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Perspective

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Could bio-detection dogs be used to limit the spread of COVID-19 by travellers?

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The coronavirus disease-2019 (COVID-19) crisis has not only deeply affected those with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections, and their families, but it has also had an unprecedented global economic impact. The travel and tourism sectors have been particularly hard hit, with aircrafts grounded, hotels closed and travel restrictions and quarantines introduced around the world. The United Nations' World Tourism Organization predicts there will be declines of 58–78% in international tourist arrivals this year.[1]

There are increasing numbers of COVID-19 cases in many countries, including Australia, Brazil, France, Spain and Japan. Whilst some of the apparent surge may be a result of increased testing, there is a concern of a second wave. In the Spanish flu pandemic of 1918, which killed 50–100 million people, it was the second wave that produced the greatest number of deaths.[2]

As a defence against a second wave of COVID-19, it is critically important that measures are put in place to prevent the importation of new cases from countries with a high incidence of COVID-19. Some countries, like the United Kingdom (UK), require inbound travellers to self-isolate when they arrive from such countries or territories. For example, currently, travellers returning to the UK from Spain, which generates almost 12% of its gross domestic product from tourism and is the most popular destination in the world for British tourists, are subject to compulsory self-isolation for 14 days, alongside any travellers showing signs of COVID-19. Other countries have a stricter quarantine, with travellers being required to self-isolate in specific quarantine centres, and others have closed their borders to arrivals.

Screening travellers for COVID-19 at airports is an attractive option that could prevent imported infections, and may reduce the need to enforce quarantine on travellers. Infrared thermal image scanners have been used previously during epidemics, but modelling studies indicate that, even under best-case assumptions, thermal screening will miss more than half of infected people.[3] Many cases are fundamentally undetectable through these scanners because infected individuals may be presymptomatic or do not have a fever at the time of scanning. There remains a need for a sensitive, rapid, non-invasive means of screening large numbers of asymptomatic people, both at departure and on arrival into ports. Previous work with bio-detection dogs suggests that highly trained dogs may offer a viable solution to COVID-19 detection.

Detection of Disease-Associated Odours by Dogs

There is evidence that respiratory infections cause the release of specific odours. The analysis of volatiles liberated in breath, urine, faeces and sweat has shown that microbial infections are associated with the production of specific volatile organic compounds (VOCs), and that the ratio of these VOCs differs depending on the infectious microorganisms.[4] This area of

research has led to interest in using volatiles as biomarkers of infectious diseases such as cholera.

Other, more recent work by the authors, demonstrated that asymptomatic malaria infection also causes changes in VOCs, which vary throughout the infection.[5] Further work by the same team demonstrated the use of trained dogs in identifying malaria parasites in asymptomatic children.[6] The dogs were trained using odour samples collected on socks worn by confirmed positive asymptomatic or negative children in The Gambia. The dogs were then trained to distinguish between the odours of socks worn by infected and uninfected children. Once training was completed, a second set of specimens was used in a double blinded study to determine the specificity and sensitivity of detection. The study demonstrated that dogs could identify malaria with a degree of sensitivity and specificity broadly in line with the World Health Organization's criteria for the procurement of rapid diagnostic tests.[6] The findings of this research are highly relevant for COVID-19 detection, since a high proportion of COVID-19 cases are thought to be asymptomatic or present with mild symptoms. Further, it is likely that some SARS-CoV-2 infections are transmitted by asymptomatic infected individuals, and the lack of symptoms may render them undetectable by other screening measures.

Previous research on the odours accompanying viral infections has provided evidence that distinct VOCs are produced by infections with different viruses. For example, patterns of VOCs produced in response to infection in B lymphoblastoid cells were found to be unique for H9N2, H6N2 and H1N1 viruses.[7] There is also evidence that dogs can detect and learn the smell of virus-associated volatiles in real time, with sensitivities of ~96% and specificity of ~98%.[8]

Could Trained Dogs Be Used for the Detection of COVID-19?

