



# CCT TG Body Temperature Measurement

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# Introduction

- Body temperature measurement – the challenge of using IR thermometry in health settings
  - Forehead thermometers
  - Thermal imaging
  - Ear thermometers
- National and international action
  - National Body Temperature Measurement Group
  - CCT TG on body temperature measurement
- Summary

# Forehead and temporal artery thermometers

# Forehead/temporal artery thermometers

- Different types of IR forehead thermometers
- Measurement site – region of forehead – or maximum temperature across forehead scan
- In some cases IRFT “repurposed” industrial point and measure devices
- Issues:
  - No standardisation
  - Variable emissivity correction
  - Questionable correction for background thermal radiation
  - Unreliable targeting
  - Measurement site not a clinically recognised body temperature measurement site

## Typical forehead thermometer

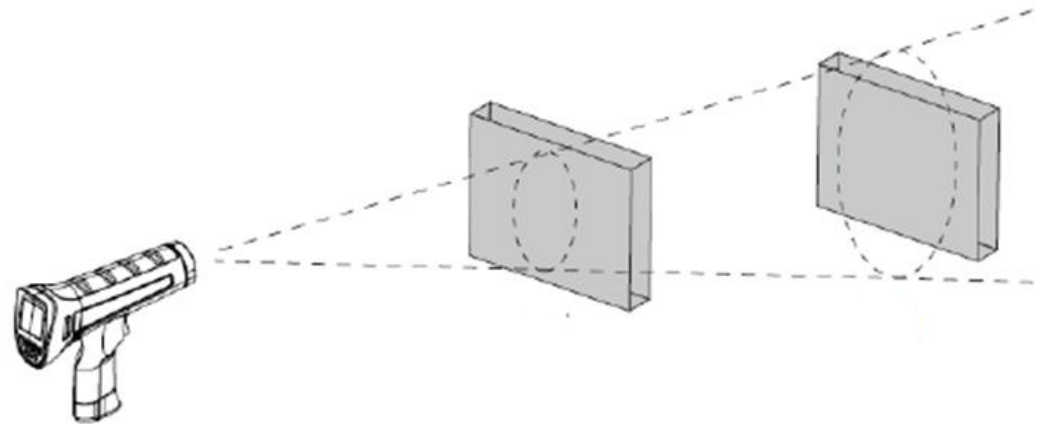
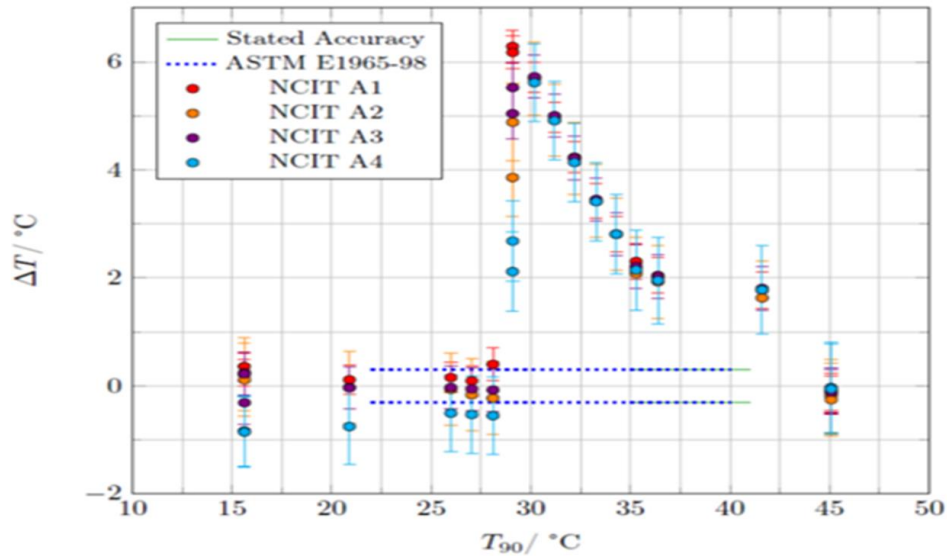


