Should temperature screening by thermal imaging systems be part of the policy response to curb Covid-19 transmission?

HIS Evidence were asked to examine whether mass screening by thermal imaging systems should feature in local and national strategies being implemented to control Covid-19 transmission. This is to support the work of Public Health Scotland and the Scottish Government. A rapid review of existing guidance and current evidence was undertaken, with the findings summarised in this report.

**HIS Evidence Conclusion:**

The evidence on whether screening by thermal imaging systems is effective in controlling infectious disease transmission is weak or inconclusive at best. The most recent review suggested that screening alone or alongside a questionnaire was not effective at detecting infected persons.

The evidence on implementation and impact of screening during previous outbreaks suggests that screening measures alone were not effective at detecting imported cases. Evidence on whether screening would be effective in healthcare or other community settings besides ports of entry is lacking. The uncertainty around the effectiveness of thermal imaging systems arises from variability in analytic validity, extreme difficulty in detecting asymptomatic carriers and absence of clinical specificity to epidemic/pandemic strains.

**Scope**

Thermal imaging systems (TIS) refer to infrared thermographic devices and thermal imaging cameras, which may be deployed in clinical and community settings for mass temperature screening. This report examined evidence on the effectiveness and clinical validity of TIS specific to the infectious disease context.
Existing Guidance

The World Health Organisation technical guidance (last updated 19 March 2020) advises that if temperature screening has been implemented to detect ill travellers at international points of entry, no-touch thermometers, either handheld or thermal imaging cameras, should be used. Manual thermometers that require contact with skin or mucous membranes should not be used.

The U.S. Food and Drug Administration (FDA) issued guidance for industry and FDA staff (April 2020) on the regulatory status, performance and labelling of TIS. An additional document discussing the benefits, limitations and proper use of TIS was published in May 2020. This document stated that in airports, workplaces, grocery stores and other similar settings, TIS as one method of initial temperature assessment, could be considered when used as part of a larger approach to risk management. In a hospital emergency room, TIS may help to quickly assess temperature and triage patients to determine who needs more evaluation or isolation. However, it was stated that in nursing homes, infection control practices are preferred to TIS due to the risk of inaccurate measurements and missing asymptomatic individuals. The document also clarified that TIS are not effective at determining if someone definitively has Covid-19.

The International Organisation for Standardisation (ISO), issued deployment, implementation and operational guidelines for identifying febrile humans using TIS (2017) [1]. The guidelines acknowledge that individual screening can be useful to separate potentially infectious individuals and minimise the likelihood of transmission. However, such screening is challenged by a lack of clinical sensitivity (e.g. asymptomatic individuals might not be detected) and clinical specificity (e.g. individuals exhibiting symptoms might not be infected with a pandemic strain).

The independent non-profit organization, ECRI (originally founded as Emergency Care Research Institute), issued a position statement to inform policy decisions (published 27 April 2020) stating that relying on mass temperature screening and questionnaire strategies to prevent Covid-19 transmission, would be ineffective and would propagate a “false sense of security”[2]. Uncertainty about the effectiveness of TIS based screening was a product of questionable analytic validity, due to a combination of human and environmental factors, and lack of clinical validity in detecting the presence of Covid-19.

Evidence Reviews

The most recent review was a March 2020 clinical evidence assessment conducted by ECRI [3]. The objective of this assessment was to review the accuracy of TIS for identifying visitors or staff entering health care facilities who may have potentially infectious diseases.

The authors conducted literature searches in Pubmed, Embase and ECRI Guidelines Trust for relevant studies that examined the use of TIS at airports and health care facilities. Search dates were from Jan 1, 2008 to March 13, 2020. Overall, 16 studies were included, comprising of two systematic reviews, three simulation studies, six diagnostic cohort studies, three case-control studies and two case series. Conclusions were presented as a narrative synthesis without any calculation of combined estimates.
Overall, there was unfavourable evidence to suggest that screening by TIS alone or alongside a questionnaire was effective for detecting infected persons. This was primarily due to the generally low or inconsistent sensitivity of the devices examined. Simulation studies estimated that screening could miss up to half of all infected individuals, even under best-case scenarios. Characteristics of individual studies included in this review are presented in Table 1.

A critical appraisal of the ECRI evidence assessment by the Canadian Agency for Drugs and Technologies in Health (CADTH) did not reveal major limitations within the assessment, and concluded that several factors could affect the performance characteristics of TIS (e.g. environmental temperature, operating distance, antipyretic use)[4]. Further, the accuracy of temperature screening can be subject to significant variation based on agent characteristics and epidemic stage.

A 2014 CADTH review, primarily focused on the analytic validity of TIS highlighted the poor scientific evidence available for the utilization of infrared skin thermometers and thermal scanners for mass screening [5]. Evidence for the accuracy of infrared skin thermometers was equivocal and somewhat in favour of the accuracy of thermal scanners. The generalisability of the evidence found is nevertheless uncertain due to many confounders associated with temperature measurement.

What impact has TIS based screening had during past outbreaks?

The 2014 CADTH review concluded that fever screening at international airports was generally not effective at detecting H1N1 and other influenza viruses, or dengue fever, likely due to the long incubation periods and delayed appearance of febrile symptoms for these infectious diseases [6].