Dogs have extremely sensitive olfactory systems, capable of detecting concentrations as low as 1.5 parts per trillion, and there is growing interest in their use for medical purposes. Several studies have now shown that medical detection dogs can be trained to detect different cancers and bacterial infections. The SARS-CoV-2 pandemic has encouraged several groups to investigate the use of detection dogs in identifying COVID-19 through changes in body odour. In Germany, preliminary findings indicate that trained detection dogs were able to discriminate between samples of SARS-CoV-2 infected and non-infected individuals with an average diagnostic sensitivity of 83%.[9]

With a view to a more practical future application, a team in France trained detection dogs in the identification of COVID-19 positive individuals from axillary sweat. Although the number of samples used was relatively small, the authors concluded that there is a very high degree of evidence that the armpit sweat odour of COVID-19 positive individuals is different from that of SARS-CoV-2 uninfected individuals, and that dogs can successfully detect infection through these differences.[10]

Whilst these results are encouraging, there are significant limitations with these studies. For example, only seven participants were recruited in the German study and there was a lack of relevant SARS-CoV-2 uninfected individuals to control for confounding factors. It is possible that with such a small number of independent samples the dogs remember the odour of the individuals rather than a distinct odour associated with SARS-CoV-2 infection. It should also be noted that the study required the donation of saliva samples and tracheobronchial secretion samples, and that the positive group was comprised of individuals showing clinical symptoms, which would limit the application of this proof-of-concept study to clinical settings. The limitations of both these studies highlight the need for a scientific study with a robust design and sufficient sample size to evaluate the diagnostic sensitivity and specificity of COVID detection dogs in reliably identifying asymptomatic carriers of SARS-CoV-2.

In March this year, we commenced a prospective three-phase study in the UK involving collection of body and breath odour samples from >300 asymptomatic and mildly symptomatic participants. Phase 1 is a proof-of-principle study to demonstrate that medical detection dogs can be trained to identify asymptomatic or mild symptomatic infections with SARS-CoV-2 with high sensitivity and specificity. Phase 2 is an assessment of the capability of the trained dogs to detect people with asymptomatic or mildly symptomatic SARS-CoV-2 infection. This important step will move the research team closer to deployment of dogs, and will require the sensitivity and specificity of the dogs to be assessed at COVID-19 test centres where they can sniff individuals waiting to donate swab samples for formal diagnosis. Phase 3 will deploy trained dogs at UK ports of entry to screen travellers for SARS-CoV-2 infection. Further complementary work is being done to identify which VOCs are associated with an infection with SARS-CoV-2, which may lead to the development of sensors for detection of people with a COVID-19.

If bio-detection dogs prove to be effective in the detection of asymptomatic or mildly symptomatic individuals, there is enormous potential for them to be used at key entry points, such as airports and sea ports, to support efforts to screen departing or incoming passengers, which is crucial for ensuring safer, and fully operational, global travel in the future and for any elimination strategies. Each trained dog can screen ~250 people in an hour and they could be stationed before entering the terminal building, at the security checkpoint for outbound passengers and staff, and at border control for inbound passengers. Positive individuals and their contacts could then isolate to prevent the spread of infection to others. This will be of significant benefit to the economy and the control of the pandemic, as it could eliminate the need to keep borders closed or to require the quarantine of all travellers. Dogs could also be used in localized outbreaks, and at other venues where large numbers of people need to be screened rapidly, for example, at train stations, stadiums and workplaces. If we are able to demonstrate that dogs can detect COVID-19 with high accuracy, we propose the development of a preparedness and response platform using pre-trained pathogen detection dogs that could be trained and deployed rapidly during the early stages of an outbreak, and can be operational within weeks. Disease detection dogs could help improve health security at border entry points by reducing the likelihood of re-introduction of SARS-CoV-2, and potentially other viruses, into at-risk countries.

Author Contribution

J.G.L conceptualized the manuscript. All authors contributed to writing the manuscript.

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Conflict of Interest

The authors disclose that they are involved in the UK-based COVID-19 bio-detection study referred to in the article.

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