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LETTER TO THE EDITOR

Modern approach to infectious disease management using infrared thermal camera scanning for fever in healthcare settings

Dear Editor,

Sun and colleagues have recently reported in this Journal the use of radar systems including thermography for use in infectious disease screening at airports.[1,2] We conducted a prospective study to assess the value of the use of infrared thermal cameras in detecting fevers in both patients and healthcare workers between May 2015 and February 2016 in a university hospital center in Southern France.

We used the MOBOTIX M15D infrared thermal camera (MOBOTIX®, Germany) and Genius™ 2 Tympanic Thermometer (COVIDIEN®, Ireland) for measuring temperature. Initially, we tested the infrared thermal camera for detecting fever (temperature of patients $\geq$38.5 °C) using the original parameters as recommended by the manufacturers (Fig. 1). We then performed a temperature pre-test using an infrared thermal camera on one hundred people, including 50 out-patients and 50 members of the medical staff. Nineteen percent of temperature measurements were false positive fevers, and occurred during a period of strong variations in room temperature over the pre-test period (May 2015), ranging from 21 °C to 30 °C.

We then performed a calibration test of the infrared thermal camera by taking into account room temperature variation. The correlation between camera detection temperatures according to ambient temperature revealed a decrease in the detection threshold as the temperature rises in the room. Linear regression was reported (Fig. 2). We identified a correction with an equation: detection temperature $= -38.99 + (-0.429)$ ambient temperature $+ 0.338$ thermal sensitivity of the camera (R). We observed that temperature detection varies by 0.429 °C per degree of room temperature variation. From this equation, we calculated R for the detection of temperature at 36.4 °C for an ambient temperature of between 21 °C and 30 °C and performed a linear regression to find the equation for adjustment of the camera: $R = 1.16\ Ta + 225.96$.

Once the device has been adjusted to room temperature, we performed 625 temperature measurements, including 246 measures of in-patients and out-patients, and 379 measures of healthcare workers by staying for a few seconds in front of using an infrared thermal camera. We identified 14 cases (2.24%) of fever in our study. Five febrile cases detected by the tympanic thermometer and infrared thermal camera had an upper respiratory infection. Thirteen febrile cases were detected both with the tympanic thermometer and infrared thermal camera (true positive). Two cases were detected only by the infrared thermal camera, which were confirmed to be false positive cases. One febrile case was not detected with the infrared thermal camera (false negative: 38.5 °C). Six-hundred and nine cases were afebrile, i.e. fever was not detected by both techniques (true negative: n = 609 cases).

The sensitivity of the infrared thermal camera in detecting febrile cases was identified as 0.9286 (95% CI: 0.6613–0.9982); and the specificity of the infrared thermal camera in detecting febrile cases was identified as 0.9967 (95% CI: 0.9882–0.9996). The positive predictive value of the infrared thermal camera in detecting febrile cases was identified as 0.8667 (95% CI: 0.5954–0.9834). The negative predictive value was identified as 0.9984 (95% CI: 0.9909–1).

In this paper, we reported on an initial study of automated fever screening using infrared thermal cameras in a French clinical infectious diseases unit. The sensitivity of infrared thermography camera in mass screening for fever in our study was higher than previous studies (ranging from 4% to 89.6%).[3–9] The specificity of our study was higher than that reported in the literature (ranging from 75.4% to 99.6%).[3–9] The positive predictive value was higher in our study than that reported in the literature (ranging from 0.9% to 76%); and the negative predictive value was higher in our study than that reported in previous studies (ranging from 86.1% to 99.7%).[3–9]

In our study, we observed that ambient temperature had a direct effect on threshold fever detection using infrared thermal cameras. The effects of ambient temperature variation on the performance of infrared thermal cameras have been reported.[3,6,8–10] Ng *et al.* proposed maintaining the ambient temperature at between 20 °C and 25 °C for optimal conditions for fever screening using infrared thermal cameras.[3] Chan *et al.* observed a small effect of ambient temperature on the performance of infrared thermal cameras, with a rate of 0.196 °C per

