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Identifying Febrile Humans Using Infrared Thermography Screening: Possible Applications During Covid-19 Outbreak

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ABSTRACT

Since the first case of Covid-19 reported in late 2019, it has quickly spread throughout the world and became a pandemic. Because of its high transmission rate, Covid-19 is a huge threat to public health worldwide. Fever is a common symptom of patients with severe acute respiratory syndromes (Sars), including Covid-19 disease. Infrared thermography (IT) is widely used to mass-screen the skin temperature of people in crowded places, such as hospitals and airports. This is of importance for patients and health professionals as it drastically decreases the risk of transmission due to the minimal contact between the evaluator and the subject. Infrared thermography strategy has already been widely used for the screening of febrile people during the outbreak of other pandemics such as H1N1 and Ebola. We here describe the potential of IT to identify febrile people who may be infected with COVID-19 and provide recommendations for their monitoring and management during this pandemic based on literature data.

Keywords: Covid-19. Sars. Mass-screening. Fever. Skin temperature.

IDENTIFICAÇÃO DE SERES HUMANOS FEBRIS USANDO TRIAGEM POR TERMOGRAFIA INFRAVERMELHA: POSSÍVEIS APLICAÇÕES DURANTE A PANDEMIA DE COVID-19

RESUMO

Desde o primeiro caso de COVID-19 relatado no final de 2019, a doença se espalhou rapidamente por todo o mundo e se tornou uma pandemia. Devido à sua alta taxa de transmissão, a COVID-19 é uma enorme ameaça à saúde pública em todo o mundo. A febre é um sintoma comum de pacientes com síndromes respiratórias agudas graves (SARS), incluindo a doença de COVID-19. A termografia infravermelha (TI) é amplamente usada para rastrear em massa a temperatura da pele em locais com grande aglomeração, como hospitais e aeroportos. Isso é importante para pacientes e profissionais de saúde, pois diminui drasticamente o risco de transmissão devido ao contato mínimo entre o avaliador e o sujeito. A estratégia de TI já foi amplamente utilizada para a triagem de pessoas febris durante o surto de outras pandemias, como o H1N1 e o Ebola. Aqui, descrevemos o potencial da TI para identificar pessoas febris que podem estar infectadas com COVID-19 e fornecemos recomendações para seu monitoramento e gerenciamento durante essa pandemia com base em dados da literatura.

Palavras-chave: COVID-19. SARS. Rastreamento em massa. Febre. Temperatura da pele.

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INTRODUCTION

The coronavirus disease 2019 (Covid-19) is a severe acute respiratory syndrome mainly spread through respiratory or physical contact. The outbreak first took place in Wuhan, China, in December 2019 and quickly spread across several regions worldwide. Regardless of the intense control measures to identify and control the disease, its effects on public health are already devastating. Covid-19 patients usually suffer from several symptoms, such as fatigue, shortness of breath, dry cough, and high fever (KIMBALL *et al.*, 2020).

Fever is the most common presenting symptom in patients with Covid-19 disease (YAN *et al.*, 2020). Wang *et al.* (2020) observed that the majority of the patients affiliated hospitals of Nanchang university, Nanchang, China, from Jan 21 to Feb 2, 2020 presented fever (91%). Fever is considered to be a complex and potent biologic response to infection and injury. The increase in body temperature plays a huge role in cell signaling and gene expression patterns, which affects the innate immune system function and cell apoptosis and recovery (HASDAY *et al.*, 2011). In times like these, the academic community plays a huge role in directing strategies to combat the spread of the disease (CARVALHO; LIMA; COELI, 2020)

Fever can be classified as acute, sub-acute and chronic, depending on the duration (<7 days, 7 < 14 days, and >14 days, respectively). Moreover, it can be classified as low grade fever (38.1-39ºC), moderate grade fever (39.1-40ºC), high grade fever (40.1-41.1ºC), and hyperpyrexia (>41.1ºC) depending on the body temperature (OGOINA, 2011). It has been reported that most of the patients infected with Covid-19 in Beijing presented low to moderate grade fever (<39.1ºC) (TIAN *et al.*, 2020). Furthermore, Guan *et al.* (2020) extracted data from 552 hospitals in 30 provinces and observed that fever was identified in 43.8% of the patients on presentation but developed in 88.7% during hospitalization. This is an indicator that the incidence of fever increases as the disease progresses.

