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Review Article

Smart Health Technologies for COVID-19 Pandemic: Internet of Medical Things perspectives

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Abstract

Contact tracing is an activity of paramount importance during the work with an individual either symptomatic or asymptomatic diagnosed with the infectious disease of interest. The aim of contact tracing is to identify, provide support for those contacts as well as to prevent further infective dissemination. Contact tracing enables us to adequately identify, voluntary quarantine or self-quarantine and monitor those COVID-19 suspect cases.

A contact is defined as an individual exposed to a case or a case's environment such that they had an opportunity to acquire the infection. A high-risk subpopulation is a population that has the risk of infection or severe disease.

The incubation period is defined as the interval between the onset of invasion by an infective particle and the first sign/symptom of the infective process. In the case of SARS-CoV-2, the incubation period is on average 4-5 days but may be as long as 14 days.

The infectious period is a time during which a case can transmit a disease to others and starts 2 days before someone develops symptoms.

During an isolation a case needs to be separated from others. During a quarantine a close contact is separated from others to prevent the disease transmission to the susceptible individuals and contact's activities are restricted for the duration of their incubation period.

Contact tracing is carried out by the adequately educated staff. They should possess a qualitative background, language skills, cultural access to social and medical support for the suspected individuals.

Occupational Health and Safety (OHS) efforts aim to ensure a healthy and safe working environment, prevent work-related diseases and promote health. OHS issues may affect the Rapid Response Team (RRT) as well as the incident being investigated. Risk assessment should consider the tasks, the environment, the exposure as well as preventive controls available.

The current coronavirus pandemic 2019 (COVID-19) represents a major public healthcare crisis with epidemiologic models predicting hazardous consequences. The major concern is a high morbidity rate. Contact tracing using of smartphone apps is a powerful approach to control and reduce the lethal outcomes of the COVID-19 pandemic. However, the use of smartphone technology is limitated due to the potential exposure of sensitive personal information.

Keywords: COVID-19; Contact tracing; Data protection; App

Introduction

Contact tracing (CT) is a strategy to stop communicable disease transmission and thus reduce morbidity and mortality in the population. The purpose of CT is to identify contacts as early as possible to prevent the spread of further transmission.

During the COVID-19 pandemic the healthcare system aims:

1. To provide optimal care for COVID-19 patients;
2. To maximize the effectiveness and efficiency of the delivery of healthcare;
3. To introduce effective infection control and preventive strategies against COVID-19 in health care settings.

The COVID-19 pandemic started in December 2019 report from the seafood and live animal market in Wuhan. Coronavirus consists of a core of genetic material surrounded by an envelope of protein spikes forming a crown known as corona. The common transmission modes of COVID-19 are through droplets, contact and airborne [1].

Contact tracing is an activity of vital importance during the work with an individual either symptomatic or asymptomatic diagnosed with the infectious disease of interest. The aim of contact tracing is to identify, provide support for those contacts and to prevent further infective dissemination. Contact tracing enables us to adequately identify, voluntary quarantine or self-quarantine and monitor those COVID-19 suspect cases.

Of utmost importance is to understand the modes of transmission of respiratory infections. There are six core elements of the cycle of infection and the responsibility of healthcare professional is in breaking the cycle. The first element in the infectious chain is an infectious agent, which can cause disease. It could be a virus, bacteria or fungi. The second element is the reservoir of an infectious agent as the human, animal or the environment habitat in which the agent normally lives, grows and multiplies. A pathogen leaves a host through coughing, through the blood if cut or through faeces by toileting. Furthermore, the entry of the infectious agent enters another person's body is similar to the port of exit, so it can be a mouth, nose, eyes, an open cut etc [1, 2].

Indirect transmission is a transfer of an infectious agent from a reservoir to a host by suspended air particles (airborne), inanimate objects (vehicles) or animate intermediaries (vectors). Airborne transmission occurs when infectious agents sized less than 5 microns are carried by dust or droplet nuclei suspended in the air. Vehicles refer to indirectly transmitting infectious agents through food, water, or inanimate objects. Vectors may carry an infectious agent through mechanical means or may support growth or changes in the agent. In the case of COVID-19, there are no known mosquitos'vectors to be carriers of the virus. The additional skills are necessary to prevent spreading and contracting the virus [1, 2].

Background of COVID-19

Coronaviruses are enveloped positive RNA viruses sized 60-140 nm with spike projections on their surface. There are several coronaviruses as HKU1, NL63, 229E and OC43 present in the circulation in the human population.

The incubation period is the interval between the onset of infective agent invasion and the first sign(s)/symptom(s) of the infective process. In the case of SARS-CoV-2, the incubation period is on average 4-5 days and may be as long as 14 days [3].

The infectious period is a time during which a case can effectively transmit a disease to others and usually starts two days before someone develops signs/symptoms.

The close contact is separated from others to prevent the disease transmission to the susceptible individuals. It is recommended to quarantine contacts for the duration of their incubation period [4, 5].

Contact tracing definition

Classification and definition

A contact is defined as an individual who has been exposed to a case or a case's environment which can result in acquiring the infection. A high-risk subpopulation is a population which has an increased risk of acquiring infection or severe disease [6-8].

Contacts can be classified into high-risk and low-risk contacts based on the definition. High-risk contacts are defined as a person that came in close proximity with the confirmed case such as touched body fluids of the patient (respiratory tract secretions, blood, vomit, saliva, urine, faeces), had direct physical contact with the patient's body including clinical examination without proper usage of personal protective equipment (PPE), touched or cleaned the linens, clothes, or dishes of the patient, shares the household with the patient or came into a close proximity within one meter with the confirmed case without using PPE.

