grade fever (38.0-38.9°C), and • high-grade fever (>39.0°C)
Interventions	Patients had all three temperatures assessed within 30 to 60 after arrival to clinic: • Forehead skin thermometer (FST) (Coolkids®, NanoMed, Thailand) was placed on the patient's dry forehead for 15-20 seconds or until the color of the liquid crystal stopped changing. Five FST measurements were performed to decrease measurement error. • Ear temperature by ITT (Microlife IR1DE1-1®, Microlife AG, Switzerland) was performed by pulling the pinna slightly backward and upward, the probe was placed into the external ear canal, pressing the button, and ending the measurement after hearing the "BEEP" within approximately 2-3 seconds. Ear temperaturewere performed three times.

<table>
<tr><td></td><td>
Rectal temperature measurement (RMT) was performed with a rectal mercury-in-glass thermometer (RMT) which was coated with petroleum jelly, and gently placed into the rectum until the probe was no longer visible (around 2-3 cm) for 3 minutes).
The measurers were trained and assigned to measuring only one type of temperature. They were blinded to the other assessed temperatures.
</td></tr>
<tr><td>Outcomes</td><td>
Primary outcome(s):
Mean values of FST and ITT were compared with rectal temperature*
Secondary outcome(s):
Not reported
Safety outcome(s):
Not reported
*Outcomes of interest to the CMH CPG or CAT development team
</td></tr>
<tr><td>Notes</td><td>
Results:
The mean (SD) for each type of temperature modality follows:
RMT = 38.39 (0.90)°C
FST = 37.36 (0.90)°C
ITT = 37.37 (0.93)°C
Agreement between RMT and other sites*:
FST: Mean difference = 1.04°C 95% CI [-0.25, -2.32]
ITT: Mean difference = 1.03°C 95% CI [0.06, 1.99]
*lack of agreement between rectal temperature and FST and ITT
Mean difference of RMT compared to other sites when categorized by fever level were all statistically significantly different ($p < 0.001$) for all levels of fever.
Area under the curve by ROC for:
FST = 0.906 95% CI [0.873, 0.939]
ITT = 0.951 95% CI [0.929, 0.973]
Most appropriate cut-off point for diagnosing fever for the two experimental methods were:
FST = 37.1°C
ITT = 37.02°
<table>
<tr><th>Method</th><th>TemperatureCut-off Points</th><th>Sensitivity[95% CI]</th><th>Specificity[95% CI]</th><th>PPV[95% CI]</th><th>NPV[95% CI]</th></tr>
<tr><td rowspan="2">FST</td><td>≥ 38.0</td><td>48.3%</td><td>100%</td><td>100%</td><td>51.2%</td></tr>
<tr><td>37.0</td><td>90.1%
[85.2%, 93.9%]</td><td>56%
[46.1%, 65.5%]</td><td>79.2%
[73.4%, 84.3%]</td><td>75.3%
[64.5%, 84.2%]</td></tr>
<tr><td rowspan="2">ITT</td><td>≥ 37.6</td><td>62.1%</td><td>99.1%</td><td>99.2%</td><td>58.6%</td></tr>
<tr><td>37.0</td><td>89.2%
[84.1%, 93.1%]</td><td>84.4%
[76.2%, 90.6%]</td><td>91.4%
[86.6%, 94.9%]</td><td>80.7%
[72.3%, 87.5%]</td></tr>
</table>
</td></tr>
</table>