Figure illustrating the effect of incorrect distance on measurement area

# Variable performance in lab – ( $T_{90} - T_{meas}$ ) (claimed U = $\pm 0.3$ °C)

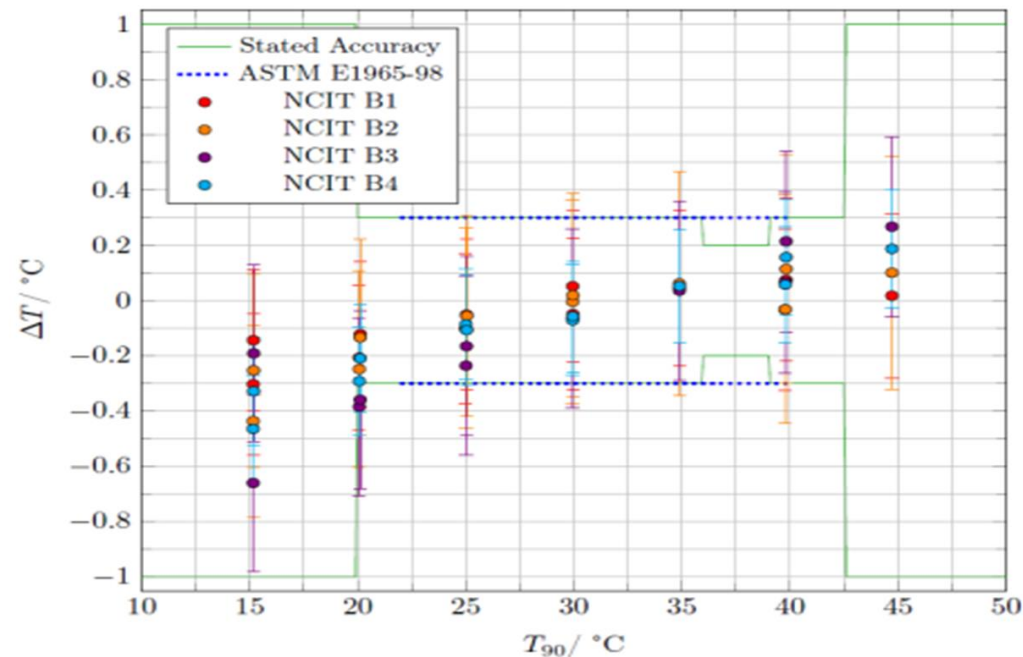
Calibration for Thermometer type A numbers 1-4



Fletcher, T., Whittam, A., Simpson, R., Machin, G.,  
“Comparison of non-contact infrared skin thermometers”, *J. Med. Eng. Technol.* **42** 65-71 (2018)  
<https://doi.org/10.1080/03091902.2017.1409818>

Can't always rely on batch testing or CE marking – need regular traceable calibration to assure performance

Calibration for NCIT type B numbers 1-4



# Clinical assessment very negative

- Bolton, S., Latimer, E., & Clark, D., “Temporal artery and non-contact infra-red thermometers: is there sufficient evidence to support their use in secondary care?”, *Global Clinical Engineering Journal*, **2**(2), 8-16. (2020), <https://doi.org/10.31354/globalce.v2i2.67>
- “A review of the literature for both TAT and NCIT has indicated that in their current form neither is suitable as a replacement for oral or tympanic thermometers in clinical practice.”
- “The evidence suggests that they are not acceptable methods for detecting temperatures outside the normothermic range and do not detect fever accurately”.

# Clinical assessment very negative

- Aw, J., “The non-contact handheld cutaneous infra-red thermometer for fever detection during the COVID-19 global emergency”., *J. Hospital Infection*, 0195-6701, (2020) doi.org/10.1016/j.jhin.2020.02.010
- “Among.. cutaneous infra-red thermometers evaluated for their ability to measure temperature traceable to ITS-90 the majority performed outside the accuracy range stated by the manufacturers and the medical standard”
- they were “less accurate than the tympanic thermometer and other infra-red thermal systems”
- “A local study found” them “to have a low sensitivity (29.4%) when compared with the oral thermometer to detect fever”



# Forehead thermometers summary

- Widely used (perceived to be good for infection control) and misused (too far away from subject for e.g.)
- No standardisation for clinical use
- Measurement site not formally recognised for body temperature measurement
- Laboratory assessment of performance – generally poor
- Clinical assessment of performance - generally negative
- Q: As metrologists should we be actively discouraging the use of such devices?