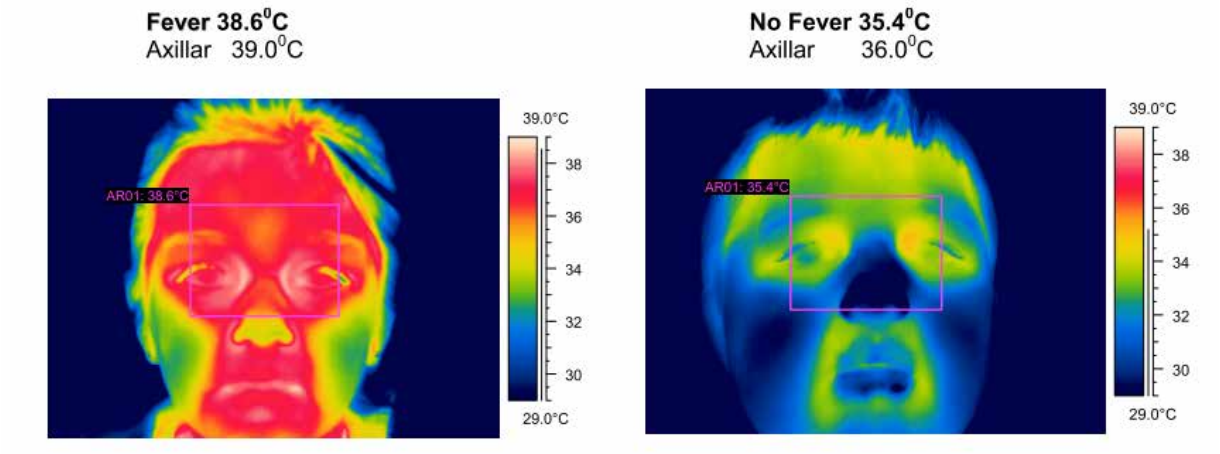
Over the past few years, due to the outbreak of pandemics such as H1N1 and Ebola, several countries carried out mass-screening in public places. They aimed to decrease the spread of these pandemics by limiting the exposition of people with flu-like symptoms in common public spaces, such as airports and hospitals. However, manual screening can represent a high risk of contamination for the health professional (SANCHES *et al.*, 2013). Because of that, the use of thermographic cameras has emerged as an efficient and safe method of skin temperature mass-screening (RING *et al.*, 2008). Currently, infrared thermography (IT) is the best viable mass fever screening for outbreaks of both infectious disease pandemics such as Ebola virus (GHASSEMI *et al.*, 2018) and severe acute respiratory syndromes (Sars) such as H1N1 influenza pandemic (HEWLETT *et al.*, 2011; PASCOE *et al.*, 2010). The quick notification and visualization method of infection cases in the early stages should be incorporated as the standard for epidemiological surveillance (LANA *et al.*, 2020). Therefore, IT can be a useful tool for early identification, diagnostic documentation, and prognostic evaluation of Covid-19 cases.

INFRARED THERMOGRAPHY AS A TOOL TO COMBAT INFECTIOUS DISEASES

Infrared thermography, also known as the thermal image, is an imaging approach used for a wide range of medical applications (BRIOSCHI; BRIOSCHI, 2009) able to register images with cancer (ARORA *et al.*, 2008), peripheral vascular disorders (BAGAVATHIAPPAN *et al.*, 2009) and fever (HEWLETT *et al.*, 2011). This equipment can be found in the Brazilian market from R$ 2,500 up to R$ 70,000 depending on the image quality. Moreover, it is a practical tool in sports sciences (QUESADA, 2017) and physical training evaluations (MENEZES *et al.*, 2018). In recent years, it has become a more accessible tool of remote sensing for body temperature. The IT device is composed of a portable camera (around 3 kg and 220 mm x 135 mm x 130 mm). Its portability and practicability enable the transport and management of the device in several situations. Taking into consideration fever as one of the main symptoms of the Covid-19 pandemic, the use of IT seems to be a promising tool against the spread of the disease.

The skin temperature can be monitored to establish a baseline temperature of the individual. This is important because body temperature is closely related to inflammation and systemic infection with the presence of fever. On the other hand, the primary temperature of the subject must also be assessed, as a 38ºC fever does not necessarily indicate a disease if the previous temperature were superior. For this reason, the International Organization for Standardization (ISO) provides general guidelines for the deployment, implementation, and operation of a screening thermograph intended to be used for non-invasive febrile temperature screening of individuals under indoor environmental conditions to prevent the spread of infection of pandemics (ISO, 2008, 2009).

Figure 1 – Fever screening thermography



Source: Pascoe *et al.* (2010).