Chiappini et al., 2011

Methods	Cohort
Participants	Participants: Children (18 months to 18 years) Setting: Five Italian centers (1 Pediatric ED, 3 Pediatric Clinics, 1 Primary Care Center) Number enrolled into study: N = 251 Gender, males (as defined by researchers): • 127 (50.59%) Race / ethnicity or nationality (as defined by researchers): • Not reported Age, median in years, (range / IQR): • 4.5 (3.0 – 8.6) Inclusion Criteria: • Age of 18 months to 18 years • Stable clinical conditions Exclusion Criteria: • Patients with underlying chronic conditions • Patients with skin infection, rash, recent topical treatment, or abundant sweating in measurement areas
Interventions	• One person completes two bilateral axillary temperature measurements, read five minutes after placement Axillary temperatures were measured using mercury-in-glass thermometer (Thermovedo, Pic, Artsana, Italy). • Followed by three temperature measurements using non-contact infrared thermometry (NCIT) in the mid-forehead (Thermofocus, model 0800; Tecnimed, Varese, Italy).
Outcomes	Primary outcome(s): • Assess the performance of the NCIT applied to the mid-forehead in comparison with the axillary temperature recorded by the mercury-in-glass thermometer in children.* Secondary outcome(s): • Assess diagnostic accuracy of NCIT for detecting children with fever (defined as an axillary temperature measured by mercury-in-glass thermometer >38 °C) • Compare the discomfort caused of NCIT and axillary temperature recorded by the mercury-in-glass thermometer. *Outcomes of interest to the CMH CPG /CAT development team
Notes	Results: • Clinical repeatability of NCIT was 0.108°C, similar to mercury thermometer clinical repeatability of 0.114°C. Bias was 0.015°C (SD 0.089) and the percentage of outliers >1°C was 1.59% (four children). • Mean body temperature obtained by mercury-in-glass and NCIT was 37.18°C (SD 0.96) and 37.30°C (SD 0.92), respectively (p = 0.153). No significant correlation between the difference between the body temperature values recorded with the two methods and age (p = 0.226), or room temperature (p = 0.756). • NCIT measurement in predicting axillary temperature >38.0°C by mercury-in-glass thermometer was calculated: sensitivity 0.89, 95% CI [0.80,0.97], specificity 0.90, 95% CI [0.86, 0.94], positive predictive value 0.70, 95% CI [0.59, 0.81] and negative predictive values 0.97, 95% CI [0.94, 0.99].

	• Calculating the ROC curve to determine the best threshold for axillary temperature >38.0 °C, for a mid-forehead temperature of 37.98 °C the sensitivity of the NCIT was 88.7% and the specificity 89.9%. • Variability for different people performing measurements showed no statistical difference (nonparametric test Kruskal–Wallis, p = 0.07 for NCIT; p = 0.45 for mercury thermometer). Limitations: • This study compares NCIT to axillary temperatures taken with mercury thermometers, not core temperatures.

Dante et al., 2020

Methods	Cohort
Participants	**Participants:** Pediatrics Less than 14 years of age **Setting:** Five Italian Hospitals **Number enrolled into study:** *N* = 433 **Gender, males (as defined by researchers):** • 57.5% **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in Italy. **Age,** median in years, (range): • 5.0, (0-14) **Inclusion Criteria:** • Consecutively admitted patients needing body temps **Exclusion Criteria:** • Children in critical condition • Not able to tolerate multiple BT measurements **Covariates identified:** • Not reported
Interventions	• Data regarding age, gender, time of detection, and body temperature (BT) values in Celsius (°C) using forehead (FHD), axillary (AXL), and tympanic (TYM) sites were collected • FHD BT was measured using the infrared Chicco® Easy Touch thermometer which provided BT measurements in <30 s (mean = 5–8 s) by scanning the infrared radiation from the temporal artery • AXL BT was measured using the digital Chicco® Digi Baby thermometer which provided BT measurements in about 1 min by heat conduction • Infrared Chicco® Comfort Quick device was used to detect TYM body temperature values. • All the measurements were performed simultaneously on clean and dry skin, waiting at least 30 min after meals or baths, and making sure that the ear had not been in contact with pillow before the TYM measurement
Outcomes	Primary Outcome: • Investigate the interchangeability of infrared forehead, digital axillary, and infrared tympanic thermometers while identifying the most reliable non-invasive BT measurement method in Italian pediatric setting.
Notes	Results: • TYM mean value: 37.05 °C • FHD mean value: 36.87 °C • AXL mean value: 36.81 °C • FHD versus AXL: +1.79 °C to -1.67 °C • Bland Altman analysis FHD: 95% LoA (+0.94 °Cto -1.02°C) Authors conclusion: Differences between paired measurements fell within broad 95% LoA. The devices are not interchangeable.

