

# **Protocol for Rapid Point-of-Contact Public Screening for SARS using Clinical Digital Infrared Thermal Imaging**

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## **Position Paper: Recommended screening protocol for the efficient, rapid recognition of hyperthermic individuals with SARS using clinical digital infrared thermal imaging in public places**

Keywords: SARS, public health screening, disease detection, clinical thermal imaging, infrared thermal imaging, DITI, point-of-contact screening, hyperthermia screening, core temperature screening, mass population studies

### **I. WORLDWIDE PUBLIC HEALTH PROBLEM**

The rapid emergence of severe acute respiratory syndrome (SARS) worldwide presents a potential public health dilemma and potential epidemic due to lack of rapid, efficient and cost-effective point-of-contact screening. Establishing point-of-contact screening has been advocated by public health experts as a major step in control of exposure of the public to SARS. Urgent introduction of such a point-of-contact screening modality demands action by the medical and scientific community worldwide.

### **II. OBJECTIVE**

The American College of Clinical Thermology (ACCT) proposes that the most effective point-of-contact screening of individuals in public places is clinical digital infrared thermal imaging. This position paper describes the protocol, scientific basis and clinical efficacy of this screening modality. The ACCT proposes that this modality satisfies requisite characteristics for such screening, namely, accuracy of temperature measurement, sensitivity, non-contact, reproducibility, adaptability to test venue, efficiency, speed of testing and cost-effectiveness.

### **III. SCREENING PARAMETER – CORE BODY TEMPERATURE**

The most common physiologic parameter detectable in individuals with viral syndromes is elevated core body temperature. This parameter is the target physiologic parameter of interest in clinical thermal imaging as a screening modality and most accurately represents core body temperature when applied to a specific body site, namely, the medial canthal areas of the face.

### **IV. CLINICAL SCREENING PROTOCOL**

The aim is to rapidly identify any individual in a public place with an abnormal physiological temperature that could be related to the SARS virus. As digital infrared thermal imaging (DITI) is a non-contact screening modality, it can be used without the need for the subjects' consent and without any clinical risk.

## A. MASS POPULATION SCREENING PROTOCOL

To screen large groups of individuals quickly and efficiently the following protocol is advised:

### 1. THERMAL IMAGING STEP - STANDARDIZED POSITIONING AND FRAMING

An infrared image of the subject's face via a single whole head view with the subject looking directly at the camera should be captured and processed. This imaging step should comply with standard thermographic framing and positioning protocols for a region of interest of the anterior view of the head.



A region of interest (ROI) framing and positioning of the head.

### 2. THERMAL IMAGING DURATION

The subject should remain in position for at least two (2) seconds to allow adequate data acquisition.

**TECHNICAL ADVISORY #1:** *A trade-off exists between speed of imaging and sensitivity. The longer a detector can sample a stable temperature, the better the accuracy. ADVISORY that moving subjects will cause inaccurate data due to air movement across the skin surface. Movement also causes changes to the ambient infrared radiation being reflected from the subject's skin surface that will be detected at the same time as the emitted physiological infrared radiation. Movement also creates dynamic changing of the angles of the skin surface and will also affect the reliability of the thermal data.*

**TECHNICAL ADVISORY #2:** *Infrared cameras should detect in the narrow range of infrared that is emitted by the human body. Emissivity of human skin is nearly 100%, so a technically appropriate camera should detect as close to 100% of the emitted radiation as possible. The unwanted effects of environmental infrared should be minimized. Sources of reflected infrared radiation include indirect sunlight, nearby electrical sources (outlets, cables, wiring), lighting (primarily incandescent) and other radiative sources. These environmental radiative sources can account for unacceptable inaccuracies if a non-specific or unstable range of detection is used.*

**TECHNICAL ADVISORY #3:** *Interpretation of thermograms should be integrated with software that provides instant statistical analysis of an operator-determined region of interest.*

### 3. THERMAL IMAGE ANALYSIS

The thermal image should be instantly analyzed and summarized in a readable output using a narrow temperature range of detection that covers the full range of physiological temperature. A range of 8 °C is proposed as optimum for the purposes of thermal screening of a single site. These analytic parameters should be pre-set and unchanged during imaging, thereby establishing reproducibility and efficiency of testing sessions.

