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# Diagnostic Accuracy of Non-Contact Infrared Thermometer in Comparison with Mercury Thermometer and Digital Thermometers

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## ABSTRACT

**BACKGROUND:** Body temperature is a vital parameter in patient assessment. Fever is a common presentation in patients arriving at all health care setups. [1] It is a transient pathological state characterised by a disturbance in the hypothalamus thermoregulation system and, as a result, an increase in the body's temperature above the normal range. Normal body temperature values range from 36.5 to 37.4 °C depending on physiological variations, patient characteristics, and measurement sites. [2] Fever is a sign of underlying pathology – infection, infestation, inflammation, autoimmune diseases, malignancy, medication adverse reaction, intracranial haemorrhage or pulmonary embolism. Fever is also an important symptom in COVID-19 patients, typically appearing 12–14 days after exposure. And that made screening patients for elevated body temperature an essential initial triaging tool during the pandemic. [3] [4] A clinical thermometer is the equipment used for measuring body temperature. Several thermometers are available, each with its advantages, disadvantages, applicability, reliability and sensitivity. [5] Mercury-in-glass thermometers were the standard way to measure temperature for many years. They were taken off the market in the late 2000s because mercury is toxic to the environment. After that, many thermometers came into use, including digital, tympanic or axillary thermometers and non-contact infrared thermometers. Presently digital thermometers occupy the bedside at both homes and hospitals, including clinics. [6] [7] [8] The COVID-19 pandemic brought in, at large scales, the use of a non-contact infrared thermometer as a screening tool to measure body temperature. [9] [10] Our knowledge of the relative performance of different types of thermometers, including differences in temperature measured, is limited despite the essential role they play in clinical practice. So, it's essential to understand how different thermometers work and how accurate they are at making diagnoses. [11] [12] This is especially crucial considering the triage significance of fever measurement in clinical settings, especially emergency care, to refer patients to appropriate care pathways.

**OBJECTIVES:** To evaluate the diagnostic accuracy of non-contactable infrared thermometers in comparison with mercury and digital thermometers.

**METHODOLOGY:** The prospective observational study was conducted on 210 patients of both genders, of all age groups, presenting with or without fever to the ED of AIMS, Kochi, and a quaternary during the period from January to June 2022. The data we collected and statistically analysed from the study population are age, sex, presenting complaints, co-morbidities, heart rate, blood pressure, respiratory rate, SpO2, and body temperature being simultaneously measured with mercury, digital and non-contact infrared thermometers. The temperature of all patients was recorded using mercury, a digital thermometer placed in each axilla simultaneously, and a non-contactable infrared thermometer on the forehead. Mercury in glass thermometer was placed in axilla with the bulb of the thermometer in the tip of the axilla for 2 minutes. The digital thermometer was placed in a similar fashion in the other axilla and removed from the axilla after the beep was heard and temperature displayed was noted. The infrared thermometer is placed near the forehead or wrist, with

a 5cm gap between the two. The trigger button is gently pressed, and the temperature shown on the LCD screen is recorded.

**RESULT:** The study group included 53% males and 47% females. 58% belonged to the age group between 46 and 75 years, 30% between 16 and 45 years of age, 11% between 76 and 99 years and 1% below 15 years of age. Fever was present in 20.5% of the patients and the rest had other symptoms like vomiting, diarrhoea, cough, dyspnoea, fatigue, weakness, body pain and pedal oedema. 57% had two comorbidities, 29% were with more than 2 comorbidities while 14% had no known comorbidities. The body temperatures measured by mercury and digital thermometers were almost identical – Normal in 85.5%, above normal in 14% and below normal in 0.5%; but with a non-contact infrared thermometer, the same were 97.5%, 2.5% and 0% respectively.

**DISCUSSION:** This study is highly relevant in the current scenario where the pandemic situation is almost over and a lot of institutions who invested in NCIT have started considering them for use as alternative devices for recording temperature. In our study, non-contact infrared thermometer failed in detecting fever in several affected patients, or misread normal temperature as elevated and was not capable of detecting hypothermia. Additional research is required to compare its accuracy and precision to other invasive and non-invasive core body temperature testing methods. The study finding of a rise in heart and respiratory rates in fever patients, though non-specific, concur with inferences from other similar studies.