Fortuna et al., 2010

Methods	Prospective Cohort - use of prospective convenience sample
Participants	Participants: Children aged one month through four years presenting to a tertiary pediatric emergency department Setting: USA, urban tertiary pediatric emergency department Number enrolled into study: • N = 200 (each participant received both the control (rectal thermometry) and the intervention (mid forehead non-contact infrared thermometry) Gender, males (as defined by researchers): Not identified by researchers Race / ethnicity or nationality (as defined by researchers): The study occurred in Michigan. The authors did not identify race or ethnicity of the participants. Age, mean in years, (IQR in years): • 1.4 (0.7, 2.0) Inclusion Criteria: • Children aged one month through four years of age • Triage levels 3-5, acuity not too high as to preclude participation • English-speaking parent or guardian • No contraindication to rectal thermometry usage • No skin abnormalities on the forehead where temperature would be taken Exclusion Criteria: Not identified by researchers Covariates Identified: • Patient age • Ambient temperature of the room
Interventions	Each participant: • A Welch Allen SureTemp thermometer, model 678, was used for rectal temperatures, calibrated using the manufacturer calibration key. • The thermometer was placed into the rectum to a depth of 1.5 cm from the anal margin and read 15 seconds after placement then recorded. • Immediately after the rectal temperature was taken, the same person utilized the Thermofocus non-contact infrared thermometer, model 1500, to record the skin temperature on the mid part of the forehead. This thermometer was calibrated to the room temperature. The device was held perpendicular to the forehead and held still until the device signaled that a reliable reading was taken. • The operator then recorded the temperature from the device display.
Outcomes	Primary outcome(s): • Agreement between measurements taken by infrared and rectal thermometry • Correlation between the two measurements* • Bias, determined by correlating the rectal temperature to the difference between the infrared and rectal termperature* Secondary outcome(s): • Impact of patient age and ambient temperature of room on measurement agreement Safety outcome(s): • Not reported

	*Outcomes of interest to the CMH CPG /CAT development team
Notes	Results: • Routine use of infrared thermometry was not indicated based on the lack of sufficient agreement with rectal thermometry measurements. • Average rectal temperature of all participants was 99.6°F (98.7°, 100.5°) • Average infrared temperature was 99.5°F (98.6°, 100.3°) • Coefficient of determination (r2) value between the two measurements was 0.48 (P < .01) • Monotonic linear relationship between the two thermometry measurements was highly statistically significant (P < .01); however, correlation was modest with an unacceptably broad 95% prediction band for an infrared measurement given a rectal temperature (on the order of 4°F). • Infrared thermometry tended to overestimate the rectal temperature of patients with lower temperatures and underestimate the rectal temperature in those with a fever (r2 = 0.149, P < .01). • No statistically significant contributions on the level of agreement were found in linear models incorporating patient age and ambient temperature of the room. Limitations: • Authors note the possibility that difficult to measure selection bias against the test device was present, although nothing was found to suggest that in the analysis of the data. • Inter-rater accuracy was not evaluated. Despite all operators provided with detailed training on the device and data collection, inexperience may have proved a disadvantage for the test device. However, the authors note their belief that the use of the infrared thermometry in the study would not differ significantly from how it would be used during non-experimental use.

Franconi et al., 2016

Methods	Observational Cohort
Participants	**Participants:** Pediatrics **Setting:** Emergency Department, Italy **Number enrolled into study:** *N* =205 subjects with 217 paired measurements **Gender, males (as defined by researchers):** • 53.9% **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in Italy. **Age,** median in years, (range): • 4.5, (0.01-13.42) **Percent subjects in age groups** • ≤ 1 year, 24% • >1 - 5 years, 29.3% • > 5 -10 years, 35.3% • > 10 years, 10.7% **Inclusion Criteria:** • Consecutively admitted to a pediatric emergency department **Exclusion Criteria:** • Unable to tolerate concurrent temperature determination by two methods • Admissions with life threatening conditions **Covariates identified:** • Environmental temperature, but not controlled for
Interventions	• Nurses trained for the study, obtained two body temperature measurements simultaneously at an axillary site and and infrared measure ○ Axillary thermometer- Smart Care Digital Thermometer (Model HA3030424, Pic, Italy) placed in contact with a clean dry armpit ○ Infrared thermometer- Hartmann Thermoval Duo Scan (Model 925082; Hartmann, Germany) was placed 5-6 cm from the center of the forehead
Outcomes	**Primary outcome(s):** • *Agreement of axillary and infrared thermometer assessments **Secondary outcome(s):** • Not reported **Safety outcome(s):** • Not reported *Outcomes of interest to the CMH CPG or CAT development team
Notes	**Results:** • Axillary vs. infrared thermometer assessment, MD = 0.41 (0.81), p = .000 • Bland Altman analysis showed agreement. The mean value of differences for 95% of measures were between -1.18 and +1.99º C **Limitations:**

	• Environmental temperature when assessments were made varied, in an unspecified manner