### 4. STANDARDIZED SETTINGS OF COLOR SCALES

Assignment of settings of a color scale relative to the temperature range is proposed to optimize visual interpretation and identification of suspect temperatures and thermal pattern distribution.

**TECHNICAL ADVISORY #4:** *Physiologically significant color changes should be within half a degree Celsius (0.5 °C). A standard medical color scale is recommended in this protocol, affording an image with 16 colors that are divided between 8 °C, thereby yielding 0.5 °C per color. Accordingly, flexibility with these temperature settings and color scale will afford compensation for variations in ambient temperature. As a result, the sensitivity of the screening can be easily adjusted to suit particular requirements of testing venues.*

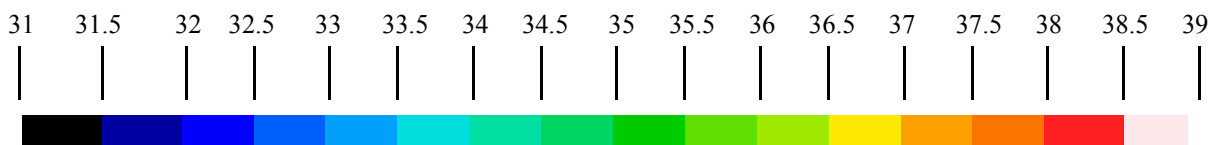
## 5. POSITIVE THRESHOLD TEMPERATURE DIFFERENTIATION

The positive threshold temperature for screening is 38 °C, per the WHO and CDC guidelines. With this threshold, the upper level of the color scale (red) becomes a positive indicator on visual inspection alone.

**TECHNICAL ADVISORY #5:** Based on the pre-set color scale established in item (4) above, differentiation of threshold versus non-threshold colors is achieved as follows: the color range for the positive threshold temperature and above of 38 to 38.5°C should be seen as color Red, and above 38.5°C should be seen as white. The colors for temperatures below the positive threshold temperature in descending temperature range is achieved as follows: the temperature gradient of 37 to 37.7°C should be orange, a mid range of 36.7 to 37°C should be yellow, and a range of 34 to 36.5°C should be green.

## B. EXAMPLES OF NON-THRESHOLD & THRESHOLD TEMPERATURE DIFFERENTIATION

The following color scale is recommended for mass population screening for SARS.



Typical display screen set-up:

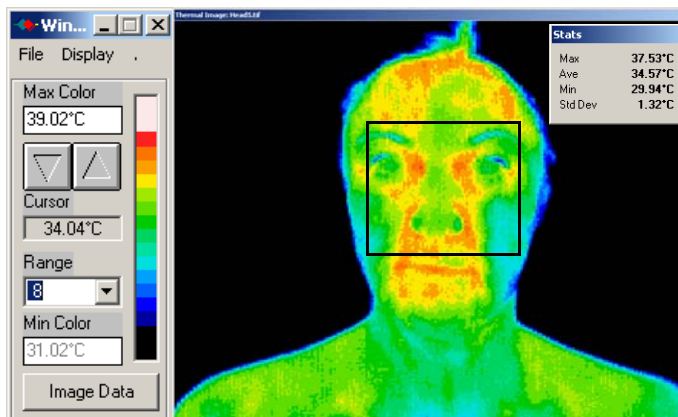


Fig. 1 shows a normal subject. The highest temperature in the image is 37.53°C, a sub-threshold temperature reading.

