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# **Original Research Article**

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# Diagnostic accuracy of digital thermometer compared to mercury in glass thermometer for measuring temperature in children

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### **ABSTRACT**

**Background:** A wide variety of devices are available to record temperature from skin, oral or rectal mucosa and the tympanic membrane. The accuracy of different devices is varied and the primary objective of this study is to compare the diagnostic accuracy of digital thermometer against mercury in glass thermometer in children. The secondary objective was to determine the average time taken by the digital thermometer to record the temperature.

**Methods:** This descriptive study was conducted in a pediatric ward at Institute of Child Health and Hospital for Children, Egmore, Chennai. In all 92 febrile children aged 1 month to 12 years admitted in the ward, temperature was measured at the time of admission using both digital and mercury in glass thermometers placed in each axilla after obtaining informed consent. Concordance and discordance of both measurements were determined using Pearson Correlation coefficient and Bland altman plot. Average time taken by digital thermometer to record temperature was noted.

**Results:** There was a good correlation between mercury and digital thermometer recordings (r=0.976, p<0.001). The Bland-Altman test showed that almost all residual values (estimated-observed) are random and the fall within the 95% confidence interval. The average time taken by the digital thermometer to record the temperature was 88.03 seconds (95% CI-54.58 to 121.49).

**Conclusions:** Digital thermometer is as accurate as mercury in glass thermometer in recording temperature. The average time taken by the digital thermometer to record temperature is  $88.03 \pm 17.07$  seconds.

Keywords: Digital thermometer, Mercury in glass thermometer, Temperature measurement

#### INTRODUCTION

Fever is one of the most common symptoms in children and is a cause of parental anxiety. The definition of fever depends on precise temperature recordings. An appropriate recording of the absence of fever reassures both parents and health care providers thereby avoiding the need for inappropriate medical consultations and

investigations. It is therefore, essential that the measurement of fever be accurate and reproducible.

There are many types of thermometers. The conventionally used thermometer is mercury in glass thermometer. Though rectal temperature measured using mercury thermometer is the gold standard, axillary temperature measurement is used routinely in practice. But the main disadvantage of mercury is that it is an

environmental hazard. Hence the Canadian Pediatric Society no longer recommends the use of mercury thermometers.<sup>2</sup> Electronic or digital thermometers work on the principle of superconductivity.<sup>3</sup> The measured temperature is displayed as a number (in Fahrenheit) in the panel which can be easily read. The main disadvantage is its cost.

Though mercury thermometer remains the gold standard, considering its disadvantages that it is not environment as well as user friendly, if digital thermometer is as accurate as mercury thermometer, it can be used for recording the temperature in clinical practice as well as at home. Most studies comparing digital and mercury in glass thermometer were done in adults. There are very few studies done in pediatric population. Hence this study was done to compare the accuracy of digital and mercury thermometer in children and to determine the time taken by digital thermometer to record temperature in children.

#### **METHODS**

This descriptive study, which is an evaluation of diagnostic test, was conducted in a pediatric ward of the Institute of child health and hospital for children, Egmore, Chennai. The study was commenced after obtaining Institutional ethical committee approval. Children between one month and twelve years of age who were admitted in the ward with complaint of fever or children found to be febrile on admission were included in the study. Febrile children whose caregiver did not consent were excluded from the study. Sample size of 92 was calculated based on previous study which shows  $0.48^{\circ}$ C limits of agreement.<sup>4</sup>

Basic demographic details of all eligible children were noted. After obtaining informed consent from the caregiver, temperatures of all eligible children were recorded using mercury and digital thermometer placed in each axilla simultaneously. Mercury in glass thermometer was placed in axilla, with the bulb of the thermometer in the tip of axilla for 5 minutes as per

IMNCI guidelines and temperature was noted in Celsius to the accuracy of  $0.10^{\circ}$ C. The digital thermometer was placed in a similar fashion in the other axilla and removed from the axilla after the beep and the temperature displayed was noted. The time taken for the temperature to be displayed was noted using a stop watch. The temperature displayed in Fahrenheit was converted to Celsius using the formula.

 $T(^{\circ}C) = [T(^{\circ}F)-32] \times 5/9$  where Tc=Temp. in Celsius and Tf=Temp. in Fahrenheit

Date and time of temperature measurement was also be noted. The mercury as well as digital thermometers used were manufactured by Hicks thermometers India limited. Recommendations given by the manufacturer were followed while using the thermometers. All children were managed as per unit protocol.

Mean and standard deviation of demographic data, recordings, the difference between both recordings and time taken to record temperature in a digital thermometer were calculated. Correlation coefficient was calculated using Karl Pearson correlation graph. A regression line was fitted. Limits of agreement were calculated using Bland altman test. P value less than 0.05 was considered significant.

## **RESULTS**

Temperature recording was done in 92 children of age between 2 months to 12 years using mercury in glass and digital thermometers. Mean age of children screened was  $50.2 \text{ months} (50.2\pm42.15)$ . 62 (67.4%) of them were male and 30(32.6%) were female.

The mean, standard deviation, minimum and maximum values for mercury and digital thermometer recordings and their difference are shown in Table 1. The mean (standard deviation) of the difference between the recordings was 0.26 (0.04) while the 95% confidence interval was 0.18 to 0.34.