Rubia-Rubia et al., 2010

<table>
<tr><td>Methods</td><td>Cohort</td></tr>
<tr><td>Participants</td><td>Participants:
Setting: Canary Islands, University Hospital, April 2006 – July 2007
Number enrolled into study: N = 201
Gender, males (as defined by researchers): 74%
Race / ethnicity or nationality (as defined by researchers): Not specified
Age, mean / median in months / years, (range / IQR): Adults (age 18+), mean 59 +/- 10 years
Inclusion Criteria:
• Patients over 18 years old admitted to the intensive care unit of a University Hospital, Canary Islands who had a catheter placed in the pulmonary artery with a device for measuring central temperature (PAC) as part of their management.
• Patients admitted April 2006 – July 2007
Exclusion Criteria:
• Patients with any impediment to placing a thermometer in their axilla, ears or forehead
• Patients with a low systolic blood pressure (SBP </= 110 mmHg)
• Patients with fever treatment in the last two hours
Covariates Identified: Not specified</td></tr>
<tr><td>Interventions</td><td>Body temperatures measured infrared (IR) thermometers vs pulmonary:
• Infrared Thermometer placed in right ear, "core equivalency" mode
• Infrared Thermometer placed in right ear, "oral equivalency" mode
• Infrared Thermometer placed near frontal right temple
• Pulmonary Artery Central (PAC) (control measurement)</td></tr>
<tr><td>Outcomes</td><td>Primary outcome(s): Accuracy of measurement
• Correlation Coefficient
• Sensitivity
• Specificity
• Mean Difference</td></tr>
<tr><td>Notes</td><td>Results:
<table>
<tr><th></th><th>Correlation Coefficient</th><th>Sensitivity</th><th>Accuracy in considering fever, %</th><th>Specificity, %</th><th>Mean Difference [Range]</th></tr>
<tr><td>PAC</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>IR, Ear, Core Equivalency</td><td>Not specified</td><td>Not specified</td><td>@ 38.5º C PAC: 89
@ 38.7º C PAC: 69
@ 38.9º C PAC: 59</td><td>@ 38.5º C PAC: 98
@ 38.7º C PAC: 95
@ 38.9º C PAC: 93</td><td>-0.1, [-0.7; 0.5] (No correlating PAC temperature specified)</td></tr>
<tr><td>IR, Ear, Oral Equivalency</td><td>Not specified</td><td>Not specified</td><td>@ 38.5º C PAC: 64
@ 38.7º C PAC: 53
@ 38.9º C PAC: 52</td><td>@ 38.5º C PAC: 91
@ 38.7º C PAC: 90
@ 38.9º C PAC: 91</td><td>0.2, [-0.8; 1.2] (No correlating PAC</td></tr>
</table></td></tr>
</table>

					temperature specified)
IR, Temple	Not specified	Not specified	@ 38.5° C PAC: 47 @ 38.7° C PAC: 33 @ 38.9° C PAC: 41	@ 38.5° C PAC: 83 @ 38.7° C PAC: 80 @ 38.9° C PAC: 88	1.0, [-0.4; 2.4] (No correlating PAC temperature specified)

Limitations/Notes:

- Note: patients with "continuous fever treatment" were not excluded from study
- Note: Models of IR thermometers not specified
- Note: Primary conclusion of study was that the Gallium-in-glass thermometer in bilateral axillae for 15 minutes gave the most accurate results
- Limitation: Several models of IR thermometers were used, the model that was the least difference from the PAC were used. No models of thermometers were specified.

Selent et al., 2013

Methods	Cohort
Participants	Participants: Children, age 6 months-17 years, presenting to Emergency Department (ED) Setting: Urban Children's Emergency Department, Georgia, USA Number enrolled into study: 855 Gender, males (as defined by researchers): • Group 1: Traditional Thermometer: 469 • Group 2: OptoTherm: 469 • Group 3: FLIR camera: 468 • Group 4: Thermofocus: 387 Race / ethnicity or nationality (as defined by researchers): Not reported Age, mean / median in months / years, (range / IQR): • Group 1: 3-5 years: 238 • Group 2: 3-5 years: 237 • Group 3: 3-5 years: 238 • Group 4: 3-5 years: 195 Inclusion Criteria: • Age 6 months-17 years • Verbal consent by guardian • Verbal assent by participants age 7+ • English or Spanish speaking Exclusion Criteria: • Non-English or Spanish speaking • Called for evaluation before completion of screening • Unable to tolerate infrared thermal detection system (ITDS) Covariates Identified: • Parental perception of fever • Antipyretic medication used within 8 hours • Date and time of measurement • Positioning of participant • Presence of parent in the ITDSs field of view • Room temperature • Participants emotional state during measurement
Interventions	• Group 1: Temperature taken by ED staff through rectal, oral or axillary thermometry based on hospital's standards and protocols. • Group 2: Participant positioned at recommended distance, removal of eyeglasses, hats and hoods. Faced device till reading was captured (~10 seconds), unadjusted temperature was documented • Group 3: Participant positioned at recommended distance, removal of eyeglasses, hats and hoods. Faced device till reading was captured (~10 seconds0, operator records midrange temperature. • Group 4: Collected by placing device 1 inch from child's forehead. Reding was recorded.

