The effect of automated swab robot: new technology drives new behavior

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ABSTRACT

The world is now faced with a devastating pandemic outbreak coronavirus disease-2019 (COVID-19). The latest coronavirus infected almost all continents and witnessed sharp rises in cases diagnosed. The engineers tend to eliminate the matter and have solutions, one in every utilizing technical innovation. Researchers from Singapore, Taiwan, and Denmark have developed a fully automated robot that may take coronavirus swabs in order for health care professionals don't seem to be exposed to the chance of infection. The objective of this study is to present the potential effects of robotics to help healthcare professionals on getting specimens and testing for COVID-19. These possible consequences include positive and negative outcomes and as a result, the overall impact on the profit or loss to society is far from obvious. The paper discusses two theoretical scenarios, distinguished fundamentally by the different behavioral responses of the automated swab robot and the selection of results in line with policy interventions.

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1. INTRODUCTION

In the 2015 outbreak of Ebola, the United States White House Science and Technology Policy Office distinguished three expansive areas in which robotics could make a great contribution: health care, logistics, and the detection or control of voluntary quarantine compliance [1]. Health care professionals can also be exposed to the virus by direct patient interaction when using their personal protective equipment. According to the World Health Organization (WHO), as of November 2020 the outbreak coronavirus disease-2019 (COVID-19) has spread to 218 countries and territories, of which 251 have been recognized by the United Nations worldwide [2], [3]. This signifies the necessity of research into remote activity for a wide variety of applications involving dexterous utilization.

- Rise of automation caused by coronavirus

The first major implementation of robotics has been in manufacturing applications. Similarly, the war on infectious diseases requires an atmosphere that is uncomfortable for human workers, but suitable for robots [1], [4]-[6]. Remote temperature measurement robots in public areas and ports of entry show the application of modern diagnostic and screening technologies [7]. The coronavirus disease transmits not only through interpersonal contact with the respiratory tract, but also through exposed surfaces. Instead of manual disinfection, requiring the mobilization of the workforce and posing a risk of exposure to cleaners, a stand-alone or disinfection robot can contribute to the remote process of disinfection [1], [8]. Increasing the use and development of automated technology is catalyzing the pandemic. This study has a potential positive and negative effect on the use of technology and information in robotics. It seems perfect as a robot for repetitive work, making it great for swabbing [6].

2. METHODOLOGY

As a tool to examine the effects of automated swab on safer COVID-19 testing, researchers have opted to use the system dynamics method used to evaluate the complex conditions that would emerge from the two theoretical scenarios. The causal loop diagram (CLD) approach method and the Ishikawa diagram describe the primary variables and the causal relationship between them. The ease of seeing the interrelationship of variables is expressed in the causality that is created and the actions that will occur with the application of the scenario. CLDs include variables that are indicated by their names and causal connections, arrows that point from the independent variable to the dependent variable [9].

Figure 1 provides an illustrated CLD for the interaction of different variables in a society that responds to the spread of COVID-19 [10]. The increase in the probability of infection due to human interaction is consistent with an increase in transmission events. It also inhibits the rate of increase in the number of infectious people. The factors established in Ishikawa diagram was based on the conducted open-ended questionnaire survey to a random sample of 100 medical technologists. Figure 2 presents the possible contributing causes (public awareness, human, public outrage, and environment) or interacting variables, listed on the smaller “bones” under various cause categories, resulting in the society’s response to the spread of COVID-19.