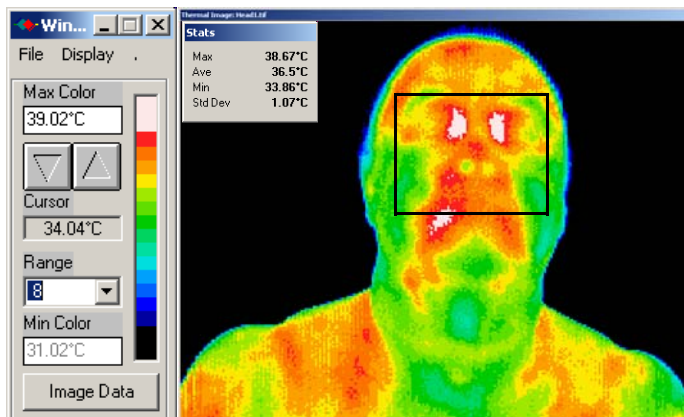


Fig. 2 shows a febrile subject. The hottest temperature in the image is 38.67°C, a positive threshold temperature reading

Based on the pre-set color scales proposed above, rapid differentiation between threshold and non-threshold temperatures is achieved by efficient colorimetric interpretation alone. Detailed statistical analysis with easily readable output should appear simultaneously on-screen for statistical corroboration of visual findings.

## **V. THERMAL PHYSIOLOGY**

The human body produces heat which must be lost to the environment. The interface between this heat production and the environment is the skin, therefore the body depends on heat transfer from the skin for thermoregulation. The skin is a dynamic organ, which under sympathetic nervous control is constantly adjusting to balance internal and external temperature conditions. Thermal imaging is the most efficient technique for the study of skin temperature distribution.

### **A. THRESHOLD TEMPERATURE GUIDELINES (WHO and CDC)**

The WHO and CDC guidelines relating to SARS establish that a suspect case will have a temperature of greater than 38°C.

### **B. CLINICAL INFRARED THERMOGRAPHY AS A SCREENING MODALITY FOR SARS**

The foundational clinical basis of utilizing clinical thermography as a SARS screening modality is the correlation of temperature recordings with various conditions from disease and injury as it relates to autonomic function.

The fever produced by the SARS virus 2 to 7 days before there are any other clinical symptoms will alter autonomic function which can be detected with thermography.

### **C. PHYSICS**

In order to detect accurate skin temperatures that relate to core temperature and fever, close to absolute temperature should be recorded. Cameras with internal black body sources need careful calibration and an external control temperature should be used. Uncooled staring cameras, particularly focal plane array (FPA) methods, will require additional reference temperatures and regular cross referencing and correlation with a control temperature.

In contrast, thermoelectrically or cryogenically cooled cameras are preferred for their stability and minimal thermal drift. A reference temperature should be stable to better than 0.1 °C.

## **VI. CONCLUSION**

With the recent accelerated utilization of thermal imaging in screening for SARS, the ACCT proposes per this position paper that it is necessary to incorporate the clinical science of thermology to gain the optimal benefit from this modality and ensure its successful performance in helping to contain and manage this epidemic. The clinical screening protocol for this modality described herein satisfies the worldwide need for rapid, non-contact, safe and reliable mass population testing.

## **VII. REFERENCES**

Chan EK; Visualization of dynamic subcutaneous vasomotor response by computer-assisted thermography. (IEEE Trans Biomed Eng, 1990 Aug)

Chan FH; Generation of three-dimensional medical thermograms. (Biomed Mater Eng, 1996)

Cline M, Ochoa J, Torebjork E; Chronic hyperalgesia and skin warming caused by sensitized c nociceptors. (Brain, 1989)

Darton K; The use of infra-red thermography in a rheumatology unit (Br J Rheumatol, 1990 Aug)

Dotson R, Ochoa J, Marchetti P, Cline M; Sympathetic neural outflow directly recorded in patients with primary autonomic failure. (Neurology, 1990;40:1079-1085)

