Australian Government
National Health and Medical Research Council

NHMRC

National COVID-19 Health and Research Advisory Committee[a]

Date of advice: 23 November 2020

Thermal scanning

Question:

What is the evidence of public health benefits of thermal scanning and body heat scanning devices during the COVID-19 pandemic?

Notes:

This advice is point in time and may need further review as more evidence is available.

This report was reviewed by NCHRAC members Professor Jonathan Carapetis AM and Professor Bruce Robinson AC.

Key findings

1. Reports in April and May 2020 to the Australian Government advised that thermal screening will lack sensitivity to reliably detect COVID-19 cases in community settings, and that the limitations of general screening for temperature are unlikely to be outweighed by the benefits.

2. There is no evidence published since May 2020 to challenge the findings of these two reports.

3. Literature published since May 2020 continues to show that fever is one of the key symptoms of SARS-CoV-2 infection. It is prevalent in approximately 78–83% of patients (all ages) and in approximately 51–59% of patients aged 18 years or younger.

4. However, using fever to predict SARS-CoV-2 infection can result in false positive results (since there are other causes of fever) and false negative results (since an infected person may not have elevated temperature at all or in first few days of infection [asymptomatic or presymptomatic], fever can fluctuate, or fever can be supressed by medication, etc.)

5. Evidence continues to suggest that thermal scanners and non-contact infrared thermometers are not reliably accurate, and exhibit low sensitivity and low positive predictive value (the probability of test positives being true positives).

[a]NHMRC is providing secretariat and project support for the Committee, which was established to provide advice to the Commonwealth Chief Medical Officer on Australia's health response to the COVID-19 pandemic. The Committee is not established under the NHMRC Act and does not advise the NHMRC CEO.

Background:

- There are two types of non-contact temperature screening devices:
    - thermal imaging systems/thermal scanners/body heat scanners that produce a coloured image indicative of skin temperature using an infrared thermal camera, and
    - hand-held infrared skin thermometers.
- The focus for this paper is on thermal/body heat scanning; however evidence related to infrared skin thermometers is also included since both methods are often discussed together in the literature.
- Mass screening with non-contact temperature screening devices has been used during outbreaks of infectious disease pandemics. Scanners were used in Australia during the H1N1 pandemic in 2009 (refer to Attachment 1 for more information).

Context

AHPPC considered the use of thermal scanners as a border measure in May 2013 (Attachment 1) and based on the findings of three reports, agreed that thermal scanners should not be deployed during a pandemic, or in response to avian influenza A (H7N9), given their lack of effectiveness and efficiency. AHPPC was advised that thermal scanners should only be used in illnesses whose clinical characteristics are within the technical capabilities of the equipment such as the ability to detect high fever in a relatively high proportion of infected travellers, with the illness itself having a short incubation and latency periods.

Two rapid reviews about this topic have been prepared recently to provide advice to Australian governments about the use of thermal screening in the COVID-19 pandemic:

- Evidence check: Thermal imaging for detection of fever (NSW Health Critical Intelligence Unit, Agency for Clinical Innovation), published on 9 April 2020 (Attachment 2). This review concluded that thermal screening will lack sensitivity to reliably detect COVID-19 cases in community settings.
- Predictive value of temperature screening for COVID-19 (Professor Caroline Miller, South Australian Health and Medical Research Institute for the South Australian Government), published on 12 May 2020 (Attachment 3). This review concluded that in most settings, the limitations of general screening for temperature are unlikely to be outweighed by the benefits.

Approach

A rapid review of the evidence was conducted over 2–12 November 2020 to identify any up-to-date guidelines or health technology assessments (HTA) that had been informed by one or more well conducted systematic reviews, systematic reviews or other key literature published since May 2020. Various search/identification strategies were used, including:

1. Searching the Therapeutics Goods Administration and U.S. Food and Drug Administration for any registered HTAs
2. Searching the international guideline database (GIN) and HTA database (INAHTA)

3. Pubmed searches using the terms [fever covid-19 systematic review] or [thermal scanning systematic review] or [thermal imaging covid-19]
4. Google search using the term [thermal scanning covid]
5. Cochrane library search for systematic reviews on the topic Infectious disease/COVID-19, and
6. Using references identified by NCHRAC during the preparation of recent advice on other topics.

Evidence was included for further consideration if it addressed one or more of the following aspects[b]:

- How well does the presence or absence of fever predict SARS-CoV-2 infection, i.e. what is the clinical validity of thermal scanning?
- Do thermal scanners and non-contact infrared thermometers accurately and reliably measure skin temperature as a proxy for core body temperature, i.e. what is the analytic validity of thermal scanning?
- What are the health-related benefits of thermal scanning in the context of the potential negative consequences, i.e. the clinical utility of thermal scanning?