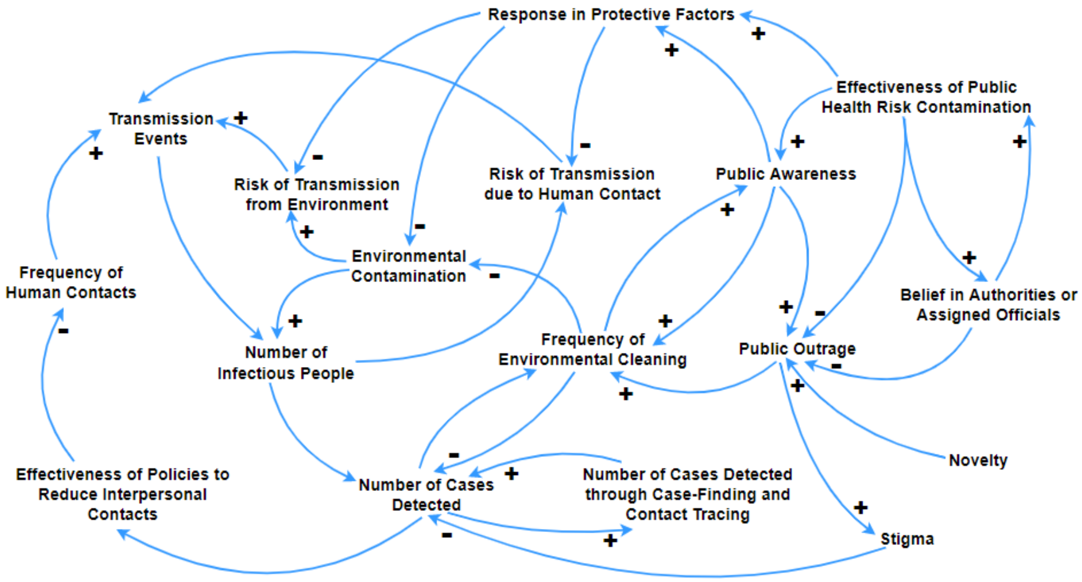


Figure 1. CLD showing the interacting variables in a society corresponding to the spread of COVID-19

2.1. Scenario development

In view of the degree of uncertainty regarding the possible effects of automated swab robot on safer COVID-19 testing, the researchers have chosen to apply scenario-analysis methods. The goal of this approach is to gain valuable perspectives by exploring a number of different futures.

2.1.1. Scenario 1: behavioral responses of automated swab robot

The given scenario presupposes major changes in behavior related to operation and use of automated swab robots. Researchers discover the possible impact of automation technologies on medical applications. Figure 3 illustrates an Ishikawa diagram for a variant of factors related to ‘community and health congestion’ in response to the use of automated swab robots. This new technology serves as a replacement to the conventional swabbing process. Two categories underpin the behavioral responses for the adoption of Automation in safer and more efficient COVID-19 testing. These categories are; a) consumer preference changing to favor automation; and b) increasing familiarity of automation technologies.