During the SARS epidemic of 2003, thermal scanning of over 35 million international travellers entering Canada, China, Hong Kong, and Singapore did not pick up a single SARS case. Exit screening of over 7 million people also failed to find a single SARS case [7, 8]. Singapore had six imported SARS cases, excluding the initial index case, none of which were detected by screening at the airport but had presented to hospital subsequently when fever developed [9]. During the H1N1 pandemic in 2009, an aggregate of four confirmed cases per million screened travelers was reported across 10 countries [7]. In Japan, screening identified 10 out of 151 imported cases of H1N1 [10]. For Zika virus disease, five cases were identified of 21 million people screened [7]. However, routine entry screening at airports in Taiwan was successful in identifying about half of the imported cases of dengue fever [11].

It is unclear whether TIS based screening in other community and healthcare settings would vary in effectiveness from levels observed at airports and border crossings. There was no available evidence on the implementation and impact of TIS based screening in healthcare settings during previous infectious disease outbreaks. One study reported on Singapore’s experience of daily temperature monitoring of all schoolchildren between 6 – 16 years of age during the SARS outbreak. In total, nearly half a million children had mandatory temperature screening during this period, but none of the children diagnosed with SARS were detected through school temperature screening [9].
<table>
<thead>
<tr>
<th>Reference (year)</th>
<th>Sample size</th>
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<td><strong>Systematic Reviews</strong></td>
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<td>CADTH (2014)</td>
<td>NR</td>
<td>Not defined</td>
<td>All TIS (TT)</td>
<td>Poor available evidence for all TIS. [5]</td>
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<tr>
<td><strong>Diagnostic Cohort Studies</strong></td>
<td></td>
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<tr>
<td>Chen et al (2020)</td>
<td>528 (261 indoor, 267 outdoor)</td>
<td>Fever clinic &amp; Emergence Dept.</td>
<td>NCIT (TT)</td>
<td>Wrist measurement more stable than forehead measurement. [12]</td>
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<tr>
<td>Hogan et al (2015)</td>
<td>548</td>
<td>Emergency Dept.</td>
<td>NCIT (OT)</td>
<td>Use of a simple hand-held NCIT had insufficient performance characteristics to be relied on as a primary screening tool. [13]</td>
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<tr>
<td>Tay et al (2015)</td>
<td>430</td>
<td>Primary health care centre</td>
<td>3 brand named TIS (OT)</td>
<td>High specificity for all devices. Sensitivities of old generation and hand-held device were low and should not be used for fever screening. [14]</td>
</tr>
<tr>
<td>Nguyen et al (2010)</td>
<td>2,873</td>
<td>Emergency Dept.</td>
<td>3 brand named TIS (OT)</td>
<td>When compared with oral temperatures, 2 out of 3 TIS were reasonably accurate for detecting fever and predicted fever better than self-reports. Accuracy varied by choice of cut-off temperature. [15]</td>
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<tr>
<td>Chiang et al (2008)</td>
<td>1,032</td>
<td>Medical centre</td>
<td>2 TIS (TT)</td>
<td>TIS readings can be used as proxy for core temperature. An effective TIS with a strict operating protocol can be rapidly implemented at a hospital entrance. [16]</td>
</tr>
<tr>
<td>Hausfater et al (2008)</td>
<td>2,026</td>
<td>Emergency Dept.</td>
<td>NCIT (TT)</td>
<td>NCIT does not provide a reliable basis for screening outpatients. [17]</td>
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<tr>
<td>Study</td>
<td>Dataset Size</td>
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<td>Bardou et al (2016)</td>
<td>625 (379 healthy controls)</td>
<td>Healthcare setting</td>
<td>IRT Camera (TT)</td>
<td>Infrared thermal cameras are a rapid and reliable way to detect fever in infected persons in clinical settings. [18]</td>
</tr>
<tr>
<td>Sun et al (2017)</td>
<td>38 (22 healthy controls)</td>
<td>Hospital</td>
<td>IRT Camera (AT)</td>
<td>Multiple vital sign based screening (temperature, respiration, heart rate) more efficient at detection compared to fever based screening. [19]</td>
</tr>
<tr>
<td>Sun et al (2016)</td>
<td>87 (33 healthy controls)</td>
<td>Airport Clinic</td>
<td>IRT Camera (AT)</td>
<td>Multiple vital sign based screening by TIS performed well versus axillary temperature. [20]</td>
</tr>
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<td>Sun et al (2014)</td>
<td>155</td>
<td>Hospital</td>
<td>1 brand named TIS (AT)</td>
<td>Promising results for close-range fever screening. Ineffective at long operational distance (1-3 meter). [21]</td>
</tr>
<tr>
<td>Suzuki et al (2010)</td>
<td>50</td>
<td>NR</td>
<td>IRT Camera (AT)</td>
<td>Ear temperatures are more accurate than facial temperature. [22]</td>
</tr>
<tr>
<td>Gostic et al (2020)</td>
<td>NR</td>
<td>Unspecified</td>
<td>TIS</td>
<td>Screening estimated to detect less than half of infected travelers in a growing epidemic. Screening effectiveness predicted to increase marginally as growth of the source epidemic decelerates. [23]</td>
</tr>
</tbody>
</table>

NCIT – Non contact infra-red thermometer (wrist or forehead temperature); TT – Tympanic thermometer; OT – Oral thermometer; AT – Axillary thermometer; TIS – Thermal imaging system (hand held or camera); NR – Not reported
References


3. ECRI. Infrared Temperature Screening to Identify Potentially Infected Staff or Visitors Presenting to Healthcare Facilities during Infectious Disease Outbreaks. 2020; Available from: [https://www.ecri.org/components/Hotline/Pages/28606.aspx](https://www.ecri.org/components/Hotline/Pages/28606.aspx).


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