IT system can acquire thermal images series between 10°C and 40°C at 60 frames per second, which is demonstrated through a captured image of 320 x 240 pixels of resolution. Considering the human body core temperature, it can screen febrile patients by measuring the skin temperature of the frontal area of the face. If the temperature is over 37.5°C, which represents a fever state, an alarm system will go off. Once the fever state is confirmed, further diagnostic methods such as serological, molecular, and radiological are recommended in order to detect the contamination (OZMA; MAROUFI; KHODADADI, 2020).

The human adult face has several thermoanatomic points, symmetrically positioned in both right and left sides of the face. The areas of high intensity in the face are medial palpebral commissure, labial commissure, temporal, supratrochlear and external acoustic meatus (HADDAD *et al.*, 2016). The thermal imaging of the eye region is the fastest non-contact region for fever assessment (RING *et al.*, 2013).

The IT uses a thermovisor to capture the emissions of heat from different parts of the body and display them in a screen with a rainbow color pallet, which represents different levels of body temperature. The temperature must be screened in a controlled ambient, at around 22ºC. The imaging is displayed in a 320 x 240 pixels screen with a numeric representation of heat (0.1ºC of accuracy). The software of the camera processes all images, which can be used for further analysis. However, there are some limitations regarding the assessment of skin temperature using IT, such as the distance between the subject and the evaluator and the temperature of the ambient, which can alter the results of the screening. Moreover, the use of cosmetics, creams, gels or any other type of skin treatment, as well as heavy clothes, can distort the radiation emission, resulting in an underestimation of skin temperature (QUESADA, 2017).

On the other hand, the guidelines suggested by the ISO must be carefully followed, as there is a need for quality assurance, regular calibration, training and documentation of the data collected. The thermal imaging must be seen as the first stage of the evaluation. The suspected passenger must then be medically checked in order to confirm any infection exposure. Currently, some facial recognition devices are being used to check the temperature of the skin in public places. The use of IT would extend this procedure to a simultaneous temperature check. It is already well established that a series of multifaceted public interventions are associated with improved control of the Covid-19 (PAN *et al.*, 2020). The use of IT technology might as well contribute to these strategies in order to decrease the spread of the pandemic.

WHY SCREEN FEBRILE PATIENTS WITH INFRARED THERMOGRAPHY?

To this day, there are no viable means to diagnose and monitor all cases of Covid-19 infection. However, it is possible to track the virus by notifying the cases of fever, followed by further analysis. In April and May 2003, during a Sars outbreak, over 72.000 patients and visitants entered the facilities of the Taipei Medical University-Wan Fang Hospital, in Taiwan. A total of 305 febrile patients (0.42%) were detected through IT. Further analysis verified that three patients were contaminated with Sars. This suggests that IT is an efficient and reliable tool to mass-screen suspected patients in the early stages of severe acute respiratory syndromes with fever (CHIU *et al.*, 2005).

Infrared thermal imaging technology has been widely used in several clinical settings, including to assess emitted temperature and detect several diseases, such as seasonal influenza (NEGISHI *et al.*, 2020), vascular disorder (BAGAVATHIAPPAN *et al.*, 2009), breast cancer (ARORA *et al.*, 2008), H1N1 influenza (HEWLETT *et al.*, 2011), and Ebola (GHASSEMI *et al.*, 2018). A mass-screening system using IT technology could significantly improve the prospect for conducting high quality Covid-19 pandemic countermeasures. However, credibility and acceptance of thermal imaging is subject to critical use of the technology and appropriate comprehension of thermal physiology.

IT represents the best approach regarding the mass-screening of febrile subjects during the outbreak of infectious pandemics, such as H1N1, Ebola, and Covid-19. They can accurately estimate the body skin temperature when following appropriate standards. Therefore, this method should also be used in public places by authorities in order to identify subjects with Covid-19 in the early stages of the disease. This would be extremely helpful to combat the spread of the pandemic.

CONCLUSION

The outbreak of the Covid-19 pandemic has shown to be a big challenge globally, taking in consideration its elevated rate and speed of contamination. In order to better face this challenge, it is necessary to quickly identify those who are presenting the symptoms of the disease. Infrared thermography is a fast, painless, noncontact, and noninvasive imaging method used for the diagnosis of fever. Here we have suggested the use of IT as a strategy to quickly and safely mass-screen the skin temperature, in order to detect febrile people who may be infected with the Covid-19. Public authorities should establish and improve the intervention system based on scientific advice and the standard procedures, to effectively deal with the problems caused by this public health emergency. More importantly, as Covid-19 has already affected countries in all continents, this could assist other regions on how to decrease the spread of the disease and prevent possible local outbreaks

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