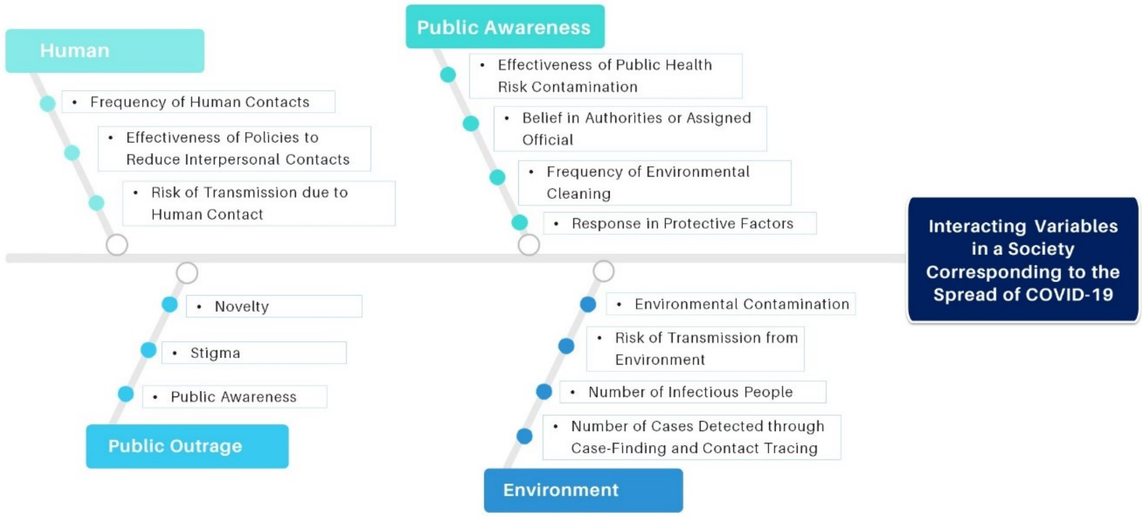


Figure 2. Ishikawa diagram for the society's response in the spread of COVID-19

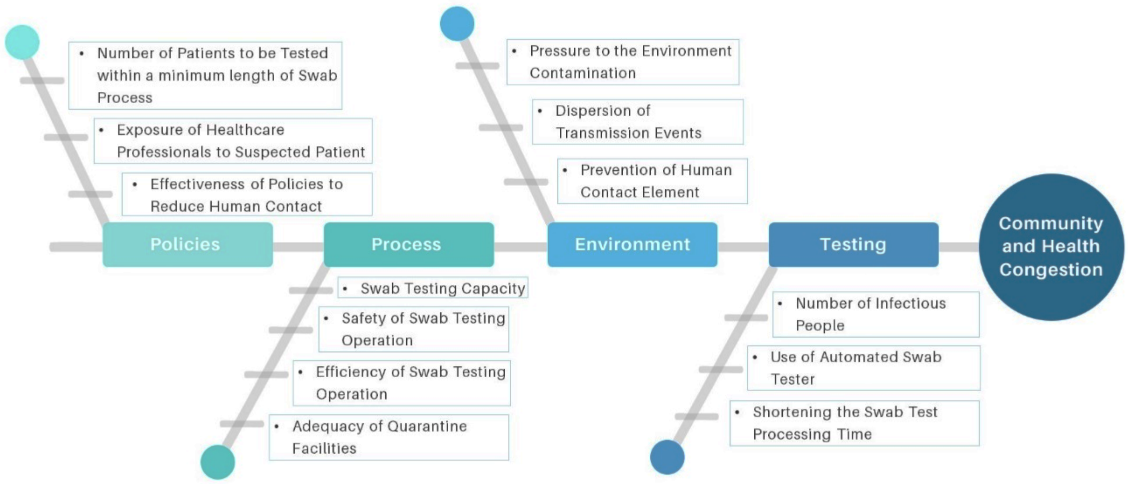


Figure 3. Ishikawa diagram of the behavioral response of using automated swab robot

a) Consumer preferences in favor of automation technologies

As part of the urgent need to respond to the COVID-19 pandemic, governments, health care providers and businesses have looked at the artificial intelligence (AI) applications to compensate for human workers' unavailability [11]-[13]. Human element meanings of people will begin to alter consumer desires and see emerging technology as helping them to protect their health and enhance their well-being. These positive events show automation developments in a new light on the medical sector as helping assistants rather than intimidating overlords.

b) Increasing familiarity of automation technologies

By removing repetitive manual labor from these research practices, physicians, and health specialists could fully-concentrate on patient care and critical medical decisions. Creating and introducing new technology to speed up research and to report results rapidly, while at the same time protecting patients' privacy [14], [15]. This illustrates the familiarity and change to automation technology in the battle against COVID-19.

2.1.2. Scenario 2: Selection of Effects in accordance to manual swab test policy and automated swab procedure

Without good policies and standardized processes, it will be difficult to direct research and innovation programs. However, policies and procedures must be adopted and enforced in order to have the desired result. The policies released by WHO are intended for healthcare providers who are collecting specimens subject to testing for COVID-19 [16]. Automated swab test retains the same gentle touch and precision as healthcare specialists who perform very delicate procedures, said Dr. Luke Tay, one of the project's team members [17].

a) Manual swab test policy

Testing policy is the general concept that a medical practitioner should obey the exams. The initial diagnostic tests for COVID-19 are based on the Provisional Guidelines provided by the WHO for the Middle East respiratory syndrome coronavirus (MERS-CoV) laboratory testing in which countries suggest the collection and testing of nasopharyngeal and oropharyngeal swabs. The decision to test should support clinical and epidemiological factors (refer to Figure 4), and there are a handful of rules listed [16].

