# Non-contact infrared thermal imagers for mass fever screening—state of the art or myth?

During the severe acute respiratory syndrome (SARS) outbreak, the installation of non-contact infrared (IR) thermal image sensors (NCIRTIS) at national entry and exit points aimed to stop people with acute, febrile respiratory illnesses leaving and entering SARS-affected regions (Fig). This was done in line with WHO recommendations[1] but the exact method of fever detection for exit and entry screening was not specified. This experience offers valuable information concerning the value of using the same detection methods for the impending avian influenza pandemic. Different types of IR sensors were employed but they all work under the same physical principles and are therefore prone to the same intrinsic errors.[2]

**Fig. High-resolution infrared image of one of the authors, with a full beard wearing un-tinted spectacles in a round necked T-shirt**

Black denotes low temperature, white for higher temperature, and red when exceeding the pre-set threshold temperature. Note the capital hair, moustache, and beard just below the lower lip are shaded dark grey. The spectacle lenses and the bottom of the beard are black. The highest temperature region of the face is commonly the forehead

Non-contact infrared thermal image sensors have several theoretical advantages over traditional clinical thermometers. They do not touch the subject, thereby avoiding transfer of the contagion through contact; they operate at a distance, thereby limiting the health risk to the operator; and they display temperature in 1 to 2 seconds in contrast to the 30 seconds taken by traditional oral thermometers. However, significant disadvantages are numerous. In particular, their measurements are heavily influenced by personal and physiological factors.[3] The fundamental obstacle with NCIRTIS is that it measures only surface temperature, not body core temperature.

There are few retrospective evaluations of NCIRTIS' use in blind mass fever screening. During the SARS epidemic of 2003, thermal scanning of over 35 million international travellers entering Canada, China, Hong Kong SAR, and Singapore did not pick up a single SARS case. Screening at exit from Canada, Hong Kong SAR, Taiwan, and Singapore of over 7 million people also failed to find a single SARS case.[4]

There are few technical studies evaluating the use of NCIRTIS in blind mass fever screening and none are conclusive.[5,6] Furthermore, there are currently no established standards available for testing the NCIRTIS systems used to detect body temperature.[7] However, this does not seem to discourage the numerous commercial vendors selling the NCIRTIS now being used for mass blind fever screening.[8,9]

Most manufacturers routinely carry a disclaimer saying their product is not for medical use. One manufacture ventures to explore such 'off-label' use with the following 'frequently asked questions' and answers on their website[10]:

"Q: Are any XYZ infrared thermometers designed to measure the temperature of the human body?

A: No.

Q: Are any of XYZ's products designed specifically for medical use?

A: No……."

Despite this, these are followed by several leading questions indicating that XYZ's non-contact IR thermosensor equipment is used widely for clinical body temperature measurement.

There are opponents to the use of NCIRTIS for fever screening. One company specialising in thermal imaging goes so far as to declare that "Non-contact thermal imaging is simply not suited to SARS screening."[11] Their key objections are:

1. Thermal imaging measurement typically carries a ±2% or at least 1°C error, whichever is the larger;
2. Most detectors are capable of differentiating temperatures within a tenth of a degree; however this is a measurement relative to the surrounding areas, whereas absolute temperature measurement is required for body temperature taking;
3. Thermal stability of the receiver unit and the atmospheric or ambient temperatures also play large roles in this process. Airports or transit lounges cannot establish environmental controls for the effective thermal imaging that is required for potential SARS screening. Environ-

mental IR pollution and environmental temperature must be controlled within two degrees Celsius;
4. Air-flow must be consistently controlled.

They summarised the issue by saying it would be wonderful if it were possible to set up a simple mass screening procedure for SARS, but unfortunately thermal imaging cannot be that 'magic bullet' because:

- Thermal imaging (non-contact) scanners and devices simply do not offer the required quantitative accuracy;
- Airports cannot offer an environment controlled well enough for accurate scanning;
- The body does not offer a surface suited to accurate and reliable temperature measurement other than, possibly, the interior of the deep ear canal.

Some NCIRTIS manufacturers refuse to sell their equipment for mass blind fever screening. An example is the Omega Engineering Inc which put out an alert saying "All OMEGA's IR devices…are NOT to be used as a diagnostic tool in relation to the SARS epidemic or any other infectious diseases, since they are NOT designed for, intended to, or capable of measuring human body temperature…" The company prohibited sale of their equipment "…to areas affected by SARS (China, Hong Kong, Singapore, and Taiwan)."[12]

There is no argument that with the imminent avian influenza pandemic, there will be a surge of public interest in thermal image scanners.[7] The Canadian installations at Toronto and Vancouver cost an estimated Can$7.55 million. Retrospectively (in 2005), the authorities questioned the effectiveness of NCIRTIS at detecting SARS among inbound or outbound passengers from SARS-affected areas.[13] Another report noted that "Fourteen people flew into Canada with SARS and were not detected by the airport screeners. Another three with SARS were able to leave".[14]

The low prevalence of SARS during the 2003 epidemic together with the deterrent effect NCIRTIS installations may have had on ill-would-be travellers, may have contributed to the zero detection rate of fever as a physical sign of SARS. In the event of an avian influenza or highly pathogenic avian influenza (HPAI) pandemic, the prevalence of symptomatic HPAI travellers with HPAI will be enormous compared with that for SARS. This then begs the question of whether NCIRTIS will be effective for fever detection when prevalence is several folds higher as will be the case in an HPAI pandemic. It is possible that the deterrent effect of NCIRTIS on an ill person's plan to travel will be magnified if and when the HPAI pandemic becomes a world catastrophe.

The authors note that although NCIRTIS is in widespread use for blind mass screening for fever, no responsible manufacturer has claimed NCIRTIS equipment is capable of measuring absolute body temperature, and certainly not core body temperature.

Despite the experience of scanning tens of millions of individuals to screen for fever since the advent of the SARS epidemic, there are few evaluations of the effectiveness of NCIRTIS as a means of controlling the spread of SARS. The authors have been unable to find an independent study suggesting that blind mass fever screening with NCIRTIS is an effective means of SARS screening at national borders. In a report to the WHO, Bell of the CDC[4] found zero detection of SARS by NCIRTIS, as did the Canadian report.[13]

It would appear that, for now, the aforementioned problems with NCIRTIS measurement prevent this mode of relative temperature sensing from being comparable to the clinical need to measure absolute core body temperature in order to detect the small temperature elevation indicating fever. The presence of such scanners at entry and exit points may have had a deterrent effect on travel by ill persons during the SARS outbreak but there has been no evaluation of this.

The authors surmise that if NCIRTIS could not pick up any SARS cases by fever detection, then this method of temperature measurement is unlikely to be useful for detection of the fever caused by avian influenza. The effectiveness of prominent NCIRTIS installations as a means of deterring ill people from travelling remains to be studied.

With their unproven efficacy at SARS detection, authorities should not rely unduly on the use of NCIRTIS in mass fever screening for avian influenza detection at national entry or exit points. In the absence of a 'magic bullet' able to carry out non-contact mass fever screening, border authorities would be well advised to continue practising such time-honoured public health measures as health and hygiene education, handing out of health information leaflets and health declarations from all travellers.

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