**CONCLUSION:** Our study concluded that the accuracy of non-contactable infrared thermometers is less reliable than mercury and digital thermometers for routine clinical practice. Though, the non-contact infrared thermometer was widely being used during the pandemic scenario, our study results do not favour its use other situations like the clinics, intensive care units or emergency departments.

***Keywords:*** [Mercury, Digital, Infrared, Thermometer, COVID, Healthcare technology]

## INTRODUCTION

Body temperature is a vital parameter in patient assessment. Normal body temperature values range from 36.5 to 37.4 °C depending on physiological variations, patient characteristics, and sites of measurement. It varies with respect to age, gender, site and course of the day of measurement, type of thermometer, activity status at the time of measurement and presence of disease.

In the clinical scenario, temperature variations are the heralding signs of either internal pathology or external environmental issues. While abnormal temperatures prompt an early patient evaluation and management, critical temperature values mandate urgent or emergent interventions.

Fever is a temporary pathological state that involves an alteration of the hypothalamic thermoregulation system and a consequent elevation of body temperature above the value considered normal. It is a common presentation in patients arriving at all health care setups. Fever is a sign of underlying pathology – infection, infestation, inflammation, autoimmune diseases, malignancy, medication adverse reaction, intracranial haemorrhage or pulmonary embolism.

Fever is also an important symptom in COVID-19 patients, typically appearing 12–14 days after exposure. And that made screening patients for elevated body temperature an essential initial triaging tool during the pandemic.

A clinical thermometer is the equipment used for measuring body temperature. Several thermometers are available, each with its advantages, disadvantages, applicability, reliability and sensitivity. [13]

Mercury-in-glass thermometers were the standard reference method for decades until the late 2000s when they were banned from the market due to the environmental toxicity of mercury. Following that alternative thermometers have come into use, such as digital tympanic or axillary, infrared skin scan, temporal artery thermometers, and non-contact infrared thermometers. [14]

Presently digital thermometers occupy the bedside of both homes and hospitals including clinics. [15]

Digital thermometers are temperature-sensing instruments that are easily portable, have permanent probes, and have a convenient digital display. The way a digital thermometer works depends upon its type of sensor. Sensor types include resistance temperature detector (RTD), thermocouple and thermistor.

The COVID-19 pandemic brought in, at large scales, the use of non-contact infrared thermometer as a screening tool to measure body temperature. [16]

Our knowledge of the relative performance of different types of thermometers, including differences in temperature measured, is limited despite the essential role they play in clinical practice. So, it's essential to understand how different thermometers work and how accurate they are at making diagnoses. [17] [18]

This is especially crucial considering the triage significance of fever measurement in clinical settings, especially in emergency care, to refer patients to appropriate care pathways. [19]

## OBJECTIVES

To evaluate the diagnostic accuracy of non-contactable infrared thermometers in comparison with mercury and digital thermometers.

## MATERIALS & METHODS

### MATERIALS:

**Study type:** Prospective observational study
**Sample size:** 210 patients

**Inclusion criteria:**
Both the genders
Age: All ages

**Exclusion criteria:**
Patients who didn't give consent.

**Study period:** 1st January to 30th June, 2022
**Study Place:** Amrita Institute of Medical Sciences and Research, Kochi, India

**Thermometers used for body Temperature measurement:**
Mercury thermometer- Jindal Medical and scientific Instruments company Pvt. Ltd.
Digital thermometer- Dr Trust Waterproof Flexible Tip Digital thermometer.
Non-contact Infrared Thermometer- LCARE

## METHODOLOGY

The data we collected and statistically analysed from the study population are age, sex, presenting complaints, co-morbidities, heart rate, blood pressure, respiratory rate, SpO2, and body temperature being simultaneously measured with mercury, digital and non-contact infrared thermometers.

Temperature of all patients were recorded using mercury and digital thermometer placed in each axilla simultaneously and non-contactable infrared thermometer in the forehead.

Mercury in glass thermometer was placed in axilla with the bulb of the thermometer in the tip of the axilla for 2 minutes. The digital thermometer was placed in a similar fashion in the other axilla and removed from the axilla after the beep was heard and temperature displayed was noted. The infrared thermometer is placed near the forehead or wrist, with a 5cm gap between the two. The trigger button is gently pressed, and the temperature shown on the LCD screen is recorded.