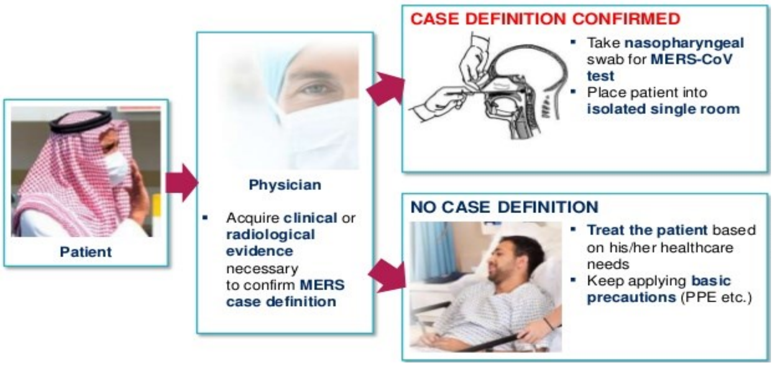


Figure 4. Assessing the patient conditions prior MERS-CoV testing

b) MERS-CoV testing policy

Before collecting and handling specimens for MERS-CoV, determine whether the person meets the current definition for a "person under investigation" (PUI) for MERS-CoV infection. Points to consider when determining which specimen types to collect from a PUI include; i) the number of days between specimen collection and symptom onset, and ii) symptoms at the time of specimen collection. Additional points to consider after indications for testing are shown in Figure 5 [16].

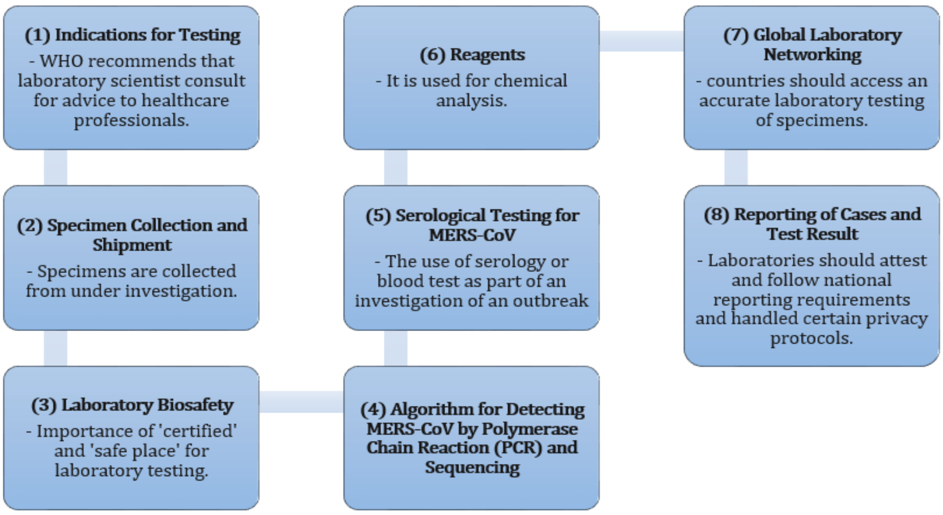


Figure 5. Manual Swab Testing Policy based on Interim Guidance issued by WHO

c) Automated swab test procedure

- Automated ‘throat swab’ robot procedure

The team of ten researchers at the University of Denmark, Europe, has developed a fully automated oropharyngeal swab robot (Figure 6) capable of performing COVID-19 throat swabs [18], [19]. Figure 7 shows the process on how the patient and the robot gather the specimen for testing. The person who will be tested will approach the robot then opens their mouth to accumulate specimens from their throat. The robotic arm has an attachment of cotton swab to take the specimen from the person that is being tested and then it will be placed in a safe container. After getting the sample, a medical technologist will examine the specimen to assess the patient if positive or negative from the virus [18].