The new evidence identified in this rapid review is summarised in the tables below.

Evidence

Each box contains the reference number, title, first author, date, source, search strategy, a summary of the findings and the relevance.

Note: It would be valuable to investigate the relationship between duration and timing of fever and infectious period in COVID-19, however the below evidence (#1-11) does not give this level of detail; stating only the prevalence of fever at any time during infection.

#1 Signs and symptoms to determine if a patient presenting in primary care or hospital outpatient settings has COVID-19 disease T. Struyf[1]|7 July 2020 | Cochrane Database of Systematic Reviews	Search strategy: Cochrane library search for the topic Infectious disease/COVID-19
This study aimed to assess the diagnostic accuracy of signs and symptoms to determine if a person presenting in primary care or to hospital outpatient settings has COVID-19 disease or COVID-19 pneumonia. 16 studies were identified, which provided data on 27 signs and symptoms of SARS-CoV-2 infection. No studies assessed combinations of different signs and symptoms and results were highly variable across studies. Most had very low sensitivity and high specificity; only six symptoms had a sensitivity of at least 50% in at least one study: cough, sore throat, fever, myalgia or arthralgia, fatigue, and headache. Of these, fever, myalgia or arthralgia, fatigue, and headache could be considered red flags (defined as having a positive likelihood ratio of at least 5) for COVID-	

[b] The concepts of clinical validity, analytic validity and clinical utility are covered in the ECRI clinical evidence assessment (#12).

19 as their specificity was above 90%, meaning that they substantially increase the likelihood of COVID-19 disease when present.
Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).

#2 Epidemiology of COVID-19: A systematic review and meta-analysis of clinical characteristics, risk factors, and outcomes J. Li[2] |13 August 2020 | Journal of Medical Virology	Search strategy: Identified in NCHRAC advice paper *Evidence for the non-respiratory effects of COVID-19*
This study aimed to determine pooled estimates for clinical characteristics and outcomes in COVID-19 patients including subgroups by disease severity and by country/region. The key finding was that fever is prevalent in 78.8% (95% CI: 76.2–81.3) of SARS-CoV-2-infected patients.	
Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).	

#3 The prevalence of symptoms in 24,410 adults infected by the novel coronavirus (SARS-CoV-2; COVID-19): A systematic review and meta-analysis of 148 studies from 9 countries M.C. Grant[3]| 23 June 2020| PLOS One	Search strategy: Identified in NCHRAC advice paper *Evidence for the non-respiratory effects of COVID-19*
The aim of this systematic review was to determine the prevalence of symptoms associated with COVID-19 worldwide. The key findings were that fever and cough are the most prevalent symptoms of adults infected by SARS-CoV-2. Fever was prevalent in 78% (95% CI: 75–81) of patients. The review concludes that the use of symptoms alone to screen adults for SARS-CoV-2 infection is likely to miss a substantial number of infected individuals.	
Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).	

#4 COVID-19 Clinical Characteristics, and Sex-Specific Risk of Mortality: Systematic Review and Meta-Analysis M. J. Nasiri[4] | 21 July 2020| Frontiers in Medicine	Search strategy: Identified in NCHRAC advice paper *Evidence for the non-respiratory effects of COVID-19*
The aim of this study was to review the scientific literature on the clinical, laboratory, epidemiologic, and mortality findings of COVID-19. The study found that fever and cough are the most prevalent symptoms of adults infected by SARS-CoV-2. Fever was prevalent in 83.0% (95% CI: 77.5–87.6) of patients.	
Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).	

#5 Epidemiological and Clinical Characteristics of 6635 COVID-19 Patients: a Pooled Analysis. N. Kaur[5] | 9 July 2020| Springer Nature Comprehensive Clinical Medicine	Search strategy: Identified in NCHRAC advice paper *Evidence for the non-respiratory effects of COVID-19*
This study aimed to perform a systematic review and pooled analysis of the current published literature on COVID-19 to provide an insight on the epidemiological and clinical characteristics of COVID-19 patients. It was found that fever is the most prevalent symptom in patients, occurring in 80.3% of patients, which is similar to the frequency of fever in SARS and MERS.	
Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).	

