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Can robots help promote testing capacity for SARS-CoV-2?

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Abstract

There is currently increasing interest internationally in deploying robotic applications to SARS-CoV-2 testing, as these can help to reduce risk of transmission of the virus to healthcare staff and patients.

We provide an overview of key recent developments in this area. We argue that, although there is some potential for deploying robots to help with SARS-CoV-2 testing, the potential of patient-facing applications is likely to be limited. This is due to the high costs associated with patient-facing functionality, and risks of potentially adverse impacts on healthcare staff work practices and patient interactions.

In contrast, back-end lab–based robots dealing with sample extraction and amplification, that effectively integrate with established processes, software and interfaces to process samples, are much more likely to result in safety and efficiency gains. Consideration should therefore be given to deploying these at scale.

Introduction

Testing is crucial to identify, curb spread and contain SARS-CoV-2. Testing capacity will therefore need to increase very substantially for the foreseeable future [1]. Robotic testing technologies may help to increase testing capacity and also minimise the risk of nosocomial transmission. There are currently two ways of testing for COVID-19: virological tests and serological tests. Virological methods work with genetic material obtained from nasal and/or throat or saliva swabs and commonly use Reverse Transcription Polymerase Chain Reaction (RT-PCR) technology to covert RNA to DNA. They detect the presence of SARS-CoV-2. Serological tests use saliva, whole blood, serum or plasma to look for antibodies. Various new testing methods that are variants of these two approaches are currently in development [2-6].

However, despite a general recognition that testing for SARS-CoV-2 is a key international priority, there is currently a lack of testing capacity contributing to the inadequate numbers of tests being undertaken [7]. In addition, existing testing procedures can endanger healthcare staff and laboratory technicians (i.e. those who have to handle blood samples and swabs). We here provide an overview of key recent developments in robotic testing for SARS-CoV-2, which can help to reduce exposure to healthcare and technical staff.

Overview of current developments in deploying robots for SARS-CoV-2 testing

Robots for SARS-CoV-2 testing procedures can be either patient-facing (e.g. collecting nasal swabs and thereby reducing exposure of those collecting swabs) or non-patient facing (e.g. liquid handling machines that reduce exposure for laboratory technicians) (see Figure 1).

Figure 1: Types of robots used for SARS-CoV-2 testing procedures

To date, patient-facing testing robots have been mainly experimental, deployed as pilots and in limited settings. Examples include remote-controlled robots taking throat swabs that have been used in parts of China [8], a robotic arm handing out test tubes to drivers in cars for SARS-CoV-2 testing [9], and a 3D-printed robotic arm taking throat swabs developed in Denmark [10]. Such robots are expensive (the Chinese robot costs ~£62,000), can only do a limited number of activities on one sample at a time (and therefore do not greatly increase the overall number of tests carried out). They can also worry patients due to a lack of personal contact [8]. Previous research has further found that patient-facing robotic applications can have unintended consequences resulting from adverse impacts on healthcare professional work practices, and on patient satisfaction [11,12]. For example, frail elderly and isolated patients depend on face-to-face contact as a source of emotional support. Attempts at making these applications more human-like may only partly address this issue, as robots that look too human-like can be perceived as threatening [13,14]. Patient-facing robots may, however, play a role in high-risk settings where infection control needs to be prioritised. They cannot replace face-to-face interactions that are required to provide high quality and safe care for the majority of patients.

Non patient-facing testing robots including liquid handlers, especially those that do not involve contact dispensing, are more promising. These robots can move liquids using magnetic plates, aspirate, dispense or transport liquid samples (sometimes using pipettes), and in some cases interpret biological or chemical events (e.g. detect if a virus is present). This reduces exposure for laboratory technicians who have to have to handle blood samples and swabs, and interface with these machines for sample preparation. Many laboratories already utilise some degree of automation, and this mitigates risks of adverse impact on existing work practices of healthcare staff.

Automated testing robots also have a high throughput and speed to tackle the large volumes of tests required during SARS-CoV-2 and in the "new normal", as they can carry out numerous tests

simultaneously [15]. For example, the Spanish Ministry of Health has recently commissioned four COVID-19 testing robots that will be able to carry out 80,000 tests a day [16]. Similarly, a newly established COVID-19 testing lab at Berkeley's Innovative Genomics Institute (IGI) uses a robotic liquid handler machine that uses pipetting to test up to 3000 cases a day [17]. Another example is a Danish pipetting robot that automates the sample preparation process and was originally used for testing for salmonella before being repurposed to test for SARS-CoV-2 [18].

However, the functionality of these machines varies. Some RT-PCR liquid handlers only help up to extraction and addition of samples for PCR/RT-PCR, whilst others also transfer the material to a thermal cycler where PCR/RT-PCR happens (i.e. extraction, and amplification). Clearly, a closed-loop process (where technicians input a sample and the machine prepares samples and tests) is preferable as it minimises human contact with samples (including testing for multiple viruses).

Another potential issue is the interfacing with existing software and associated communication of results. Some automated testing robots do not allow automatic downloading of results from the robot to the main laboratory computer, which then renders the whole process impractical as the large number of results generated has to be manually entered by technicians. This may also introduce the risk of transcription errors, which may in turn have adverse consequences for patient care [19]. Additional integration software can help to address this issue, but adds to the overall cost (in relation to both acquisition and maintenance) and may require additional programming.

Conclusions

Overall, there is a lack of empirical evidence on patient-facing virological/serological testing robots, and even if there was, these technologies would be unlikely to tackle pressing issues around scaling of testing capability. Testing robots in laboratories, however, have the potential to bring significant rapid benefits at low cost as these technologies can fulfil multiple purposes (e.g. handling other types of liquids). Moreover, they already exist in many laboratories and can therefore be readily repurposed to respond to COVID-19 (although this has to be done by the manufacturer). Most useful are likely to be non patient-facing testing robots that tackle the whole extraction and amplification cycle, as this will eliminate the need for transfer of material for the amplification stage and thereby minimise the risk of unintended consequences.

Where there are established processes (e.g. back-end lab–based robots tackling extraction and amplification) and where these interface effectively with existing software to process the results, these should be scaled up. In parallel, there is a need to stimulate research and innovation initiatives to explore the feasibility of developing a scalable front-end testing robot for high-risk settings (e.g. infectious disease wards).

Conflict of interest: The authors declare no conflict of interest.

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