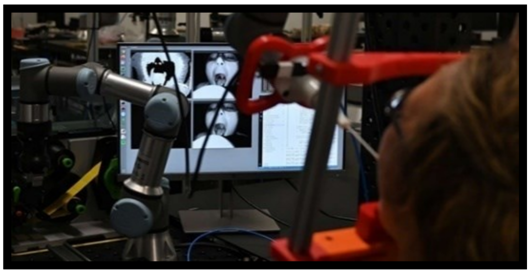


Figure 6. Throat swabbing actual operation of Denmark’s automated swab robot

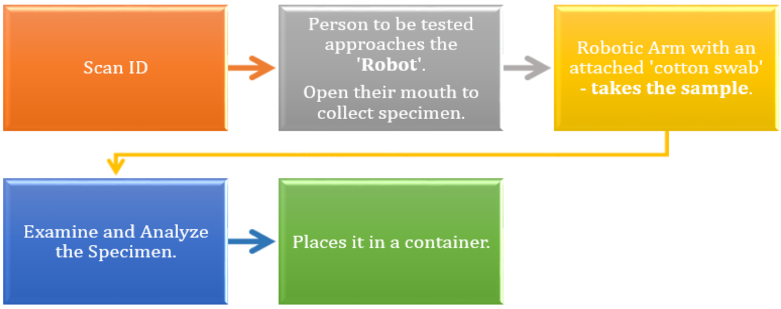
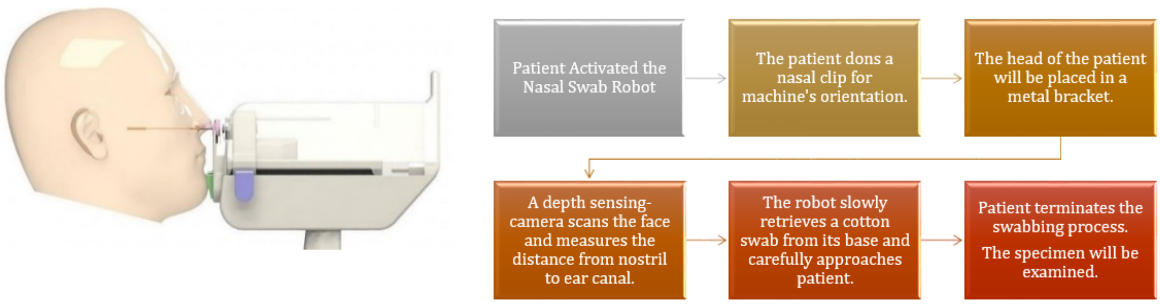


Figure 7. Procedures followed by “automated throat swab robot”

- Automated ‘Nasal Swab” robot procedure

The nasopharyngeal or nasal swab testing is another method of collecting the specimen and offers highest yield for laboratory analysis. Biobot Surgical Pte Ltd has partnered with a group of clinicians from Singapore NCCS-SGH and Duke-NUS MedSchool to set up a robot to automate the nasal swabbing required in diagnosing COVID-19 [20]-[21]. An automated nasal swab robot, known as the "SwabBot," as shown in Figure 8(a) and 8(b), is a self-managed robot that enables individuals to initiate and terminate the swab process.



(a) (b)

Figure 8. These figures are; (a) first-fully patient controlled ‘nasal swab robot’ and (b) nasal swab robot–swabbing procedure

The robotic swabbing process is said to have been completed in just 20 seconds from start to finish [20]. In order to protect the patient, the robot has an integrated feature that withdraws the swab stick if there is resistance as it goes deeper into the nasal cavity. In the improbable event that the individual can't endure the operation, they can terminate the operation by turning their heads away from the robot [20]-[22].

3. RESULTS AND DISCUSSION

3.1. Modeling simulation

The world is capable of adapting and developing certain circumstances and technologies. One of the greatest achievements and inventions that man created is technology. Robotics could be a big step towards advancement, and very helpful particularly in the field of medical technology. Amidst this pandemic, robotics and automation are some solutions to protect the welfare of people and eradicate the virus. One invention that is very capable to perform the task of medical personnel and at the same time protects the person and the patient when testing for COVID-19 is the "*automated swab robot*". Every research there will always be positive and negative effects.

