The Detection and Deterrence Value of Mass Thermal Screening during the COVID-19 Pandemic

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ABSTRACT

This article critiques the role of mass screening thermal imaging systems (MSTIS) during the COVID-19 pandemic, questioning whether such systems were sold for the purpose of restoring consumer and staff confidence at business premises rather than truly limiting the spread of the virus. It concludes that the value of MSTIS in detection and deterrence is flawed and could in fact contribute to wider contagion.
While the strengths and weaknesses of artificial intelligence is widely documented, no study before has understood its role from a security in depth perspective, specifically exploring how both detection and deterrence play mutual roles in health crises. In the case of the MSTIS, mixed messaging from government organisations and scientific studies meant that companies sold thousands of units and, to this day, are able to carry on selling such systems.

These assertions are based on a series of evidence obtained via meta-data analysis. The consequences of companies selling what have proved to be defective systems on the spread of the COVID-19 virus is impossible to measure. The article finds that that 'slow and careful' thermal screening is more effective in detection and deterrence, and their use should therefore be encouraged.

Key words: COVID-19, Thermal, Screening, Security.

INTRODUCTION

In no time since 9/11 has the security and digital industries been more depended upon than during the COVID-19 pandemic. In over a year, various technology-led solutions have been deployed to enable governments to control the pandemic, including quarantine enforcement, contact tracing, social distancing, and symptom tracking (Kitchin, 2020, p.2). Personal devices were utilised for tracking and tracing the infected; exit and entry screening processes diffused from airports, seaports, to supermarkets and factories; autonomous systems were deployed to surveil people not complying with lockdown measures; and the rush to buy health monitoring systems like thermal scanners was much like the technological equivalent to toilet paper.
Indeed, many governments and businesses looked to the technology sectors to enable tracking, tracing, and detection of the virus. The ability of some companies from the security sector to reinvent themselves as providers in health screening, including biometric information, highlighted to the world of the adaptability, versatility, and acclimatisation of digital technologies for addressing global problems. One such example is the use of hand-held or mounted thermal cameras to screen movements of people in public places and workplaces (Nellis, 2020 in Kitchin, 2020). To enable deterrence and to remove operators from contagion risk, some governments bought thermal cameras mounted on drones to monitor as well as police the breaking of lockdown restrictions (Url, 2020 in Kitchin, 2020). Other governments

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equipped emergency managers with smart helmets which boasted scanning up to 200 peoples' body temperature a minute (Reuters, 2020 in Kitchin, 2020).

Whilst the effectiveness of such systems (especially in detection) demands serious scrutiny, this article specifically focuses on the proliferation of mass screening thermal imaging systems (MSTIS), a system which has largely been accused of being ineffective at detecting fevers – a symptom of COVID-19 – by a number of national and intergovernmental organisations. Despite this, MSTIS were widely adopted by many industries as a means to get business functions 'back to normal.' It has been argued that companies pushing MSTIS undercut genuine and more quality-assured systems, potentially contributing to a false sense of safety and thus ultimately putting people at risk.

There are four issues that we grapple with here with respect to the limitations of MSTIS; the first is the fact that the technical abilities of thermal camaras often do not meet the required specifications to effectively screen people 'on mass.' The second issue is that the procedural limitations with respect to screening large numbers of people at a given time, as well as the technical limitations explained before, means that the ineffectiveness of this form of health screening is magnified. Third, 'fever detection' has certain limitations for detecting the virus as many people are asymptomatic and temperature fluctuations can happen in many different environments. All the above issues have been highlighted by national bodies in the UK, USA, Europe, Australia and by the World Health Organisation (WHO), among many others. While the strengths and weaknesses of artificial intelligence is widely documented, MSTIS, however, are still openly marketed by some security companies to this day – over a year into the pandemic at the time of writing.