## STATISTICAL ANALYSIS

Statistical Analysis was performed using IBM SPSS version 20.0 software. Categorical variables are expressed using frequency and percentage. Numerical values were represented using mean and standard deviation. Homogeneity of the distribution of variables was evaluated using the chi-square test. Non-parametric tests were used in cases of non-normal variable distribution. Comparison of the methods was done using the Spearman correlation test and Bland-Altman test.

## RESULT

### DISTRIBUTION OF AGE

A total of 210 patients included in the study satisfying inclusion criteria, age distribution group between 0-15 has 1%, 16-30 has 16%,31-45 has 14%, 46-60 has 32%,61-75 has 26% and 76-99 has 11%.

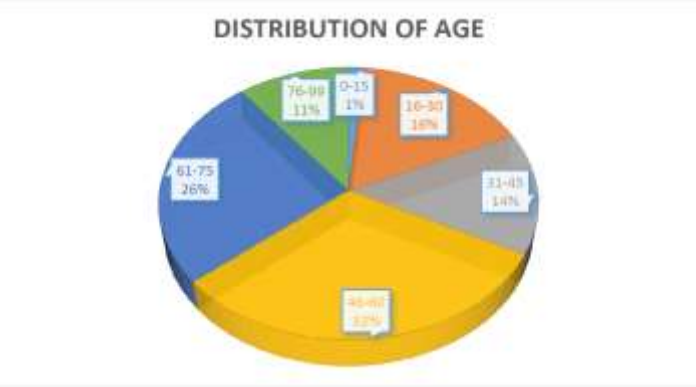


**Figure 1: Pie in 3-D graph showing the distribution of age.**

### DISTRIBUTION OF GENDER

A total of 210 patients included in the study satisfying the inclusion criteria, 112 ie, 53% are male and 98 ie, 47% are female.

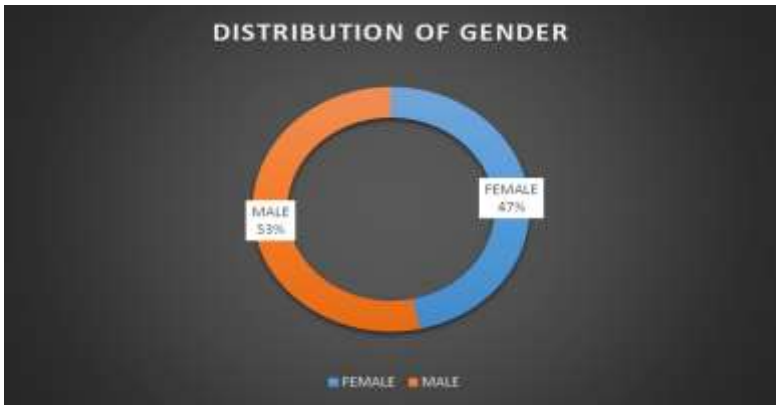


**Figure 2: Doughnut diagram showing distribution of gender.**

### DISTRIBUTION OF PRESENTING COMPLAINTS:

Among the 210 patients included in the study, 20.5% presented with fever and remaining 79.5% presented with other symptoms. (Other symptoms include vomiting, cough, loose stools, fatigue, generalized weakness, rashes, body pain, breathlessness and pedal edema)

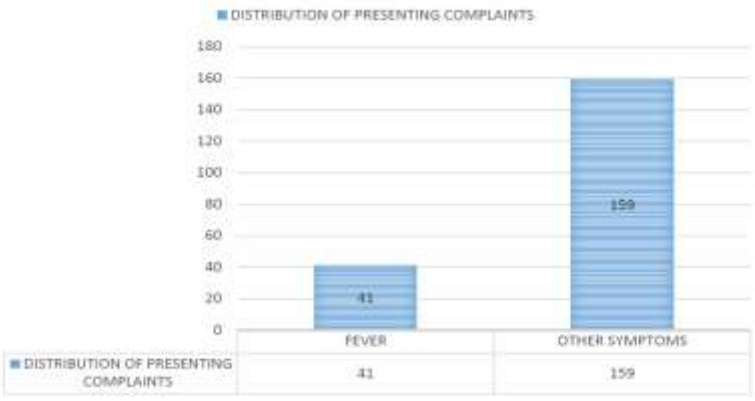


**Figure 3: Stacked column showing distribution of presenting complaints**

## DISTRIBUTION OF BACKGROUND DISEASES:

A total of 210 patients included in the study, 57% have two co-morbidities,29% have more than two co-morbidities and 14% have no co-morbidities.