Outcomes	Primary outcome(s): • Accuracy of ITDS in pediatric patients compared to traditional thermometry. Secondary outcome(s): • Not reported Safety outcome(s): • Not reported *Outcomes of interest to the CMH CPG /CAT development team

Notes	Results:
	• **Group 1:** 306 (35.8) were ≥ 38.0^{0}C
	• **Group 2:** 328 (38.4) were ≥ optimal fever threshold;
	  ○ Sensitivity 0.8295, 95% CI [0.78, 0.87];
	  ○ Specificity 0.8634, 95% CI [0.83, 0.89];
	  ○ False-positive rate 0.2287, 95% CI [0.18, 0.28];
	  ○ False-negative rate 0.0989, 95% CI [0.07, 0.13]
	• **Group 3:** 334 (39.2) were ≥ optimal fever threshold;
	  ○ Sensitivity 0.8366, 95% CI [0.79, 0.88];
	  ○ Specificity 0.8571, 95% CI [0.82, 0.88];
	  ○ False-positive rate 0.2335, 95% CI [0.19, 0.28];
	  ○ False-negative rate 0.0965, 95% CI [0.07, 0.13]
	• **Group 4:** 286 (40.1) were ≥ optimal fever threshold;
	  ○ Sensitivity 0.7680, 95% CI [0.71, 0.82];
	  ○ Specificity 0.7939, 95% CI [0.75, 0.83];
	  ○ False-positive rate 0.3287, 95% CI [0.27, 0.39];
	  ○ False-negative rate 0.1381, 95% CI [0.11, 0.17]
	• Parental Report: 400 were positive for fever per parent report; Sensitivity 0.8385 , 95% CI [0.79, 0.88]; Specificity 0.7084 , 95% CI [0.67, 0.75]; False-positive rate 0.3700, 95% CI [0.32,0.43]; False-negative rate 0.1142, 95% CI [0.08,0.15]
	• 46.8% of parents reported fever, 35.8% had confirmed fever
	• OptoTherm had 83.0% sensitivity
	• FLIR had 83.7% sensitivity
	• Thermofocus 76.8% sensitivity
	• Correlation coefficients between traditional thermometry and ITDSs were 0.78 OptoTherm, 0.75 FLIR, 0.66 Thermofocus
	Limitations:
	• Tested in only 1 urban pediatric ED
	• Inclusion of axillary measurements, do not represent core temperature but were included in the data with oral and rectal temperatures
	• Reporting fever by parent could be inaccurate related to perception of care
	• Different staff conducting readings
	• Little time given to acclimate to room temperature when initial reading was completed.
	• Only 3 ITDSs were evaluated limiting generalization to all ITDSs

Sollai et al., 2015

Methods	Prospective, observational cohort
Participants	**Participants:** Healthy at term and preterm newborns **Setting:** Level III hospital, Careggi University Hospital, Florence, Italy **Number enrolled into study:** *N* = 189 with 1134 actual temperature measurements assessed • **Group 1,** healthy term newborns, *n* = 119 with 714 temperatures assessed • **Group 2,** preterm newborns, *n* = 70 with 420 temperatures assessed **Gender, males (as defined by researchers):** *n* = 92 • **Group 1,** *n* = 64 (53%) • **Group 2,** *n* = 28 (40%) **Race / ethnicity or nationality (as defined by researchers):** The study occurred in Italy. The authors did not identify race or ethnicity of the participants. **Mean Gestational Age, mean (IQR):** • **Group 1:** 39 weeks + 6 days (IQR 38 weeks + 3 days—40 weeks + 3 days) • **Group 2:** 27 weeks + 3 days (IQR 25 weeks+ 1 day—27 weeks +5 days **Inclusion Criteria:** Newborns nursed in incubators **Exclusion Criteria:** Children with: • unstable/critical conditions • polymalformative congenital syndromes • severe congenital syndromes (ie, severe cardiopathies) **Covariates identified:** None identified
Interventions	Two non-contact infrared thermometer (NCIT), bilateral digital axillary (DAT) and bilateral infrared tympanic temperature (ITT) measurements were performed in every newborn. • NCIT measurements took place in the mid-forehead area with followed the manufacturer's instructions (Thermofocus, model 0800; Tecnimed, Varese, Italy). • DATs were measured using a digital axillary thermometer (SANITAS Hans Dislage GmbH, Uttenweiler, Germany). The temperature was read 2 minutes after placement on the newborn's axilla and after the acoustic alert sounded. • ITTs were recorded with a infrared tympanic thermometer (Braun ThermoScan PRO 4000). Temperatures occurred at stable incubator temperatures.
Outcomes	**Primary outcome(s):** • Agreement of NCIT, DAT, and ITT assessments* measured by clinical reporducibility between two source temperatures, mean of difference (the authors identify this as bias) and outliers (defined as a differentce $\geq$ 1°C) **Secondary outcome(s):** • Not reported **Safety outcome(s):** • Not reported *Outcomes of interest to the CMH CPG or CAT development team

