Opinion Paper

Giuseppe Lippi*, Riccardo Nocini, Camilla Mattiuzzi and Brandon Michael Henry

Is body temperature mass screening a reliable and safe option for preventing COVID-19 spread?

<https://doi.org/10.1515/dx-2021-0091>

Received June 30, 2021; accepted August 24, 2021;

published online September 2, 2021

Abstract: With the ongoing coronavirus disease 2019 (COVID-19) pandemic continuing worldwide, mass screening of severe acute respiratory distress syndrome coronavirus 2 (SARS-CoV-2) infection is a cornerstone of strategies for limiting viral spread within communities. Although mass screening of body temperature with handheld, non-contact infrared thermometers and thermal image scanners is now widespread in a kaleidoscope of social and healthcare settings for the purpose of detecting febrile individuals bearing SARS-CoV-2 infection, this strategy carries some drawbacks, which will be highlighted and discussed in this article. These caveats basically include high rate of asymptomatic SARS-CoV-2 infections, the challenging definition of “normal” body temperature, variation of measured values according to the body district, false negative cases due to antipyretics, device inaccuracy, impact of environmental temperature, along with the low specificity of this symptom for screening COVID-19 in patients with other febrile conditions. Some pragmatic suggestions will also be endorsed for increasing accuracy and precision of mass screening of body temperature. These encompass the regular assessment of body temperature (possibly twice) with validated devices, which shall be constantly monitored over time and used following manufacturer’s instructions, the definition of a range of “normal” body temperatures in the local population, patients

interrogation on usual body temperature, measurement standardization of one body district, allowance of sufficient environmental acclimatization before temperature check, integration with contact history and other clinical information, along with exclusion of other causes of increased body temperature. We also endorse the importance of individual and primary care physician’s regular and repeated check of personal body temperature.

Keywords: coronavirus; COVID-19; fever; screening; temperature.

Introduction

With the ongoing coronavirus disease 2019 (COVID-19) pandemic continuing to spread all around the world, and resulting in several thousand casualties almost every day, the adoption of reliable measures for widespread (mass) screening of severe acute respiratory distress syndrome coronavirus 2 (SARS-CoV-2) infections is a cornerstone of all effective strategies aimed at limiting the viral spread within the community [1]. Among the various possible options, body temperature screening by means of handheld, non-contact infrared thermometers and thermal image scanners is now widely used in a kaleidoscope of social and healthcare settings, with the purpose of detecting febrile individuals bearing potential SARS-CoV-2 infection [2, 3]. The use of alternative means for temperature assessment, such as measuring oral or axillary temperature, is not recommended, as this would necessitate physical contact, thus potentially contributing to enhancing the risk of virus transmission, and requiring time consuming and expensive systematic disinfection.

Although it is virtually undeniable that fever is one of the most common symptoms of COVID-19, being present in as many as 83% of patients with symptomatic COVID-19, as revealed by the meta-analysis recently published by Nasiri and colleagues [4], there are many persuasive reasons that mass screening of body temperature should not be considered a thoughtfully reliable, or safe strategy for identifying potential SARS-CoV-2 infections, thus limiting its value for preventing further viral spread.

***Corresponding author: Prof. Giuseppe Lippi**, Section of Clinical Biochemistry, University Hospital of Verona, Piazzale L.A. Scuro, 10 37134 Verona, Italy, Phone: 0039 045 8122970, Fax: 0039 045 8124308, E-mail: giuseppe.lippi@univr.it. <https://orcid.org/0000-0001-9523-9054>

Riccardo Nocini, Department of Surgery, Dentistry, Paediatrics and Gynaecology, University of Verona, Verona, Italy

Camilla Mattiuzzi, Service of Clinical Governance, Provincial Agency for Social and Sanitary Services, Trento, Italy

Brandon Michael Henry, Cardiac Intensive Care Unit, The Heart Institute, Cincinnati Children’s Hospital Medical Center, Cincinnati, OH, USA

Potential drawbacks of body temperature mass screening

The extremely high rate of asymptomatic SARS-CoV-2 infection is indeed the first of such reasons. A currently accepted definition of “asymptomatic” SARS-CoV-2 infection is that of a subject who has been infected by the virus but does not display fever, chills, upper or lower tract respiratory symptoms (e.g., sore throat, nasal congestion, cough, dyspnoea, etc.), gastrointestinal symptoms (e.g., nausea, vomiting), taste or olfactory abnormalities, conjunctivitis, myalgia, fatigue, headache and functional or mental decline [5]. The results of a recent meta-analysis convincingly demonstrated that the rate of subjects with SARS-CoV-2 infection who will remain asymptomatic until negativization of SARS-CoV-2 molecular testing is over 70% [6]. These asymptomatic individuals, who could not obviously be detected by body temperature monitoring, are an ample reservoir of the virus, and may then be capable to transmit the infection to a relevant number of healthy subjects. Other than having a viral load that is globally comparable to that of symptomatic COVID-19 patients [7], subjects with SARS-CoV-2 asymptomatic infection can disseminate the virus in the community, especially during high exhaled air-emitting activities carried out without wearing face protections (e.g., shouting, singing, exercising and so forth). This notable infectious potential is testified by the evidence that asymptomatic cases of SARS-CoV-2 infection may be responsible for over 50% of the total number of new cases [8].