Even if the effectiveness of such technologies is limited, politicians, policy makers and citizens may consider the use of thermal screening as a supplementary tool to combat the spread of the virus (Kitchin, 2020). The rush to roll out such technologies is possibly necessary as 'force multipliers' as a supplementary part of a wider spectrum of measures. Indeed, in criminology and counterterrorism literature, the deterrence factor (fear of getting 'caught') can be equally if not more important than the security measures' ability to detect and enable response, especially if the technologies or procedures in question have weaknesses (Schneier, 2003). Since research has shown that people who experience symptoms are still willing to endanger others by not testing and self-quarantining (Technical Advisory Group, 2021), deterrence thus plays an extremely important role in health crises.

Expanded, as previously noted, the element of deterrence – including threats of fines, compulsory testing, and surveillance – played a role during the COVID-19 pandemic. However, while the element of deterrence has been documented in security literature and security crises, it has not been fully understood in the context of health crises. The deterrence value in health crises demand much more discussion than what current academia – mostly from security studies, not health science disciplines – give time and energy for. The article therefore asks: Even if ineffective, do thermal imaging systems provide a deterrence value that goes beyond its actual effectiveness? The article hereafter scrutinised both 'slow and careful' and rapid thermal screening.

The article first provides a brief history of thermal technology and the present market landscape. Drawing on Bruce Schneier's theory of 'security theatre,' it then explores the 'allure' and 'security spectacle' attached to modern digital technologies and how this resonates with the development and distribution of MSTIS. In particular, it draws on how sensor fusion – the idea of combining different sensors to reduce uncertainty – appeals particularly to the 'cost-benefit' sales pitch, potentially overriding the needs for safety and security to the betterment of efficiency, productivity, and customer reassurance. It then draws on the concerns expressed by national and intergovernmental organisations, as well as previous scientific research, that has contested the viability of mass fever screening. It discusses the parallels of the importance of deterrence and detection in both security and health crises. Its overriding conclusion is that, at least from a 'security' trade-off perspective, MSTIS neither contribute substantially to detection and deterrence.

BRIEF HISTORY OF THERMAL TECHNOLOGY

Infrared cameras detect the infrared energy emitted, transmitted or reflected via infrared spectroscopy frequencies at temperatures above zero and 'converts the energy factor into a temperature reading or thermogram' (Omega, 2021). The sensor array is constructed as a grid of pixels which react to the infrared wavelengths and then converts them into electronic signals. The processor picks up the signals and, using algorithms, converts them into colours expressing different temperature values (RS, 2021).

Thermal technology traces its roots back to the 1800s, but has subsequently been used in many civilian (1965 – present) and military applications (1920s – present) throughout the decades. It was the development of handheld units in the 1980s and 90s, however, that made thermal imaging systems far more versatile, user-friendly and did not require active cooling to work (RS, 2021). These were, however, expensive and only became 'financially viable option for most civil uses until the early 2000s, which saw dramatic reductions in the production costs of uncooled arrays' (Ibid). The lower costs led to an increase in popularity of thermal cameras in various sectors, including, but not limited to, emergency response, architecture analysis, medical diagnostics, environmental control, and many others (Marlowe Fire and Security, 2021). Thermal cameras were also becoming increasingly easier to use as smart sensors, microcircuitry and WiFi connectivity became more widely available (RS, 2021). This made thermal cameras more portable, less bulky, lighter, and thus making installation and use possible in a variety of different locations. Regardless of these technological advances, important considerations for effective use include elements such as field of view (including target size and distance), surface being measured (emissivity considerations), atmospheric and environmental effects, response time, signal processing and other elements (Omega, 2021).

Thermal imaging technology has proved particularly useful for health monitoring where body temperature fluctuations are a known symptom. As a non-contact temperature measurement device, it is arguably safer for operators to use than other temperature measurement devices that require physical contact. Indeed, its first widespread civilian use began in airports, seaports, and border crossings around the world in 2003, particularly in East Asia during the SARS epidemic (Nellis, 2020). Some governments resorted to using more advanced military-grade thermal imaging technologies than those commercially available during this time (Hochreutiner, 2020). Other crises like the EBOLA outbreak in West Africa in the early 2010s saw the continuation of this niche market.