# Alert submitted to Chief Scientific Officer June 2020

- Alert: Issues with using non-contact forehead thermometers for fever screening
- Studies have shown poor correlation between obtaining temperatures using forehead thermometers and those measured by more established methods such as tympanic (ear) and oral (see for e.g. Bolton *et al*, 2020, Aw 2020, Crawford 2015). The errors are sufficiently bad that their use will mean that fevers are either missed (or even falsely detected) in many cases. The accuracy of these devices can be significantly influenced by the environment they are used in, and the error increases with the distance of the thermometer from the forehead. The inbuilt correction in the device for the skin's emissivity (how much thermal radiation it emits) is at best unsubstantiated, and this can cause further errors.....

# Thermal imaging for fever screening

# Is reliable fever screening with thermal imaging possible?

- Some established local standards eg Singapore TR 15- 1 ('03), TR 15 -2 ('04)
- Remote thermal imaging touted as a way to reliably detect fevers, and so *by implication* a first line of defence against Covid-19
- Thermal imaging of skin as a measure of core body temperature, unless under carefully controlled conditions, faces same challenges as forehead thermometry + difficulty of measuring moving target in varying thermal environment

# Credible? Believable?

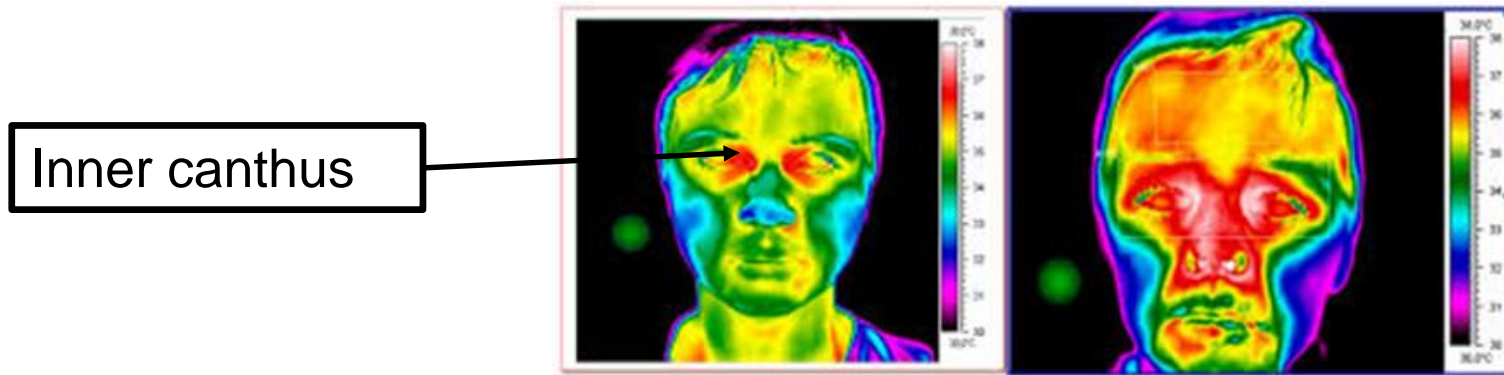


# Credible? Believable?

**IMPOSSIBLE!**



# Reliable fever screening *may* be possible with thermal imagers



- IEC80601-2-59: “Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening” (2008) [for airports - widely ignored....]
- Specifies the inner canthi of the eye – only “reliable” part of face for thermometry - can be done at ports of exit and entry
- Clinical study using traceably calibrated devices needed to show if inner canthi and body temperature (ear/oral) are tightly correlated

# Fever screening with thermal imaging

- Detection of fevers using thermal imaging by mass screening unlikely to be truly effective without further investigation
- Accepted international recommendations and standardisation required
- Clinical research in conjunction with metrologists required to firmly establish (traceable to ITS-90) correlation between inner canthi and body temperature
- What is our role as metrologists to improve this situation?