A second important aspect concerns the concept of “normal body temperature” and/or “fever”. Besides the fact that the “normal” temperature varies according to the body district where it is recorded (i.e., rectal temperature is typically higher than oral and tympanic) [9], the definition of “normal” as related to body temperature seems quite challenging. In a recent population study, Diamond and colleagues found a lower oral temperature than in previous studies (i.e., 36.1 °C), which is keeping with a trend of progressive decline in body temperature values recorded over the past decades [10]. Notably, the authors also found that the oral temperature differed by sex, since female participants displayed higher values. An earlier meta-analysis also found that body temperature in the elderly (i.e., ≥60 years) is lower (e.g., decreased by ~0.2 °C) than in younger adults [11]. Taken together, these findings suggest that relying on a “standard” normal temperature of 37.0 °C may lead to failure to detect that someone’s body temperature may have increased over that individual’s homeostatic point, thus leading to false negative results for many infected individuals.

Importantly, we must also consider the fact that symptomatic patients may likely be taking over the counter fever-reducing medications as part of standard home care for upper respiratory tract infections. Such medications may contribute to reducing a modestly high body temperature so that it is within “normal” limits, thus resulting in another potentially substantial number of false negatives on body temperature screening.

The third point considers measurement reliability. Recent evidence attests that peripheral thermometers have an accuracy that is frequently outside the predefined clinically acceptable range (e.g., ±0.5 °C), and their inaccuracy is especially high using non-validated devices [12] or when testing febrile patients [13]. Even more importantly, a recent meta-analysis revealed that the cumulative sensitivity and specificity for detecting fever were 81 and 92%, respectively, for both handheld non-contact infrared thermometers and thermal image scanners, which are the two most frequently used devices for purposes of mass body temperature assessments [14]. These figures underlie a nearly 20% false negative rate, which translates into the risk that over one-fifth of COVID-19 febrile patients may be missed by only relying on this practice. Notably, the sensitivity and negative predictive value of thermal image scanners were found to be even lower in outbreak/pandemic settings [14]. Repeated measurements may carry some benefits in terms of lowering imprecision, though this would not obviate possible inaccuracy (i.e., negative or positive bias) compared to central body temperature assessment [15].

A fourth aspect that should be emphasized is that body temperature scanning is also highly dependent on the environmental (e.g., outside) air temperature. An interesting study published by Dzien et al. [16] found that forehead temperature measured with infrared thermometers increases gradually over time in people coming from a cool environment. More specifically, these authors found that the real time temperature when moving from an external environment with air temperatures between −5 and 0 °C increased from 33.2 ± 1.5 to 36.1 ± 0.8 °C after 5 min of indoor acclimatization at 20.5 °C. Even more importantly, the rate of patients detected with abnormally low forehead temperature was over 40% directly after entrance, decreasing to ~2% as soon as 5 min afterwards. The opposite effect (i.e., increase of both skin and core temperature) has been seen after prolonged exposure to higher environmental air temperatures [17]. The need of indoor hospital acclimatization has also been highlighted in another recent study, concluding that an indoor acclimatization period of approximately 5 min is necessary before systematic screening of forehead temperature [18]. Accordingly, Tay et al. reported that a handheld infrared thermoscope displayed inaccuracy as high as 70%

for detecting febrile individuals in a tropical healthcare setting [19].

Last but not least, it should not be discounted that mass body temperature monitoring for purposes of COVID-19 screening may yield relatively low specificity, especially when conducted in areas of low disease prevalence and/or in settings with other highly prevalent conditions causing mild/moderate febrile reactions such as influenza or even the common cold [20].