THE COVID 19 PANDEMIC AND THE IMPORTANCE OF PERFORMANCE

While the SARS and EBOLA outbreaks were almost exclusively confined to continental regions, the COVID-19 pandemic has hit almost everywhere on the globe. Consequentially, the demand for thermal-imaging equipment has grown exponentially, due mostly to increasing adoption at airports (Research and Markets, 2020). Leading specialist companies registered up to 700% increase in demand (Hall, 2020), and 'non-traditional' sectors, like restaurants, factories, railway stations, retailers, and various other businesses, desperate to get their businesses functioning during exceptionally low footfalls and social distancing challenges, have invested in thermal imaging cameras.

Despite their popularity, and despite their use during other crises, thermal cameras had not been approved as a medical device by some health sectors. Nevertheless, at the early stages of the COVID-19 pandemic, it was encouraged by national government bodies (for example the U.S.-based Centers for Disease Control and Prevention and the Food and Drug Administration) to use these devices where suitable, including in traditional and non-traditional sectors, many of which were 'high-risk' areas. Deemed better than self-reporting, other national bodies relaxed regulations on infrared cameras to widen access to the technology and allowed employers to screen workers and visitors with limited ethical barriers, such as right to privacy. Some independent organisations, like Big Brother Watch (2020), argued that this was an excuse to widen surveillance practices at workplaces.

However, the method of scanning and the quality of the equipment, was one important detail that companies and consumers must have to consider. Some advanced, if quite expensive, systems were better able to detect symptoms, such as those with high pixel rate. Thermal scanners were also more effective if the person being scanned was standing in front of the camera for period of time, with headwear off (hats, sunglasses etc (Food and Drug Administration (FDA, 2021)), and ideally having not just arrived from areas with contrasting temperatures. The most accurate temperature can be made by focusing on the eye ducts of the face whilst the person being scanned is standing still.

With notable advances in artificial intelligence (AI), some companies have sought to speed up this process. While AI has known advantages in certain systems and in different sectors, for thermal screening, it has been argued that using such systems for accurate mass screening would require >12 megapixels, 'which does not exist today' (Field, 2020). According the FDA, the most accurate way of measuring the tear duct requires a minimum of 3 X 3 pixels to 5 X 5 pixels, but this must be used in front of the person being scanned (FDA, 2021). The recommended distance is important, as moving the camera from 0.5 meter to 6.0 meter away from the subject will result in a temperature drop of about 2 degrees Celsius, which could lead to a greater than 50% uncertainty (Tarin, 2021). Without using the camera positioned the correct ways, as other sections of the head and face typically provide lower temperature readings (Ace, Honovich, and Rollet, 2020). Above all, there have been no previous large-scale independent clinical trials to assess the accuracy mass screening systems at different sites (Pike, 2020; European Commission, 2019; Mouchtouri et al, 2019; ECRI, 2020; Glaser, 2020; Simonite, 2020).

On top of false positives, false negatives are increased due to the fact that most people with COVID-19 are asymptomatic or only have mild symptoms that would not show any anomalies. Anomalies are also difficult to accurately detect in large groups of people (Hall, 2020). Other factors that contribute to the problem (false positives, false negatives) are issues that might lower or elevate temperature. This includes physiological stress, sweating, not using a reference black body for calibration, using the wrong camera, and subject motion (Tarin, 2021). There is also a 'very real risk of involuntary quarantines and/or harassment' (Guariglia and Quintin, 2020; Big Brother Watch, 2020). In one study using thermal systems at airports, people flagged by systems were found to have mild illnesses, such as colds or the flu (Reader, 2020)

While the effectiveness of thermal cameras picking up elevated temperature using the 'slow and careful' approach has been widely documented (detection), the deterrence, overtness or 'performative' value (queuing, standing in front of camera and an operator) is also intuitively beneficial. On the contrary, the 'performative' value of MSTIS is arguably less effective since the subjects are not standing still in front of the cameras, and because the cameras are less intrusive, even covertly used by inattentive, unmanned, or out-of-sight operators from various distances.