#6 COVID 19 - Clinical Picture in the Elderly Population: A Qualitative Systematic Review. A. Neumann-Podczaska[6] | 23 July 2020| Aging and disease	Search strategy: Identified in NCHRAC advice paper *Evidence for the non-respiratory effects of COVID-19*
The authors conducted a systematic review to summarise the clinical features, comorbidities, radiological/laboratory findings, and outcomes in the older adults.	

It was found that fever is prevalent in 83.6% of patients aged 60 years or older, and is the most common symptom of COVID-19 in this age group.
Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).

#7 COVID-19 in 7780 pediatric patients: A systematic review. A. Hoang[7] | 26 June 2020| Eclinicalmedicine	Search strategy: Identified in NCHRAC advice paper *Evidence for the non-respiratory effects of COVID-19*
This review characterises the clinical symptoms, laboratory, and imaging findings, as well as therapies provided to confirmed paediatric cases of COVID-19. It was found that fever was the most common symptom in patients aged 18 years or younger, with a prevalence of 59.1%. 19.3% of children were found to be asymptomatic.	
Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).	

#8 SARS-COV-2 infection in children and newborns: a systematic review I. Liguoro[8] | 18 May 2020| European Journal of Pediatrics	Search strategy: Identified in NCHRAC advice paper *Evidence for the non-respiratory effects of COVID-19*
This study aimed to systematically review the main clinical characteristics and outcomes of SARS-CoV-2 infections in children. It was found that the most commonly described symptoms of SARS-CoV-2 infection in children are fever and cough, with fever being prevalent in 51.6% of patients aged 18 years or younger. SARS-CoV-2 affects children less severely than adults. 15% of children were identified to be asymptomatic but have abnormal radiological findings across all studies.	
Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).	

#9 What we know so far about Coronavirus Disease 2019 in children: A meta-analysis of 551 laboratory-confirmed cases. L. Zhang[9] | 10 June 2020| Pediatric Pulmonology	Search strategy: Identified in NCHRAC advice paper *Evidence for the non-respiratory effects of COVID-19*
The aim of this study was to summarise what is known so far about COVID-19 in children. It was found that fever is the most common symptom of SARS-CoV-2 infection in children, being prevalent in 53% (95% CI: 45–61) of patients aged 18 years or younger. 18% (95% CI: 11–27) of cases were asymptomatic.	
Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).	

#10 A systematic review and meta-analysis of children with coronavirus disease 2019 (COVID-19). X. Cui[10] | 6 August 2020| Journal of Medical Virology	Search strategy: Identified in NCHRAC advice paper *Evidence for the non-respiratory effects of COVID-19*
This study aimed to provide a comprehensive and systematic analysis of demographic characteristics, clinical symptoms, laboratory findings, and imaging features of COVID-19 in children. It was found that fever was prevalent in 51% (95% CI: 45–57) of patients aged 18 years or younger. 20% (95% CI: 14–26) of cases were asymptomatic.	
Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).	

#11 Prevalence of Asymptomatic SARS-CoV-2 Infection: a narrative review D.P. Oran[11] | 1 September 2020| Annals of Internal Medicine	Search strategy: Identified in Aggarwal et al. 2020. (#13)
The authors sought to review and synthesize the available evidence on asymptomatic SARS-CoV-2 infection. They report that the likelihood that those infected with SARS-CoV-2 will remain asymptomatic is approximately 40% to 45%, and that asymptomatic persons can transmit SARS-CoV-2 to others for an extended period, perhaps longer than 14 days.	

Relevance: Provides evidence on fever as a marker of SARS-CoV-2 infection (clinical validity).

#12 Infrared Temperature Screening to Identify Potentially Infected Staff or Visitors Presenting to Healthcare Facilities during Infectious Disease Outbreaks 20 April 2020| ECRI clinical evidence assessment[12]	Search strategy: Identified via search of the U.S. Food and Drug Administration (FDA) website
This assessment was first published before the COVID-19 pandemic, and examines evidence from one systematic review about exit and entry screening, one systematic review about the effectiveness of noncontact thermometers in hospital settings, three simulation studies of detection rates for airport screening programs, and six cohort studies about infrared skin thermometer and infrared camera sensitivities. The assessment identified several factors that affect the performance of thermal screening including the environmental temperature, the operating distance from individuals being tested, the use of medications that suppress or elevate body temperature and physical activity. It also noted that clinical factors can affect accuracy of temperature screening such as latency period, time to onset of clinical symptoms, the proportion of asymptomatic individuals, the proportion of individuals who do not develop fever as a symptom and whether the epidemic is spreading or stable. The assessment concluded that temperature screening programs are ineffective for detecting infected persons because of the low number of infected individuals who have fever at the time of screening, inconsistent technique by operators, inaccuracies related to environmental temperatures and the use of fever-reducing medications. It states that using such an approach to reduce infection risk from visitors and staff entering healthcare facilities could provide a false sense of safety. The assessment was updated on 20 April 2020 to include a references to guidelines related to the use of fever screening during the COVID-19 pandemic, such as the *Enforcement Policy for Telethermographic Systems During the Coronavirus Disease 2019 (COVID-19) Public Health Emergency* from the U.S. Food and Drug Administration.	
Relevance: Provides evidence on accuracy and precision of thermal scanning (analytical validity).	