3.1.1. Positive effect of automated swab robot

We are living in a world where technology and automation are starting to develop, and some of them are implemented. Medical automation will revolutionize the way we experience medical care [23], [24]. The study present solutions on how to use the technology and knowledge on robotics to help medical personnel on collecting specimen and testing for COVID-19 shows in Figure 9.

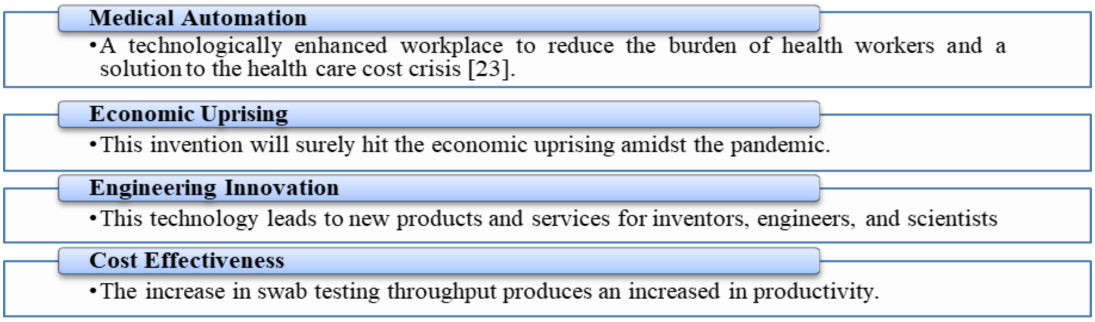


Figure 9. Steps of technology and knowledge on robotics to help medical personnel on collecting specimen and testing for COVID-19

3.1.2. Negative effect of automated swab robot

The researchers find robust negative effects of robots on employment. Other cons associated with medical robots are that of higher costs. There are hospitals doing feasibility studies to determine whether the huge expense is worthwhile [22]. Here are the following negative effects in which opinions are still divided shows in Figure 10.

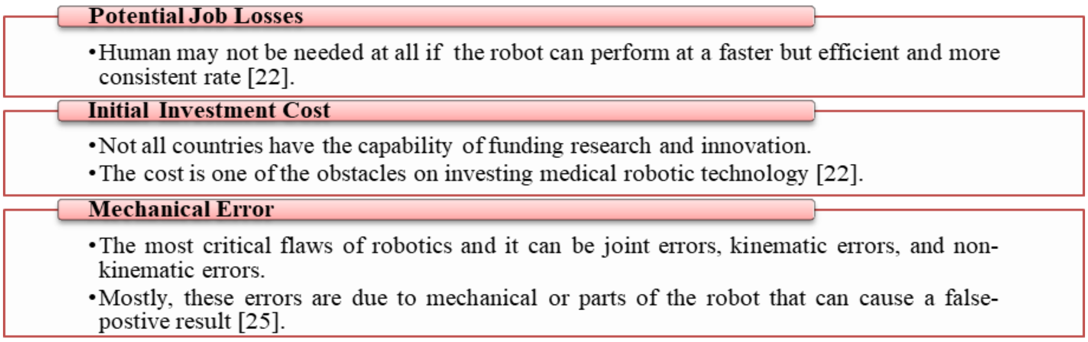


Figure 10. Steps negative effects in which opinions are still divided

The real-time reverse-transcriptase polymerase chain reaction (RT-PCR) tests have established a defined standard for the detection of COVID-19 in clinical practice [16], [25]. Technical problems being encountered including contamination during sampling (e.g. accidental contact with contaminated gloves or surfaces), contamination with PCR amplifiers, contamination with reagents, cross-contamination of samples and cross-reaction with other viruses or genetic material may also lead to false-positive results [25].

False negative is a test result that is incorrect, since it means that a person is not infected when they are actually infected, and a false positive result shows that a person is infected when they are not infected [25]. The impact of COVID-19 could lead to more research in the field of robotics, however, without continued development in research, robotics will not, on their own, be prepared for the ensuing scenario. By encouraging the group of engineers, and healthcare specialists, we can be prepared when the subsequent pandemic arrives.