Therefore, the question is, how could such a fallible fusion be justified during a global pandemic? To what extent does economics play in this unique exchange between demand and solution? To what extent does the promises of digitalism influence rational choices when the balance between the economy and business continuity collides with the general safety of citizens? While the trade-offs for businesses using such systems is obvious, these trade-offs are out of step with well-known security paradigms, that the risks and fallibilities of such measures must match with or be outweighed by the rewards (Scheier, 2003).

THE COST-BENEFIT PITCH FOR MSTIS AND THE 'REASSURANCE MECHANISM'

The cost-benefits of MSTIS during a pandemic of highly contagious virus from a business perspective are manifold even if the health screening benefits are superficial.
From a business perspective, the first point is the issue of efficiency, that handheld thermometers could be cheaper and work in certain locations, for example where there are streams of people arriving at one entrance (Harwell, 2020). The 'rapid' approach means people do not have to stop (Simonite, 2020). It was also argued that automating the work will reduce staff needs and can be done at any time of the day from multiple locations from a central command centre (Hochreutiner, 2020), with silent alarms and colour alarms when fever was detected (Marlowe Fire and Security, 2021).

Another promise of automation is reduced chances of human error by avoiding detection lapses resulting from inattention (Ibid). The speed of detection 'means people have no reason to adapt their behaviour as they enter a facility' (Sims, 2020). Other selling points for some mass screening systems was that they were 'easy and quick to install' (Sims, 2020), and that they could store data (or 'evidence') (Marlowe Fire and Security, 2021). Finally, due to heightened screening measures, airports and other businesses experienced issues with long queues. Queuing could be counterproductive for limiting the spread of the virus, but similarly detrimental for ordinary corporate functions. Other, product-specific claims, almost exclusively from sectors not traditionally involved in health screening technologies, and which are highly dubious based on previous and present research data, are expanded below.
Athena Security (specialises in gunshot detection) and Feevr (owned by X.Labs – weapons company that specialises in weapons detection) argued that their Fever detection systems 'could help make the difference between a safe workplace and a dangerous outbreak' (Glaser, 2020).

Dahua (from fire sector) reportedly claimed that its systems which are normally used for fire detection, electrical substations, and border crossings can detect fevers with ‘pinpoint accuracy’ (Ace, Honovich, and Rollet, 2020). Despite the distance between a person standing in front of a camera being very important for an accurate reading of temperature, drone company Draganfly fitted their drones with questionable thermal technology, and reportedly sold thousands of units (Gershgorn, 2020).

Other companies not traditionally from health screening sectors promised different capabilities for mass screening. Three companies Zyter, Verizon, and Hope Wish Photoelectronics Technology Co stated that their cameras could detect ‘temperatures of up to six individuals from 20 feet away as they walk into a stadium’ (Biddle, 2021). Telecommunications company Vodaphone UK argued that its newly launched Heat Detection Camera could accurately detect (within +/- 0.3 degrees) the temperatures of ‘100 people per minute’ (Hall, 2020). Security contractors Corps Security stated that their camera could scan up to 16 faces per second (Sims, 2020). Energy company Clearway argued that its mass screener could monitor the temperature of 30 individuals ‘where there was a constant flow of people’ (Clearway, 2020). Other companies, such as Arup Group, made no specific references to how many people could be scanned per second or minute with their systems, but claimed ‘precise’ forehead measurements ‘for individuals wearing any kinds of headgear’ (Chen, 2020).