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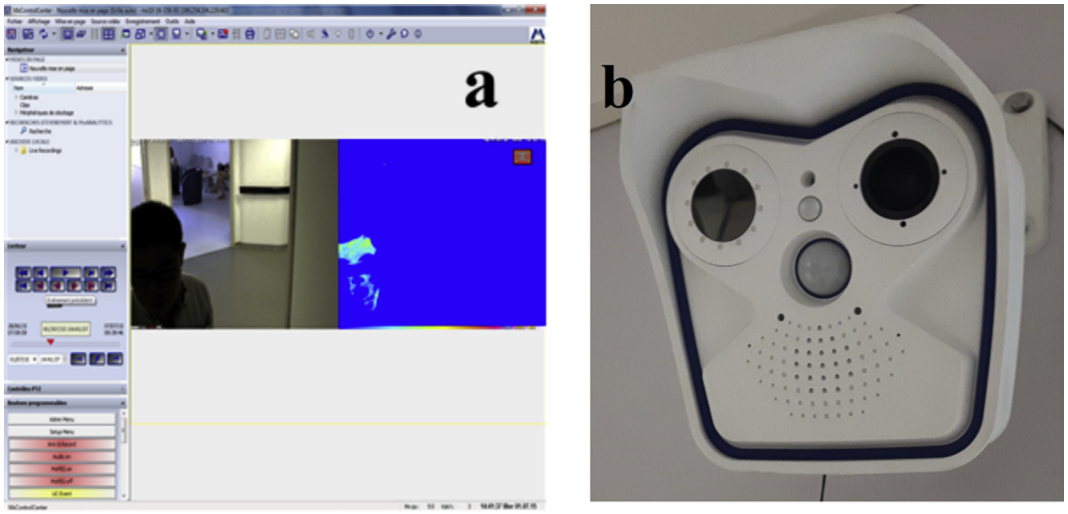

Figure 1 Febrile detected subject using MxControlCenter® (v2.5.3.5) software (a), and MOBOTIX M15D® infrared thermal camera (b).

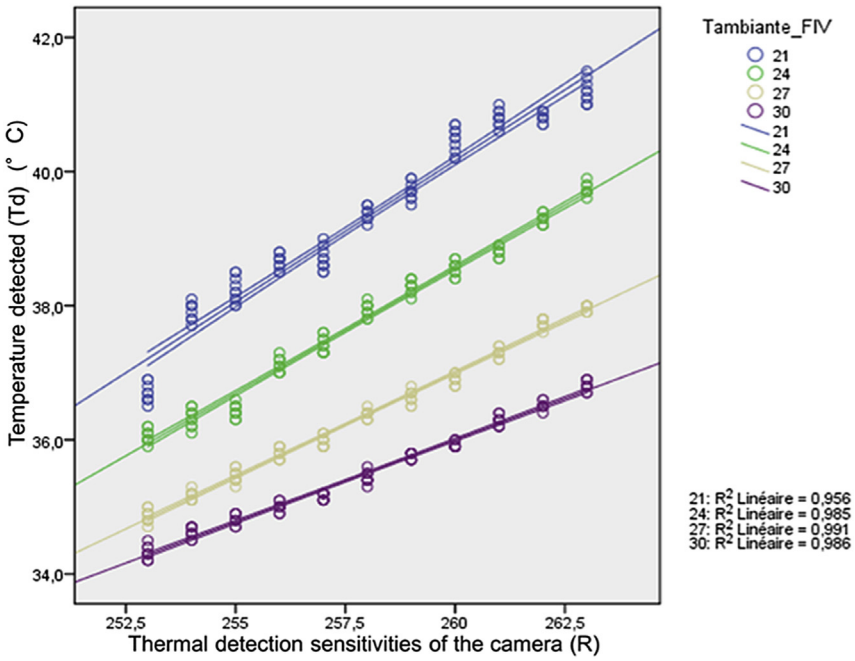

Figure 2 Influence of room temperature on threshold temperatures detected.

degree Celsius of increase in ambient temperature.[8] However, we found that the temperature detected varied by 0.429 °C per degree Celsius of variation in ambient temperature.

No previous studies proposed a model to correct this confounding factor. We are the first to report that infrared thermal cameras are a powerful tool for fever screening in situations of great variation in ambient temperature by introducing the R correction. The best values for sensitivity, specificity, positive and negative predictive values in our study may be explained by the thermal sensitivity of the infrared cameras which had been calibrated by considering variations in ambient temperature before clinical application.

The clinical effectiveness of mass screening for fever using infrared thermal cameras has recently been reported using an algorithm involving heart and respiratory rate in order to detect respiratory infectious diseases.[1] This algorithm has identified infected persons with a good sensitivity and specificity in 54 out-patients and 33 negative controls. However, this study was limited by the low number of individuals included and the high number of false positives (18%). In our study, we identified five cases presenting symptoms of contagious respiratory infection. These cases

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were isolated for the purposes of infection control. We believed that rapid fever detection using infrared thermal cameras, followed by rapid clinical intervention remains the most effective way of controlling infection. Mass screening for fever using infrared thermal cameras will be included at an early stage in the reception of patients as part of the rapid and efficient control of infection. Infrared thermal cameras are a rapid and reliable way to detect fever in infected persons in clinical settings. This modern approach should be included in the management of infectious diseases to efficiently control infection. Prior calibration of the thermal sensitivity of infrared thermal cameras according to ambient temperature is required to obtain greater accuracy.

Ethics statement

The human subject research protocol and ethical aspects of the study were approved by 'Comité de Protection des Personnes (CPP) Sud-Méditerranée 1' and 'Agence nationale de sécurité du médicament et des produits de santé (ANSM)'. A written informed consent form was signed by each individual included. Copies of the written approve are available for review by the Editor-in-Chief of this journal.

Competing interests

The authors have declared that no competing interests exist.

Financial disclosure

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