#13 Diagnostic accuracy of non-contact infrared thermometers and thermal scanners: A systematic review and meta-analysis N. Aggarwal[13] | 10 October 2020 | Journal of Travel Medicine	Search strategy: Pubmed search using term [fever covid-19 systematic review]
This study investigated the diagnostic accuracy of infrared thermal screening, via the use of handheld non-contact infrared thermometers (NCITs) and thermal scanners, by conducting a systematic review and meta-analysis. Of the 19 studies included in the meta-analysis, only one examined temperature screening in COVID-19, all others examined SARS and H1N1. It was found that both methods have a reasonable sensitivity and specificity in detecting fever. However, variation in the diagnostic performance was observed in different study settings and prevalence of fever. Therefore an analysis was performed to determine the positive predictive value (the probability of test positives being true positives) and negative predictive value (the probability of test negatives being true negatives) from the pooled sensitivity and specificity data. Thermal screening was found to have a low positive predictive value, especially in the initial phase of a disease outbreak in a given community where there would be a low prevalence of fever. In contrast, the negative predictive value was seen to be reasonably high even in the case of a relatively large proportion of the population being febrile. Based on the variable prevalence of fever reported for SARS-CoV-2 infected individuals, and the findings about the sensitivity of NCITs and thermal scanners (80.8% and 81.8%, respectively), the authors concluded that a high proportion of infected individuals would be missed by thermal screening, and that temperature screening alone does not appear to be an effective way to detect cases and to help curb the spread of COVID-19. **Note:** This paper refers to a Centers for Disease Control and Prevention (CDC) report[14] that states that 43.1% of COVID-19 infected individuals have fever. This is much less than the prevalence reported in references #2–#10 here. The prevalence of fever may impact on the interpretation of clinical utility of thermal screening.	
Relevance: Provides evidence on accuracy and precision of thermal scanning for detection of fever (analytical validity).	

#14 Infrared Temperature Devices for Infectious Disease Screening During Outbreaks: Overview of an ECRI Evidence Assessment CADTH (Canadian Agency for Drugs and Technologies in Health)[15] May 2020| Technology review	Search strategy: Identified via search of the U.S. Food and Drug Administration (FDA) website

This report examined the methodology, scientific rigour and findings of the ECRI review (#12) and provides an overview for Canadian decision makers of the findings. It summarised the main findings of the ECRI assessment, namely that there is insufficient evidence to suggest that non-contact infrared temperature screening methods were effective for detecting infected persons. It noted that the ECRI assessment was based on a large number of studies, with a broad variety of study designs. Some limitations were described however these did not result in CADTH recommending different conclusions.
Relevance: Provides evidence for public health benefits of thermal scanning during COVID-19 pandemic (clinical utility).

#15 Universal screening for SARS-CoV-2 infection: a rapid review M. Viswanathan[16] | 15 September 2020| Cochrane systematic review	Search strategy: Cochrane library search for the topic Infectious disease/COVID-19
This rapid review aimed to assess screening effectiveness or screening accuracy among general populations in which the prevalence of SARS-CoV-2 is unknown. It reviews a variety of screening approaches in additional to thermal screening Two modelling studies (Gostic et al. 2020 and Quilty et al. 2020) were identified that evaluated the accuracy of temperature screening at airports (see Additional Evidence section below). There were no concerns regarding the methodological quality of Gostic et al. 2020, and moderate methodological concerns for Quilty et al. 2020. This review concluded that one-time screening approaches with a symptom assessment, direct temperature measurement, travel history, assessment for exposure to known or suspected infected people, or combined symptoms assessment with temperature measurement may miss between 40% and 100% people who are infected. The certainty of this conclusion ranges from very low to moderate.	
Relevance: Provides evidence for public health benefits of thermal scanning during COVID-19 pandemic (clinical utility).	