Conclusions and suggestions

Though we agree that mass testing of body temperature by means of infrared thermometers and/or thermal image scanners carries the advantage of enabling quick and cost-effective screening of symptomatic patients with potential SARS-CoV-2 infection, it carries some significant drawbacks, as summarized in Table 1, which persuades us that this strategy is not sufficiently accurate, may not be effective and is indeed poorly standardized [21]. Reliable support for this conclusion comes from a recent study published by Schneider et al., who found that the measurement of fever at an outpatient clinic was also unreliable for assessing the risk of SARS-CoV-2 infection, as fever was found to be relatively less frequent (i.e., present in around one-third of all cases) in young adult COVID-19 patients with mild to moderate illness, but who are considered the highest frequency spreaders [22]. In a real-life scenario, such as that of an airport, Quilty et al. found that nearly 50% of travellers bearing a SARS-CoV-2 infection would be allowed to travel totally undetected [23]. Almost identical evidence on insufficient diagnostic value of body temperature screening for COVID-19 control has been published in other reports across a wide spectrum of social and healthcare settings [24–26]. Even more hazardous is relying on body temperature for screening potential SARS-CoV-2 infections in children of school age,

Table 1: Major drawbacks of mass body temperature screening for COVID-19 detection.

1. High rate of asymptomatic SARS-CoV-2 infection with potential for virus transmission
2. Definition of “normal” body temperature
3. Body temperature depends on the body district
4. Device inaccuracy
5. Impact of environmental temperature
6. Use of anti-fever medications by symptomatic patients
7. Relatively low specificity in patients with other pathologies

such that the US Centers for Disease Control and Prevention (CDC) currently advises against regular symptom screening in young students [27]. Notably, the use of body temperature to predict acute COVID-19 infection has also been recently challenged by Berdahl and colleagues, who found that its diagnostic accuracy (expressed as area under the curve, AUC) was 0.69 (95% CI, 0.58-0.79) and could be significantly improved by adding covariates known to influence body temperature [28].

Taking into account these previous findings, we believe that some pragmatic suggestions can be envisaged to increase the accuracy of body temperature mass screening, as summarized in Table 2. These basically encompass regular assessment of body temperature (possibly twice, then taking the average) with validated devices, constantly monitored over time and accurately following manufacturer’s instructions, the definition of a range of “normal” body temperature in the local population, patients interrogation on their usual body temperature, standardization of measurement to one body district, allowance of sufficient environmental acclimatization, integration with contact history and other clinical information (including use of anti-pyretics), as well as exclusion of other clinical causes of increased body temperature. We conclude emphasizing the importance of individual and primary care physician’s regular and repeated check of personal body temperature. This appears of pivotal importance, since fever may often precede other COVID-19 symptoms, thus enabling to timely plan SARS-CoV-2 screening or diagnostic testing.

Table 2: Pragmatic suggestions for increasing the accuracy of mass body temperature screening for COVID-19 detection.

1. Regular (also personal) measurement of body temperature with validated devices, possibly twice
2. Always follow manufacturer’s indications for use (distance, body site, number of measurements, etc.)
3. Regularly monitor device accuracy over time
4. Define the range of “normal” body temperature in the local population
5. Interrogate patients on their usual body temperature (if known)
6. Standardize temperature measurement to one body district
7. Allow sufficient acclimatization to indoor temperature (i.e., ≥5 min at 18–24 °C)
8. Integrate body temperature values with possible contact history and other clinical information
9. Rule out additional clinical causes of increased body temperatures
10. Do not exclude SARS-CoV-2 infection only based of body temperature <37.5 °C

Research funding: The authors received no funding for this work.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Competing interests: Authors state no conflict of interest.

Informed consent: Not applicable.

Ethical approval: Not applicable.