**Table 1: Summary of measurements of temperature.** 

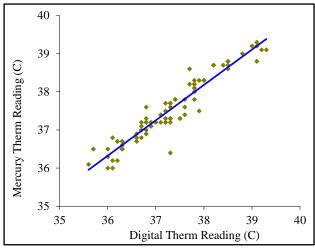
Thermometer	Observations	Mean °C	Standard Deviation	Min°C	Max°C	Mean (sec)
Mercury in glass thermometer	92	37.89	0.839	36	39.3	Standard (300)
Digital thermometer	92	37.63	0.862	35.6	39.2	88.03
Difference between digital and mercury thermometers	92	0.26	0.04	-0.9	1.8	-

On analyzing the temperature recording by mercury in glass thermometer and digital thermometer using Karl Pearson correlation scatter plot, the correlation

coefficient(r) was found to be 0.976 with corresponding p value of <0.001, which is highly significant (Figure 1). Regression line was fitted to depict how well the digital

thermometer reading predicted the mercury in glass thermometer reading. The fitted regression equation is

Mercury reading = $2.956+0.927\times$  (digital reading).



r = 0.952, p<0.001

Figure 1: Karl pearson correlation equation.

The fitted model showed adjusted  $R_2$  was 0.905 implying that about 90% of the variation is explained by the digital reading. This was also statistically significant (P<0.001). The mean, standard deviation upper limit and lower limit for the difference of estimated and observed mercury reading is 0.00, 0.25, 0.50372 and -0.50372 respectively.

A mean of zero implies nil bias, i.e. on an average there is no difference between both the thermometer recordings. The Bland Altman chart shows that almost all residual values (Estimated-observed) are random and the fall within the 95% confidence limits (Figure 2).

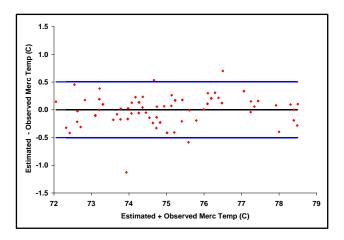


Figure 2: Bland altman chart.

The average time taken by the digital thermometer to record the temperature was 88.03 seconds (95% CI-54.58 to 121.49). The minimum and maximum time taken were 56 and 140 seconds respectively.

#### **DISCUSSION**

The results of the study show that digital thermometer agreed well with the mercury in glass thermometer for measuring axillary temperature in children.

The difference between digital and mercury thermometer temperature recordings observed in our study was similar to that stated in study done by shanks et.al whereas the study done by Kongpanichkul A et.al shows a higher 95% CI.<sup>6,7</sup> This could be due to the fact that, in that study digital thermometer reading was compared with mercury reading recorded rectally.

The mean duration taken to record the digital temperature reading in our study was more than that reported by Roy et.al,8 this could be because of the fact that the study was done on neonates who need minimal restraint for the procedure.

Though mercury in glass thermometer is the gold standard for recording temperature, there are some disadvantages. Mercury is not available in India, it is importedhence it is a drain on the country's foreign exchange. India imported almost 720,000 thermometers, costing USD 1.77 million in the year 2007-08.12.

Mercury content of a thermometer ranges from 0.5 to 3 grams. Though the amount may seem small, it is enough to pollute a small lake mercury waste from broken fever thermometers is significant. For instance, thermometers used and broken in India's health care sector emit an estimated 2.4 metric tons of mercury per year. 12 When released into the air mercury may stay in the atmosphere for up to a year, and is transported and deposited globally. It is interesting to note that, currently products containing mercury are used in large scale in hospitals and clinics and still the waste generated from these units are not considered as hazardous waste and rather classified as biomedical waste. A draft notification was circulated by the Ministry of Environment and Forest (MoEF) in 2000 for a phased elimination of mercury from consumer products, but so far action taken is minimal.

Health Care without Harm Europe (HCWH) is dedicated to transforming the health care industry worldwide, without compromising patient safety or care, so that it is ecologically sustainable and no longer a source of harm to public health and the environment with the support of NGOs from many countries including India (Toxics Link).

On the contrary digital thermometer is environment-friendly. It is also easy to use (easily readable) and has no subjective and inter observer variations and hence has a high reliability. It is also less time consuming as against mercury thermometer which is recommended to be placed for full 5 minutes according to IMNCI guidelines.

The disadvantage of digital thermometer is the cost; their cost is almost thrice that of a mercury thermometer.

This strength of the study lies in the fact that it is one of the few studies that compare mercury and digital thermometers in children. Limitations of our study are that it is neither a blinded study nor were the measurements noted by two different observers. Hence, there is chance of subjective variation in noting the mercury thermometer reading.

Since accuracy of digital thermometer is comparable to mercury thermometer besides being less time consuming and non-toxic, digital thermometer can replace mercury thermometer (which still remains the gold standard) in recording of temperature at home and in clinical practice.

#### **CONCLUSION**

The diagnostic accuracy of digital thermometer is in good agreement with that of mercury in glass thermometer for recording temperature in children aged one month to twelve years. The average time taken by the digital thermometer for recording temperature is 88.03 seconds.

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Ethical approval: The study was approved by the

Institutional Ethics Committee

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