#16 Non-contact Temperature Assessment Devices During the COVID-19 Pandemic US FDA[17]| 19 June 2020| Webpage	Search strategy: Google search [thermal scanning covid]
This page provides information on the use of non-contact temperature assessment devices during the COVID-19 pandemic. It lists the benefits of these devices, namely that they can quickly measure and display a temperature reading, require minimal cleaning between uses and may help reduce the risk of spreading COVID-19 infections. It states that these devices are not effective if used as the only means of detecting a COVID-19 infection. Factors that limit the effectiveness of these devices are that people with COVID-19 infections may not have a fever or may use fever-reducing medications, elevated temperatures can result from a variety of other reasons (from other infections to environmental conditions), devices may fail to identify elevated or misread normal temperatures as elevated, and users may fail to follow the manufacturer's instructions for use.	
Relevance: Provides evidence for public health benefits of thermal scanning during COVID-19 pandemic (clinical utility).	

#17 Thermal Imaging Systems (Infrared Thermographic Systems / Thermal Imaging Cameras) US FDA[18] | 13 May 2020| Webpage	Search strategy: Referred to on Non-contact Temperature Assessment Devices During the COVID-19 Pandemic webpage (#16)
Describes the benefits, limitations and proper use of thermal imaging systems, and answers to questions about using thermal imaging systems during COVID-19. The benefits are the distance between the person and operator, the speed of the system and that when used correctly, and that thermal imaging systems generally measure surface skin temperature accurately. However, the limitations are that the systems have not been shown to be effective when used to take the temperature of multiple people at the same time, they measure skin temperature as a proxy for core body temperature and that there are several aspects to ensuring the system is set up properly and the operator is trained adequately. The webpage states that '*a fever or higher body temperature is only one possible symptom of a COVID-19 infection. Thermal imaging systems generally detect a high body temperature accurately when used appropriately. They do not detect any other infection*	

symptoms, and many people with COVID-19 can be contagious without a fever. Also, a high body temperature does not necessarily mean a person has a COVID-19 infection. All fevers measured by thermal imaging systems should be confirmed by another method and followed by more diagnostic evaluations for other symptoms, as appropriate'.
Relevance: Provides evidence for public health benefits of thermal scanning during COVID-19 pandemic (clinical utility).

#18 Non-contact Infrared Thermometers US FDA[19] | 23 April 2020| Webpage	Search strategy: Referred to on Non-contact Temperature Assessment Devices During the COVID-19 Pandemic webpage (#16)
Describes the benefits, limitations and proper use for non-contact infrared thermometers. The benefits are that the non-contact approach may reduce risk of infection spread, the devices are easy to use, clean and disinfect, and measurements are obtained quickly. The limitations are that how and where the device is used may affect the measurement and the close distance required between the operator and the person, which increase the risk of infection.	
Relevance: Provides evidence for public health benefits of thermal scanning during COVID-19 pandemic (clinical utility).	

Additional evidence:

Two modelling/simulation studies published in February 2020 should be highlighted, since they are referred to in Attachments 2 and 3, as well as in many of the reviews identified in the above table.

Gostic et al.[20] estimated the impact of different screening programs given current knowledge of key COVID-19 life history and epidemiological parameters. Based on simulated screening using thermal image scanning and travel history questionnaires at the departure and arrival airports, it was found that in the best-case scenario the sensitivity of the screening strategy was 0.30, meaning that 70% of infected travellers would be missed because these cases have not yet developed symptoms.

Quilty et al.[21] evaluated the effectiveness of thermal passenger screening for SARS-CoV-2 infection at airport exit and entry. It was estimated that, under conservative assumptions on sensitivity (86%) of infrared thermal image scanners, 46% of infected travellers would enter a country with the infection undetected by airport entry/exit screening. A detection rate of

90% of infected travellers would only be possible with a negligible rate of asymptomatic infection, almost perfect screening sensitivity, and a short incubation period.

Other considerations

NCHRAC advises that there may be other public health risks or benefits to thermal screening for COVID-19 that as yet do not have a strong evidence base. For example, it was noted that Attachment 3 describes an indirect benefit from screening of deterring unwell people from leaving home (since they know they will have their temperature checked). However, a risk may be that temperature screening provides a false sense of security, given its limitations.

In addition, NCHRAC noted that whilst thermal screening may offer a potential benefit of being a visible and obvious alert to people that there are still risks associated with the pandemic, there may be other (and possibly better) ways to achieve this.

Any decision to use thermal scanners during the COVID-19 pandemic needs to include consideration of how to manage people found to have elevated temperatures within different settings (e.g. aged care, visitors to health care, schools, airports) and take into account the associated costs for individuals, health systems and organisations.

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