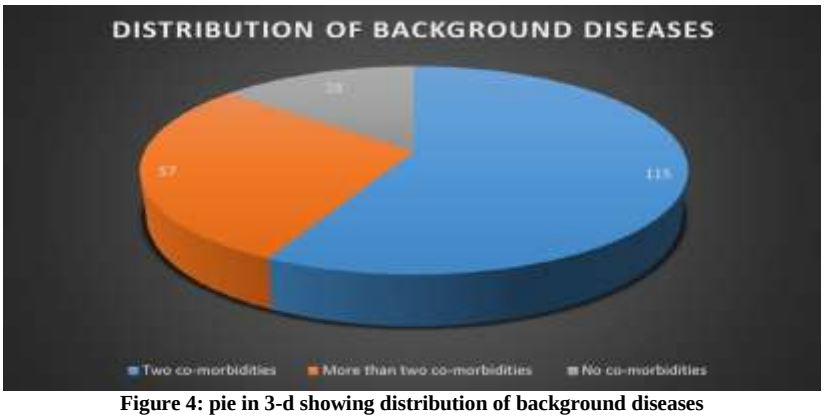


**Figure 4: pie in 3-d showing distribution of background diseases**

## DISTRIBUTION OF TYPE OF THERMOMETER AND BODY TEMPERATURE:

A total of 210 patients included in the study. In mercury thermometer, 28 have hyperthermia, 171 have normothermia, 1 has hypothermia.

In digital thermometer, 28 have hyperthermia 171 have normothermia, 1 has hypothermia.

In non-contactable thermometer, 5 have hyperthermia, 195 have normothermia and none has hypothermia

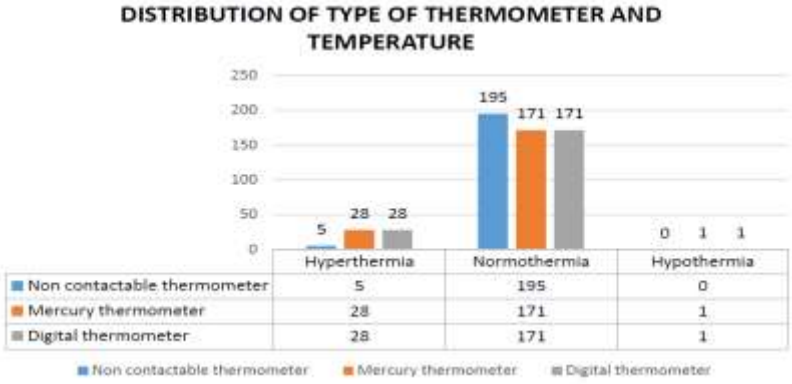


**Figure 5: Clustered graph showing distribution of types of thermometers and body temperature**

## RELATION OF HEART RATE WITH TEMPERATURE

Among the 210 patients included in the study, 28 patients have fever. Their heart rate also increased according to the increase in degree Fahrenheit.

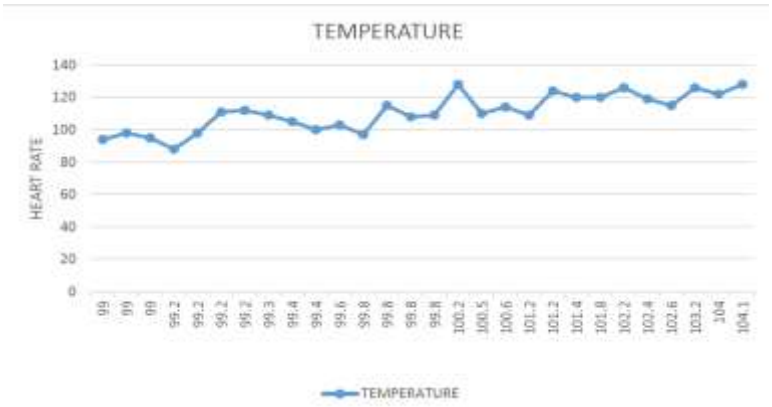


**Figure 6: Graph showing the relation of heart rate with temperature**

## RELATION OF RESPIRATORY RATE WITH TEMPERATURE

Among The 210 patients included in the study,28 patients have fever. The graph shows that their respiratory rate also increased according to the increase in temperature.