References

- Lippi G, Sanchis-Gomar F, Henry BM. COVID-19: unravelling the clinical progression of nature's virtually perfect biological weapon. *Ann Transl Med* 2020;8:693.
- Viswanathan M, Kahwati L, Jahn B, Giger K, Dobrescu AI, Hill C, et al. Universal screening for SARS-CoV-2 infection: a rapid review. *Cochrane Database Syst Rev* 2020;9:CD013718.
- Zhang J, Liu S, Zhu B. Fever screening methods in public places during the COVID-19 pandemic. *J Hosp Infect* 2021;109:123–4.
- Nasiri MJ, Haddadi S, Tahvildari A, Farsi Y, Arbabi M, Hasanzadeh S, et al. COVID-19 clinical characteristics, and sex-specific risk of mortality: systematic review and meta-analysis. *Front Med* 2020;7:459.
- Meyerowitz EA, Richterman A, Bogoch II, Low N, Cevik M. Towards an accurate and systematic characterisation of persistently asymptomatic infection with SARS-CoV-2. *Lancet Infect Dis* 2021; 21:e163–9.
- Oran DP, Topol EJ. The proportion of SARS-CoV-2 infections that are asymptomatic: a systematic review. *Ann Intern Med* 2021;174: 655–62.
- Long QX, Tang XJ, Shi QL, Li Q, Deng HJ, Yuan J, et al. Clinical and immunological assessment of asymptomatic SARS-CoV-2 infections. *Nat Med* 2020;26:1200–4.
- Li R, Pei S, Chen B, Song Y, Zhang T, Yang W, et al. Substantial undocumented infection facilitates the rapid dissemination of novel coronavirus (SARS-CoV-2). *Science* 2020;368:489–93.
- Sund-Levander M, Forsberg C, Wahren LK. Normal oral, rectal, tympanic and axillary body temperature in adult men and women: a systematic literature review. *Scand J Caring Sci* 2002;16:122–8.
- Diamond A, Lye CT, Prasad D, Abbott D. One size does not fit all: assuming the same normal body temperature for everyone is not justified. *PLoS One* 2021;16:e0245257.
- Geneva, Il, Cuzzo B, Fazili T, Javadi W. Normal body temperature: a systematic review. *Open Forum Infect Dis* 2019;6:ofz032.
- Ng DK, Chan CH, Chan EY, Kwok KL, Chow PY, Lau WF, et al. A brief report on the normal range of forehead temperature as determined by noncontact, handheld, infrared thermometer. *Am J Infect Contr* 2005;33:227–9.
- Niven DJ, Gaudet JE, Laupland KB, Mrklas KJ, Roberts DJ, Stelfox HT. Accuracy of peripheral thermometers for estimating temperature: a systematic review and meta-analysis. *Ann Intern Med* 2015;163:768–77.
- Aggarwal N, Garg M, Dwarakanathan V, Gautam N, Kumar SS, Jadon RS, et al. Diagnostic accuracy of non-contact infrared thermometers and thermal scanners: a systematic review and meta-analysis. *J Trav Med* 2020;27:taaa193.
- Hsiao SH, Chen TC, Chien HC, Yang CJ, Chen YH. Measurement of body temperature to prevent pandemic COVID-19 in hospitals in Taiwan: repeated measurement is necessary. *J Hosp Infect* 2020; 105:360–1.
- Dzien C, Halder W, Winner H, Lechleitner M. Covid-19 screening: are forehead temperature measurements during cold outdoor temperatures really helpful? *Wien Klin Wochenschr* 2021;133: 331–5.
- van Marken Lichtenbelt WD, Westerterp-Plantenga MS, van Hoydonck P. Individual variation in the relation between body temperature and energy expenditure in response to elevated ambient temperature. *Physiol Behav* 2001;73:235–42.
- Bassi A, Henry BM, Pighi L, Leone L, Lippi G. Evaluation of indoor hospital acclimatization of body temperature before COVID-19 fever screening. *J Hosp Infect* 2021;112:127–8.
- Tay MR, Low YL, Zhao X, Cook AR, Lee VJ. Comparison of Infrared Thermal Detection Systems for mass fever screening in a tropical healthcare setting. *Publ Health* 2015;129:1471–8.
- Eccles R. Understanding the symptoms of the common cold and influenza. *Lancet Infect Dis* 2005;5:718–25.
- Carpenè G, Henry BM, Mattiuzzi C, Lippi G. Comparison of forehead temperature screening with infra-red thermometer and thermal imaging scanner. *J Hosp Infect* 2021;111:208–9.
- Schneider A, Kirsten H, Lordick F, Lordick F, Lübbert C, von Braun A. Covid-19 in outpatients-Is fever a useful indicator for SARS-CoV-2 infection? *PLoS One* 2021;16:e0246312.
- Quilty BJ, Clifford S, Flasche S, Eggo RM. CMMID nCoV working group. Effectiveness of airport screening at detecting travellers infected with novel coronavirus (2019-nCoV). *Euro Surveill* 2020; 25:2000080.
- Mitra B, Luckhoff C, Mitchell RD, O'Reilly GM, Smit V, Cameron PA. Temperature screening has negligible value for control of COVID-19. *Emerg Med Australasia (EMA)* 2020;32:867–9.
- Rudolph JL, Halladay CW, Barber M, McConeghy KW, Mor V, Nanda A, et al. Temperature in nursing home residents systematically tested for SARS-CoV-2. *J Am Med Dir Assoc* 2020; 21:895–9.e1.
- Markowitz K, Strickland M, Huang A. Fever and other clinical indicators may fail to detect COVID-19-infected individuals. *J Evid Base Dent Pract* 2020;20:101499.
- Centers for Disease Control and Prevention. Screening K-12 students for symptoms of COVID-19: limitations and considerations. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/symptom-screening.html>. [Accessed 28 June 2021].
- Berdahl CT, Nguyen AT, Diniz MA, Henreid AJ, Nuckols TK, Libby CP, et al. Using body temperature and variables commonly available in the EHR to predict acute infection: a proof-of-concept study showing improved pretest probability estimates for acute COVID-19 infection among discharged emergency department patients. *Diagnosis (Berl)*. 2021;8:450–7.