3.1.3. Automated swab test versus manual swab process

To investigate the effects of automated swab testing over manual swabbing process, a causality relationship of 'Ishikawa diagram' was established as shown in Figure 11. As for the design of two different swab testing operations, the given diagram considers their corresponding system and process. The model makes an appropriate framework for discussion in the consumer preferences to be in favor of automation technologies as part of the investment in medical applications, and to provide an increase of significant advances in patient care. The newly-developed automated swab testing is theoretically designed to increase the swab testing capacity while shortening the turnaround time of the testing process.

On the other hand, the results of the traditional or manual swabbing process in this context present the trust acquired during the swab operation and the processing of specimens due to the existence of interpersonal interactions and/or the perspective of the human element reliability. Both of these factors help to offset the impact of the swab operation and suggest that the method can settle in a new balance state.

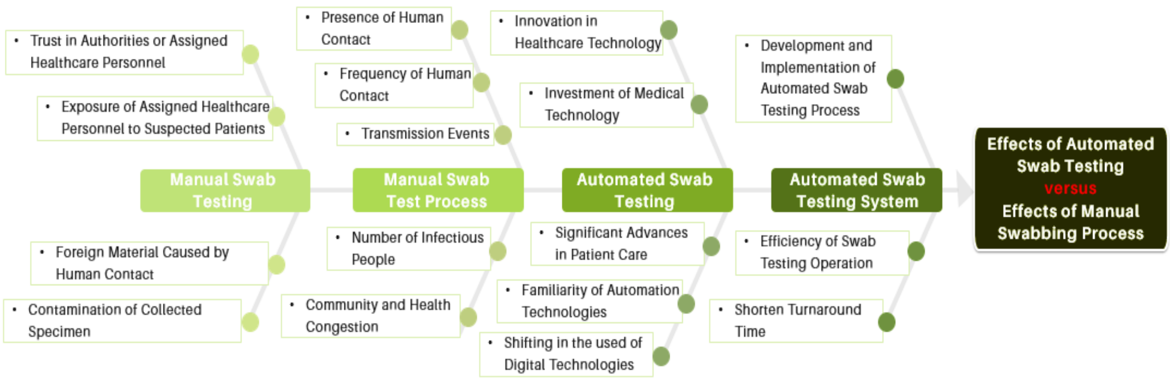


Figure 11. Ishikawa diagram for the effects of automated swab testing versus effects of manual swabbing process

3.1.4. Implementation capability

The expeditious migration to automated technologies driven by the pandemic, and acceleration of the community's automated capabilities to keep pace are the requirements to its implementation capability. Many companies that consider robotic swab testing are engaged in developing and marketing this technology. The goal is to make the job limit the virus contamination with the patient and the medical staff. The first associated hospital of Guangzhou Medical University used an automated swab robot to collect oropharyngeal (OP) samples [23]. Sampling parameters, safety, and efficacy of OP swab robot have been observed in 20 healthy individuals and 20 suspected COVID-19 patients from a fever clinic [23], [24]. The efficiency was determined on the basis of the success rate of the sampling procedure (completion in first attempt). Success sampling rates were both 95 percent for healthy individuals and pathogenic consistency for suspected COVID-19 patients [23].

The conventional process of OP swab includes proper delivery of the swab to the target tissue, adequate strength and contact-avoidance of surrounding tissue, and confirmed an improvement in the positive detection rate [25], [26]. The automated OP swab robot enables medical personnel to have clear vision through remote camera during sampling without close proximity to patients, resulting in a consistent collection of swab specimens [26].

4. CONCLUSION AND FUTURE WORK

One of the positive effects of automated swab robots is the increase in swab testing capacity that could shorten the turnaround time of the testing process. The theoretical scenarios given examined at a number of possible outcomes from the adoption of automated swab testing. They are not intended to describe a precise picture of the future, but rather to display a variety of potential futures. Within the two scenarios, changing the conventional approach to the use of automation systems would become safer, time spent, and the burden on environmental contamination will be minimized as it decreases the presence of interpersonal contact respiratory droplet transfer.

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