Ring EFJ, Jung A, Zuber J., Rutowski P, Kalicki B, Bajwa U. "Detecting fever in Polish children by infrared thermography", In Wiecek B, ed, QIRT 2008, Proceedings of the 9th International conference on Quantitative InfraRed Thermography, July 2-5, 2008, Krakow, Poland, Technical University of Lodz. Institute of Electronics, pp125-128

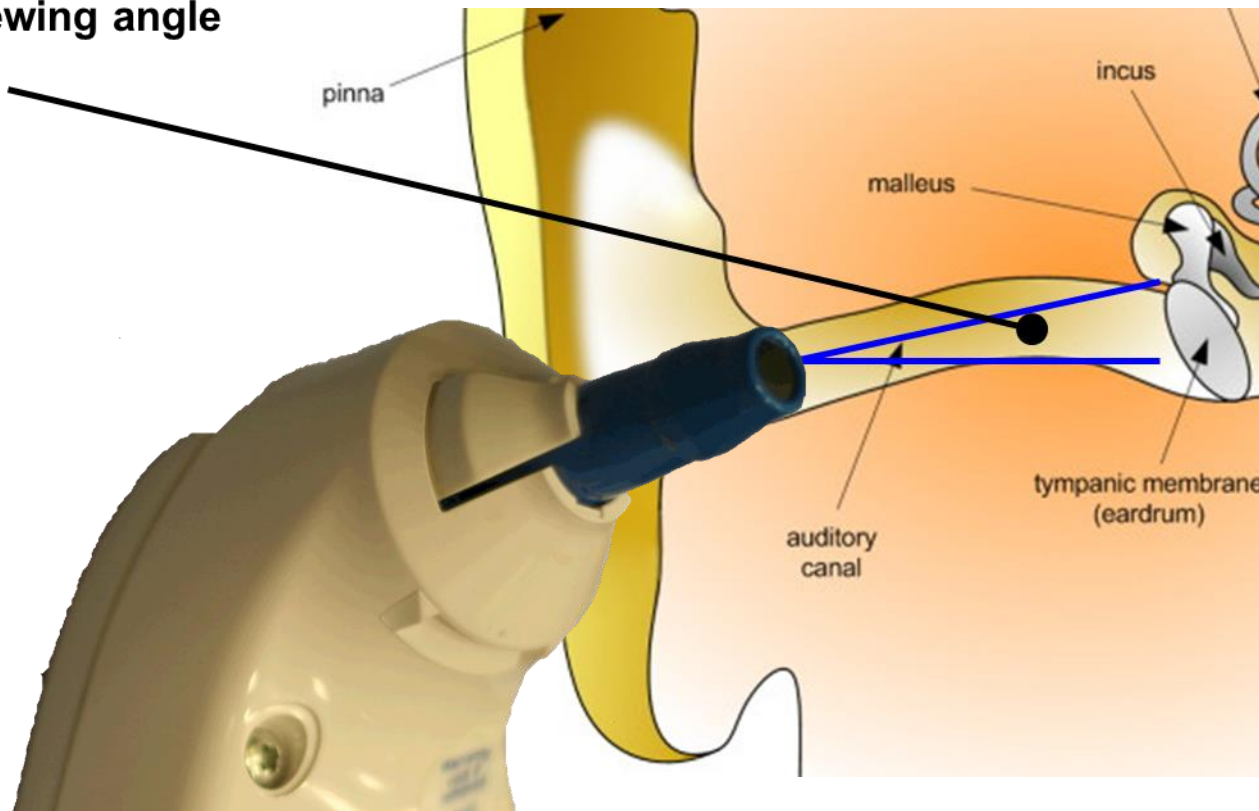
Ring, E.F.J., Jung, A., Kalicki, B., Žuber, J., Rustecka A., Vardasca R., "Ch. 5, New standards for fever screening with thermal imaging systems", In: A casebook in clinical medicine, Published September 2015 • Copyright © IOP Publishing Ltd 2015 Online ISBN: 978-0-7503-1143-4 • Print ISBN: 978-0-7503-1144-1