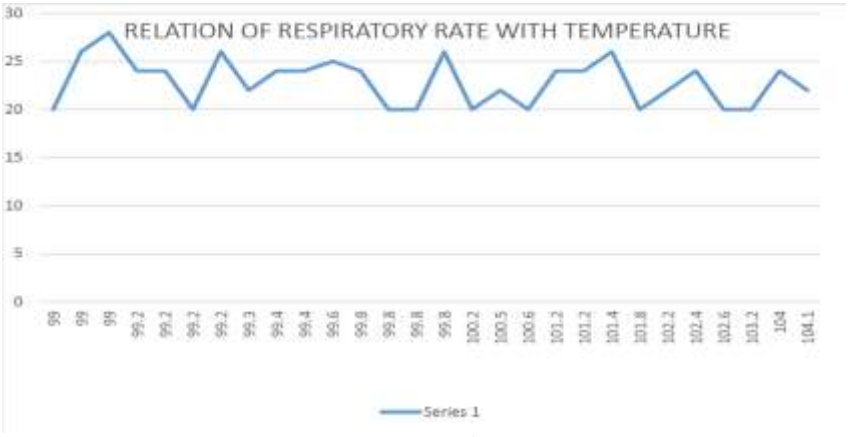


**Figure 7: Graph showing the relation of heart rate with temperature**

The results show that the temperature recorded by the Mercury and Digital thermometers are comparable and there is no statistically significant difference (p value: > 0.64). On the other hand, there was a statistically significant difference in the temperature measured between Non-contact infrared thermometer and Mercury or Digital thermometers with a p value of <0.05. On correlating variations of heart rate and respiratory rate with temperature, a positive correlation coefficient was noted (r=0.990 and r=0.883 respectively) and was found to be statistically significant with p value <0.04

## DISCUSSION

This is a prospective observational study evaluating the diagnostic accuracy of non-contactable infrared thermometers in comparison with mercury and digital thermometers.

Non-contact infrared thermometers cannot be considered as replacement of digital thermometers as they fail in multiple areas. This failure is not only related to the inability to detect fever in some affected patients, but also because these devices fail to identify elevated temperature, or misread normal temperature as elevated. Moreover, failure to follow the manufacturer's instructions for use, such as for set-up, operation, and training, is also reported as a limitation of non-contact thermometer use. [20] [21] [22]

Though non-specific, a direct correlation was also noted between the rise in body temperature and the rise in heart and respiratory rates. [23] [24]

## CONCLUSION

This is the first study of its kind, comparing the diagnostic accuracy of a non-contact infrared thermometer to that of mercury thermometers and digital thermometers in patients of all ages, ranging from paediatric patients to elderly patients.

Fever is one of the most common patient complaints in patients presenting to all kinds of healthcare setups and determining the presence of fever represents a fundamental step of health status assessment, with a bearing on medical decisions; for instance, fever can contribute to the assessment of bacterial infections, leading to the prescription of antibiotics.

However, body temperature should be evaluated in relation to individual variability, since it varies with respect to age, gender, site of measurement, type of thermometer and presence of disease. [26]

Though, the non-contact infrared thermometer was widely being used during the pandemic scenario, our study results do not favour its use in routine clinical practice.

Our study concludes that the accuracy of non-contactable infrared thermometers is less reliable than mercury and digital thermometers for use in clinics, intensive care or emergency room. Even then, its use is still validated in situations like mass screening by its nature of non-contact for temperature measurement, ease of use and patient compliance.

More research is needed to compare its accuracy and precision to other invasive and non-invasive methods of core body temperature evaluation.

Temperature measurement is imperfect. It requires awareness and appreciation of its limits.

Health professionals should consider that large errors can be found when measuring body temperature. Therefore, they should complement temperature with additional clinical elements like medical history, heart rate, respiratory rate and blood pressure for better patient evaluation.

### *Declaration by Authors*

**Ethical Approval:** Approved

**Acknowledgement:** None

**Source of Funding:** None

**Conflict of Interest:** The authors declare no conflict of interest.

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