The issue with MSTIS has not gone without debate during the global pandemic. As stated by one specialist: “What is the intended purpose of temperature scanning?” “Are you just deploying this gear for ‘feel good’ needs, or are you truly looking to measure and eliminate feverish people?” (Field, 2020). Some might question whether the feeling of public confidence and the economic gains override the safety of society – *the lesser of two evils*, i.e. that people will suffer harder and longer if businesses go bankrupt, so (dis)proportional risk is justified.
But what if proportional risk is implemented deceptively? The feeling of reassurance on the consumer side may be erroneously over-trustful of companies, including airports, to ensure their own safety. A poll at the early stages of the pandemic in the United States found that 84 percent of respondents favoured mandatory health screenings to enter public places (The Harris Poll, 2020), which demonstrates that passengers believed that such measures were appropriate and proportionate. Indeed, in light of Schneier’s theory of ‘Security Theatre,’ the visible, scientific-looking demonstration that safety is taken seriously can be misleading for consumers but cost-effective – even reputation-enhancing – for companies using them (Schneier, 2003). “You can deploy and tell people that you are doing the right thing by measuring their temperature. They won’t know if it’s true or not, of course, but they may feel better about going to your facility” (Field, 2020).

Evidence suggests that this ‘reassurance mechanism’ works, and in indeed many businesses employed the ‘slow and careful’ approach to fever screening (involving queuing, being stopped and scanned, and sometimes filling a questionnaire) with advanced systems. But MSTIS do not provide this ‘theatre’ or ‘performance,’ as those being in some cases covertly scanned by unmanned systems are not making the same calculations about whether they will get ‘caught.’ Indeed, some companies selling ‘slow and careful’ systems pointed to the psychological deterrent (see for example: Forziati, 2021), but the author has not found the same benefits expressed by companies selling mass screening technologies.
Deterrence is important for those with known symptoms. A Technical Advisory Group for the Welsh government, for example, found that 21% of people in their study would get on a plane despite having coronavirus symptoms. Considering that there was evidence one infected person on a flight could transmit the disease to other passengers throughout the plane (Technical

Advisory Group, 2021), it is therefore very important for this sector use all means necessary to stem the spread.

Despite the reassurance it brings, and the deterrence factor, the principle issue with the widespread use of thermal cameras for the purpose of surveillance of the COVID-19 pandemic is that there have been no independent tests to verify their suitability (Ace, Honovich, and Rollet, 2020). Some argue that this 'has allowed manufacturers to tout products meant for body/fire detection as a fever solution, or falsely claim pinpoint accuracy at long distances' (Ibid). Thus, not only was the lack of verification and oversight exploited as a loophole; it is the versatility and malleability of a technology – thermal imaging in this case – that makes entrepreneurial practices more agile, rapid, and potentially exploitative.

MIXED MESSAGING FROM GOVERNMENTAL ORGANISATIONS

Mixed messaging from various organisations has, however, exacerbated the issue. Before the pandemic, the WHO recommended airports to use health screening (if used appropriately), then they changed their mind (Hall, 2020; Field, 2020), cautioning that fever monitoring en mass was not scientifically possible with the available technologies of today. Nevertheless, there were further mixed messages (the ISO and FDA) from governmental and intergovernmental organisations, whilst other organisation expressed scepticism (European Aviation Safety Agency, and the UK Government) (Pike, 2020; Simonite, 2020).
The UK government stressed that those who sell thermal imagining systems which directly relate to COVID-19 diagnosis will be subject to enforcement action. 'Products which the manufacturer claims are intended for screening for COVID-19, or fever-like symptoms, would be regarded as medical devices and regulated by the [Medicines and Healthcare products Regulatory Agency]' (U.K. Government, 2020). The government's Scientific Advisory Group for Emergencies also advised that there should be no requirement for temperature screening before passengers fly to enter, depart from, or fly within the country (Goodwin and Alvarez, 2020). Similarly, the European Aviation Safety Agency found that between 1% and 20% of passengers with a fever will be missed by thermal screening equipment (Ibid). The European Centre for Disease Prevention and Control also found that thermal scans of travellers, followed by additional screening including questions about symptoms like coughing and difficulty breathing, failed to identify up to 75% of those infected (Pressman, 2020).