# Ear thermometry

# Tympanic membrane “ear” thermometry

wide viewing angle



# Tympanic membrane “ear” thermometry

- In principle reliable:

Direct relation to core body-temperature – linkage of blood flow to hypothalamus – *should* be a good measurement site

Ear thermometers are meant to measure the radiance from either the tympanic membrane or the deep ear canal+tympanic membrane – reasonable approximation to blackbody

# Ear thermometry

- Covered by International clinical thermometer standard (ISO 80601-2-56:2017)
- The laboratory accuracy within the rated output range in normal use shall be within  $\pm 0.3$  °C
- UNE-EN 12470-5 for calibrating ear thermometers

Some issues remain; Device and Physiological:

- Some devices have offsets – are they all the same (D)
- Correlation between other methods (e.g. oral) erratic (D, P)
- Repeat readings between ears don't always agree (D, P)
- Problems with the site; ear canal geometry, wax, fluid (P)

# **NATIONAL AND INTERNATIONAL ACTION**

# The National Body Temperature Measurement Group

Inaugural meeting 26<sup>th</sup> April 2019 at  
National Physical Laboratory (NPL),  
Teddington

Professor Mark Tooley FEng, CSO office, NHS England

Professor Graham Machin FEng, Head, Temperature Standards, NPL

Dr Rob Simpson, Head of Thermal Imaging, NPL

Professor David Brettle, Medical Physics, Leeds teaching hospitals NHS trust

Dr Rebecca Nutbrown, Head of Medical Physics, Royal Surrey NHS Foundation Trust, Surrey



# The NBTMG mission:

- To ensure robust and reliable body temperature measurement throughout the NHS and wider community
- To gather case studies, share stories and study data
- To suggest ways of solving the problem and what needs to be done
- To tell the community
- To obtain resources for research

# CCT TG Body Temperature Measurement

- The CCT President, and CCT Strategy WG, established a Task Group for body temperature measurement (TG BTM)
- TG under CCT WG for Non-Contact Thermometry
- The initial focus will be to improve non-contact body temperature measurement (ear, forehead, thermal imaging)

## Purpose

- The task groups purpose is to establish reliable clinical thermometry on a global basis
- Chair: Graham Machin



# CCT TG Body Temperature Measurement

- Actions to date:
- Agree groups initial terms of reference (12 June 2020)
- Hold inaugural meeting (7 July 2020)
- Establish four+one sub-Task Groups
- Report to CCT on progress (November 2020)

# New CCT task group on body temperature measurement

- Its objectives are:

- Lead a key comparison of calibrators for body temperature thermometers (ear/forehead/thermal imagers) – (Xiaofeng Lu, NIM, China)

- Collect and consolidate current best practice/standards of body temperature scanning in a) health services b) airport and other screening around the world (Igor Pusnik, UL, Slovenia)

- Collect current best practice of body temperature measurement and develop a definitive summary of the main body temperature measurement approaches (Maria-Jose Martin, CEM, Spain)

- Review standards and work with appropriate standardisation bodies (e.g. ISO/IEC) concerned with producing standards for body temperature measurement devices – (Wang Li, NMC A\*Star, Singapore)

- The TG, in collaboration with the RMOs, will establish a forum of users and suppliers/manufacturers of body temperature measurement devices to identify the problems and develop practical solutions and establish appropriate links to the World Health Organisation – (Dolores del Campo, Euramet TCT Chair)

# CCT TG Body Temperature Measurement

- Get involved!
- Contact me, or go direct to the sub-TG chairs offering your expertise and explaining how you want to contribute

# Summary

- There are three main approaches to IR body temperature measurement: forehead, thermal imaging, ear

Forehead a poor measurement site with large uncertainties, work required to a) develop standards, and to show whether, b) forehead temperature is correlated with body temperature and c) forehead is a reliable measurement site in field

Thermal imaging a) lot of poor commercial systems available b) may be possible to do fever screening – work required inner canthi/ear correlated c) national screening standards and one ISO standard

Only ear thermometry properly standardised internationally and can be reliable for body temperature measurement

- **CCT TG Body Temperature Measurement to:**  
establish reliable clinical thermometry on a global basis

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