Friedman MS; The use of thermography in sympathetically maintained pain. (Iowa Orthop J, 1994)

Geatti O; A comparison of scintigraphy, thermography, ultrasound and phlebography in grading of clinical varicocele. (J Nucl Med, 1991 Nov)

Graff-Radford SB; Thermographic assessment of neuropathic facial pain. (J Orofac Pain, 1995 Spring)

Gratt BM; Future applications of electronic thermography. (J Am Dent Assoc, 1991 May)

Gratt BM; Thermographic assessment of craniomandibular disorders: diagnostic interpretation versus temperature measurement analysis. (J Orofac Pain, 1994 Summer)

Gratt BM; Thermographic characterization of osteoarthritis of the temporomandibular joint. (J Orofac Pain, 1993 Fall)

Gratt BM; Thermographic characterization of the asymptomatic temporomandibular joint. (J Orofacial Pain, 1993 Winter)

Hsieh JC; Clinical application of infrared thermography in diagnosis and therapeutic assessment of vascular ischemic pain [published erratum appears in Ma Tsui Hsueh Tsa Chi 1991 Mar;29(1):567] (Ma Tsui Hsueh Tsa Chi, 1990 Dec)

Hunold S; Thermographic studies on patterns of skin temperature after exercise. (Eur J Appl Physiol, 1992)

Lawson W; Infrared thermography in the detection and management of coronary artery disease. (Am J Cardiol, 1993 Oct 15)

Mannara G; Ethyl alcohol induced skin temperature changes evaluated by thermography. Preliminary results. (Boll Soc Ital Biol Sper, 1993 Oct)

Matsumura H; Haemodynamic changes in early phase reflex sympathetic dystrophy. (Scand J Plast Reconstr Surg Hand Surg, 1996 Jun)

McBeth SB; Thermographic assessment of temporomandibular disorders symptomology during orthodontic treatment. (Am J Orthod Dentofacial Orthop, 1996 May)

Park ES; Comparison of sympathetic skin response and digital infrared thermographic imaging in peripheral neuropathy. (Yonsei Med J, 1994 Dec)

Plaughter G; Skin temperature assessment for neuromusculoskeletal abnormalities of the spinal column. (J Manipulative Physiol Ther, 1992 Jul-Aug)

Seifalian AM; Comparison of laser Doppler perfusion imaging, laser Doppler flowmetry, and thermographic imaging for assessment of blood flow in human skin. (Eur J Vasc Surg, 1994 Jan)

Seppely M; Facial thermography during nasal provocation tests with histamine and allergen. (Allergy, 1993 Jul)

Thomas D; Infrared thermographic imaging, magnetic resonance imaging, CT scan and myelography in low back pain. (Br J Rheumatol, 1990 Aug)

Thomas D; Somatic sympathetic vasomotor changes documented by medical thermographic imaging during acupuncture analgesia. (Clin Rheumatol, 1992 Mar)

Verdugo RJ; Use and misuse of conventional electrodiagnosis, quantitative sensory testing, thermography, and nerve blocks in the evaluation of painful neuropathic syndromes. (Muscle Nerve, 1993 Oct)

Weinstein SA; Facial thermography, basis, protocol, and clinical value. (Cranio, 1991 Jul)

Weinstein SA; Thermophysiological anthropometry of the face in Homo sapiens. (Cranio, 1990 Jul)

Winsor D; Comparison of various noninvasive techniques for evaluating deep venous thrombosis. (Angiology, 1991 Oct)

Yang WJ; Literature survey on biomedical applications of thermography. (Biomed Mater Eng, 1992 Spring)

Zhang D; Clinical observations on acupuncture treatment of peripheral facial paralysis aided by infrared thermography-- a preliminary report. (J Tradit Chin Med, 1991 Jun)

Zhang D; Research on the acupuncture principles and meridian phenomena by means of infrared thermography. (Chen Tzu Yen Chiu, 1990)

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