Notes	NCIT reproducibility was 0.0794°C (0.0455°C for infants in incubator and 0.0861°C for infants outside the incubator). • Bias was 0.047°C (0.029°C for infants in incubator and <0.0001°C for infants outside the incubator). • Zero outliers were recorded. ITT reproducibility 0.2931°C (0.1800°C for infants in incubators and 0.3250°C for infants outside the incubator). • Bias was 0.348°C (0.233°C for infants in incubators and 0.416°C for infants outside the incubator). • Eight of 188 (4.25%) outlier were recorded (all outside the incubator). DAT reproducibility was 0.1921°C (0.0995°C for infants in incubator and 0.2207°C for infants outside the incubator). • Bias was 0.159°C (0.090°C for infants in incubators and 0.200°C for infants outside the incubator). • Two of 188 (1.06%) outliers were recorded.

Teran et al., 2012

Methods	Cohort
Participants	Participants: N = 434 Setting: USA, Emergency Department (ED) and pediatric inpatient unit, Brooklyn, NY Number enrolled into study: N = 500 • ED = 250 • Inpatient = 250 Completed Study: N = 434 • ED = 219 • Inpatient = 225 Total number of children with fever: n = 167 Gender, males (as defined by researchers): n = 208 Race / ethnicity or nationality (as defined by researchers): Not specified Age, Range in months (Mean and SD): 1-48 months (14.6 +/- 10.7 months) Inclusion Criteria: All patients of the given age Exclusion Criteria: Patients were excluded if their condition precluded inaccurate body temperature measurements such as • Persistent perspiring forehead • Patients who had been using a cold cloth, hat, scarf around the head • Bathing, showering or engaging in physical activity such as running within 15 min of the body temperature reading.
Interventions	All patients were assessed with three different thermometers: • Non-contact infrared thermometer (Thermofocus) Thermofocus model 01500, TECNIMED, Varese, Italy) in the center of forehead. • (15 seconds later): Temporal artery thermometer (Exergen) (Mod TAT2000C, EXERGEN Corp., Watertown, MA, USA) starting in the center of the forehead and then slightly sliding the thermometer across the forehead keeping the sensor flat and in contact with the skin until the hairline was reached. • Three consecutive readings were performed and recorded with both thermometers. • The mean was calculated and used for statistical analysis. Reference Standard: • (15 seconds later) Glass/mercury thermometer (GMT) introduced 2 to 3 cm from the anal margin. Temperature read 5 min after insertion.
Outcomes	Accuracy : • Correlation coefficient • Mean difference • Sensitivity • Specificity
Notes	Mean temperature of patients: • Thermofocus (Non-contact infrared): 37.9 +/-0.9°C • Exergen (Temporal Artery): 37.6 +/-0.8°C

- Rectal (mercury/glass): 37.9 +/-0.9°C

Compared to Rectal (control):

	Exergen % (Temporal artery thermometer) [95% CI]	**Thermofocus** % (non-contact infrared) [95% CI]
Pearson correlation coefficient	*r* = 0.950	*r* = 0.952
Mean difference	-0.2+/-0.277°C	0.029 +/- 0.01°C
Sensitivity	91.0% [85.3, 94.7]	97.0% [92.7, 98.8]
Specificity	99.6% [97.6, 99.9]	97.0% [93.9, 98.6]

Limitations:

- Total number of males comes from the number of participants, not the total enrolled into study.
- It is unclear which of the three temperature methods were used to determine if child had a fever
- It is unclear if the number of children with a fever comes from the number of participants or the total enrolled into study
- It is unclear if the mean temperature for each thermometer is based on all the children or only the febrile children

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