The consequences of companies selling defective systems on the spread of the COVID-19 virus is impossible to measure. There is no data indicating which sectors bought what systems ('slow and careful' systems *or* mass screening systems), but generalist information points to airports (Goodwin and Alvarez, 2020) and places with high footfalls, many places – likely indoor places – where contagion is most likely.

Discussion

The COVID-19 pandemic created many hybrid situations in which security paradigms fuse with health, safety, and economic considerations. Indeed, there have been numerous calls for interdisciplinarity in health sciences (Kivits, Ricci, and Minary, 2019), and whilst cyber security and critical theoretical studies (privacy, surveillance capitalism) have long marriages with health disciplines, other traditional 'applied' security perspectives approaches have not been considered in questions about such trade-offs.

There are odd parallels between the COVID-19 pandemic and the shocking terrorism events of September 11, 2001. A sudden crisis demanded rapid technological solutions at various ports, a crisis that put significant economic strain on certain sectors, and still inconveniences consumers to this day. Some solutions, such as computer-based systems, were overly complex or technologically flawed, but may have been effective as a deterrence if only used as a 'security demonstration' (Schneier, 2003). The successes and failures of temperature screening during the SARS epidemic could have drawn similar lines between 'falling back on what you know' (Ibid, p.111), or trying new complex systems without sufficient evidence about their effectiveness. Even with known flaws, the deterrence trade-off of MSTIS does not provide an equilibrium of safety.

There are many other issues with MSTIS that are not explored here. Indeed, deterrence is not the only issue with MSTIS; the issue of AI may actually make response to high temperature readings much more difficult and complex. Schneier writes that '[d]etection is useless without response' (2003, 167). MSTIS monitoring numerous people is flawed if operators are overwhelmed. If a probability of 1 in 5 people with symptoms in a population of high infection rates are walking past cameras in their hundreds, how can there be an effective response?
Schneier also argues that most security decisions are complicated and involve multiple players with their own subjective assessments of security. Most of these players have different agendas and power relationships which often have 'nothing to do with security.' 'The question isn't which system provides the optimal security trade-off – rather, it's which system provides the optimal security trade-off for which players' (2003, p. 33). With such logic, deconstructing the agendas of all parties involved in the process of temperature screening at businesses with high footfalls, we can conclude that profit, a (misguided) sense of moral duty, the staff, and the consumer, all have roles to play in these trade-offs. Hijacking a plane will have serious consequences for all involved, but given the asymptomatic issues with the COVID-19 virus, no one is responsible when a system fails in detection, deterrence, and response.

CONCLUSIONS

Fundamentally, whilst the ambition to provide a cost-effective system to businesses struggling with the global pandemic might be well intentioned, operating in a world of 'open societies' where allowing some personal freedoms (in the West) demands technological solutions (Kitchin, 2020), from the evidence it seems that non-specialist companies are acting exploitatively by targeting industries, perhaps ignorant of specification requirements of thermal imaging systems, that are desperately looking for ways to save their business, and in turn, save jobs and livelihoods. Whilst their effectiveness has been vehemently contested by governmental organisations and industry leaders, MSTIS are still openly marketed today.
The discussion here does not necessary add anything particularly substantive to ongoing criticisms of AI and big data. Indeed, it has consistently been argued that 'voluminous streams of real-time data […] are often noisy and messy, with gaps, errors, biases, and inconsistencies that prompt questions of veracity (accuracy and precision) and reliability (consistency over time)' (Kitchin, 2014). But where deterrence and detection values are low, it leads us to question how mass screening thermal technologies contribute to 'security theatre' that supposedly works in other areas such as counter-crime and counterterrorism. The article finds that whilst more effective 'slow and careful' thermal screening could deter people who think they might have symptoms of COVID-19 from entering a business premises,

mass screening does not. This means that mass temperature checks are both ineffective in both detection and deterrence, ultimately contributing to the spread of infections and the relinquishing of responsibility.

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