Contact Tracing in Healthcare Settings during the COVID-19 Pandemic

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Abstract

The COVID-19 pandemic has caused great damages and it will likely linger for long time. Contact tracing in healthcare settings during the COVID-19 pandemic is of special importance because the population there are the most vulnerable to the pandemic. A good contact tracing technology in healthcare settings should be equipped with six features: promptness, simplicity, high precision, integration, minimized privacy concerns, and social fairness. Existing digital technologies can potentially provide elegant solutions for contact tracing in healthcare settings, of which the indoor real-time location system based on Bluetooth Low Energy and artificial intelligence may be a good candidate.

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Abstract:

The COVID-19 pandemic has caused great damages and it will likely linger for long time. Contact tracing in healthcare settings during the COVID-19 pandemic is of special importance because the population there are the most vulnerable to the pandemic. A good contact tracing technology in healthcare settings should be equipped with six features: promptness, simplicity, high precision, integration, minimized privacy concerns, and social fairness. Existing digital technologies can potentially provide elegant solutions for contact tracing in healthcare settings, of which the indoor real-time location system based on Bluetooth Low Energy and artificial intelligence may be a good candidate.

As of mid-July 2020, the COVID-19 pandemic has infected over 11 million people and led to more than half a million deaths worldwide with daily increases in caseloads. Presymptomatic and asymptomatic transmission via airborne respiratory droplets and aerosol allows COVID-19 to spread rapidly and cause loss of lives and significant economic damage.

Despite extensive measures to control the spread of COVID-19, many researchers believe that it will linger for many years.[1] There is no effective treatment for COVID-19 so far, and we may not have one in the near future. Although more than one hundred vaccines are under development, there is no guarantee that a safe and effective vaccine will be available soon. The concept of herd immunity through natural infection has also been called into question, since patients who have recovered from COVID-19 may experience loss of immunity relatively quickly, similar to other known coronaviruses.[2] Indeed, a large-scale study from Spain shows that only 5% of the population has developed antibodies, which suggests that herd immunity to COVID-19 may not be achievable.[3] Worse yet, lack of compliance with social distancing and mask wearing has contributed to a recent surge of COVID-19 in the US. These factors together suggest that the COVID-19 pandemic will remain a threat to the world for years to come and that the main methods of control will be timely testing and self-quarantining of infected individuals.

Healthcare settings are a special concern for COVID-19 spread because these areas simultaneously house a high concentration of COVID-19 infected patients and other populations that are at high risk of death should they contract COVID-19. Although the transmission rate of COVID-19 in healthcare settings has not yet been fully characterized, current estimates suggest that 20% of patient infections and 89% of healthcare worker infections have occurred in hospitals.[4] The U.S. estimated that healthcare workers constitute 5% of the its population but have accounted for 16% of its COVID-19 infections.[5] Healthcare worker infections have a compounding effect because quarantining these workers decreases the healthcare system's capacity. The high rate of asymptomatic infections and the long period of viral shedding create difficult challenges for contact tracing, especially among healthcare providers.[6]

Current manual contact tracing approaches are problematic because of their low precision and long latency in reacting to exposures. Contact tracing also raises privacy concerns, as some people may be unwilling to share personal information about their activities. The tracing process is also tedious and slow. Digital approaches based on underlying communications between smartphones via Bluetooth are more attractive than manual approaches because they are simpler, more precise, and more prompt than manual contact tracing. Such approaches can quickly inform people who may

have been exposed with automatic messages that give instructions for follow-up testing and quarantining once someone tests positive. However, smartphone-based approaches suffer from several drawbacks. Although many efforts have been made to protect privacy, many people are still concerned about their privacy when smartphones are used for contact tracing, which has prevented the massive deployment of this approach. For example, Singapore used such an approach for contact tracing, and it caused a privacy backlash.[7] Additionally, this approach will not work for people who don't own smartphones, who are typically older or lower income and therefore more vulnerable to COVID-19. This potentially creates issues of social inequality.

To effectively deal with these challenges, we propose that healthcare contact tracing approaches should have the following features: 1) *Promptness*. This aspect is critical for reducing the number of exposures originating from a specific infected patient or healthcare worker. Automation and a streamlined response process are essential to achieving promptness. 2) *Simplicity*. Effortless use and management of the system will reduce human errors and costs, and increase the willingness of patients and healthcare workers to adopt it. Key components of simplicity include well-developed user interfaces and unobstructed communication. 3) *High precision*. Common sense and our current understanding of the data suggest that distance and time are the two factors that influence the viral transmission of COVID-19. For an automated contact tracing solution to give actionable data, it must accurately measure these parameters for interactions between individuals. By their nature, these systems also have the potential to evaluate whether subjects have donned facial masks or shields, which may further refine estimates of transmission probability. 4) *Integration*. A good contact tracing system should be integrated with electronic healthcare record systems. Healthcare systems are unique in this regard, since they will typically have access to such data. 5) *Minimized privacy concerns*. Privacy concerns can be major barriers to the adoption of contact tracing techniques, since they lower patients' willingness to get involved. A good contact tracing system in healthcare settings should protect patient or staff privacy and alleviate their concerns about privacy. Possible approaches may include limiting tracing activities to within the hospitals and making system-generated data available to users, without sacrificing privacy. 6) *Social fairness*. It is socially unfair to exclude some patients because they lack access to certain digital technologies. For example, many older and low-income patients may not have access to smartphones.

Although it will be challenging to develop and implement COVID-19 contact tracing systems for healthcare settings that include all of the above features, the current state of technology can provide elegant solutions. A real-time location system (RTLS) based on Bluetooth Low Energy and artificial intelligence[8] is a good candidate. In this approach, sensors are installed in an array throughout the hospital to measure signals transmitted from small Bluetooth tags worn by patients, visitors, and healthcare workers. With the assistance of a deep learning algorithm, this system can automatically determine interpersonal distance and duration of contacts with great accuracy. It also has the potential for integration with the electronic healthcare record and hospital surveillance systems to gather additional information about patients' demographic and medical information and facial mask/shield wearing compliance to more precisely estimate the infection risk and potential severity of a contact. Concerns about privacy can be alleviated by limiting the technology's use in a specific hospital to patients, visitors, and healthcare workers who have consented. It can be offered to every patient and visitor, whether they own a smartphone or not. Such a technology could be a highly precise, prompt, simple, and socially fair approach to contact tracing in healthcare settings that would have minimal privacy concerns.

In summary, the COVID-19 pandemic may linger for a long time, and effective contact tracing technologies are urgently needed for healthcare settings. These technologies should satisfy six requirements: promptness, simplicity, high precision, integration, minimized privacy concerns, and social fairness. We believe that such technologies can be based on RTLS augmented by artificial intelligence.

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