Low-risk contacts are persons who had a contact with a confirmed case with a lower probability of acquiring disease but still they are a potential source for transmitting the disease such instances include persons that shared the same space (i.e. classmates/coworkers staying in the same room) but not having a high-risk exposure to a confirmed COVID-19case, travelled in the same vehicle without having a high-risk exposure [6].

Contact tracing is carried out by the adequately educated staff. They should possess a qualitative background, language skills, cultural access to social and medical care support for the suspected individuals [6].

Occupational Health and Safety (OHS) efforts aim to ensure a healthy and safe working environment, prevent work-related diseases and promote health. OHS issues may affect the Rapid Response Team (RRT) as well as the incident being investigated. Risk assessment should consider the tasks performed, the nature of the exposure and preventive controls available.

Contact tracing may be referred as one of the major public health (PH) measures to COVID-19. The additional measures include active case finding, physical distancing, testing, self-isolation, and vaccinations. To effectively trace a contact we need to define the term contact. In the process of traditional contact tracing, public health officials interview an infected individual, identify contacts and recommend exposed contacts to self-monitor for symptoms, self-quarantine or have a proper medical evaluation.

In case of minor symptoms,, the individual does not need to seek immediate medical care but still needs to self-isolate and regularly monitor the symptoms. In case of more severe symptoms such as breathing difficulties or pain and chest discomfort, immediate medical help is required [7].

Close contact of COVID-19 case is any person who had a close unprotected direct contact with a COVID-19 case within two metres longer than 15 minutes or with infectious secretions of a COVID-19 case or any one being in a closed environment (household, classroom, vehicle etc.) with a COVID-19 case for more than 15 minutes including a person providing care to a COVID-19 case, or laboratory workers who were handling specimens from a COVID-19 case without proper usage of PPE or with a possible breach of such equipment [6].

In a case study conducted in the USA, 55 individuals went to a wedding in Maine while guests were obliged to wear masks, but the majority did not. They also interacted closely with people they did not live with. From one COVID-19 posotove guest the virus has been transmitted to 30 people who had been at the wedding. Furthermore, through jobs, schools, families and other places of contact, an additional 147 other people were infected with COVID-19. Of them, 7 individuals were hospitalized, and 7 people died of COVID-19. Those 7 people were not present at the wedding [9].

Plan of action for contact person/s

Coordination with other components of the pandemic response (e.g., surveillance, laboratory, public health measures) are crucial for optimal health care system functioning.

During the COVID-19 pandemic, the health care system will be responsible for managinga high number of individuals with suspected or confirmed COVID-19, while continuing to provide services for urgent non-COVID-19 health care needs. Experience in other countries suggests that the COVID-19 pandemic will be very challenging for the Canadian health care system and may even overwhelm it.

However, the impacts and burden of COVID-19 on health and related health outcomes might differ according to sex/gender and other socio-demographic and economic characteristics, which would require adaptation of health care response to be effective.

During the COVID-19 pandemic, primary care providers (e.g., family physicians, nurse practitioners, nurses and pharmacists) provide assessment and treatment for ambulatory/outpatient COVID-19 patients, either in traditional settings or in specially for COVID-19 established assessment centres [10].

Basic orientation for low-risk and high-risk contacts actions

Based on the high-risk or low-risk exposure with a confirmed case we can plan our actions. High-risk contacts are advised to quarantine at home, hospital or designated facility for 14 days after the last exposure. While they are quarantined, active self-health monitoring of any signs/symptoms is recommended for 14 days after the last exposure the contact person should immediately call the designated care provider in case of fever, cough or difficulty in breathing to receive care recommendations. Asymptomatic direct and high-risk contacts should be tested according the health provider recommendtations. Contacts should immediately search medical care in case of signs/symptoms. Contacts need to remain reachable all-time for health monitoring. Contacts, regardless of whether their exposure was high-risk or low-risk, should immediately self-isolate and contact health provider if any symptom occurs within 14 days of the last exposure [6, 7].

Health and safety precautions for front-line health workers doing contact tracing

The front-line health care worker should always maintain a distance of at least one meter from the contact and if possible, an interview should be conducted outdoors or in a well-ventilated space. Triple-layer masks/FFP2 should be worn by the CT team members. Additional personal protective equipment (PPE) (e.g., goggles, gloves, gown) is not required. If interviewing any person having respiratory symptoms, the health care worker conducting contact tracing (CT) should provide him a face mask before interviewing. The CT team members need to maintain standard infection prevention and control (IPC) measures before and after each visit along with ensuring respiratory etiquette. The front-line health worker that conducts CT should not work if they have any symptoms (i.e., fever, cough, or difficulty in breathing) and need to immediately inform their supervisor of their symptoms [6, 7].

Traditional contact tracing

Traditional CT is when public health representatives interview an infected individual, identify contacts, and recommend self-monitor for symptoms, self-quarantine or obtain medical evaluation and further treatment.

Healthcare professionals in primary care settings (i.e., clinics, pharmacies) will be responsible for the assessment and treatment of patients with suspected COVID-19. The need for health care may be exhaustive regarding the pandemic scenario so strategies to both reduce and manage this demand are important.

The resource management strategies include:

1. Reducing less urgent need for health care;
2. Increasing/optimizing the existing resources use;
3. Augmenting resources;
4. Implementing strategies to allocate possible infection resources.

The qualitative COVID-19 CT refers to the following steps: a) assessing and collecting data to provide a qualitative community report; b) coordination (local, regional and national); c) define and prioritize the main team objectives; d) identify the target audience; e) define and further develop the activities that will catalyze/boost the implementation of other preventive and CT measures; f) implement and monitor the plan to evaluate their completeness [6, 8].

Virtual Assessment and Triage

Telephone, web-based, and other means of telecommunications technology should be used to provide assessment, triage, and advice. These are effective ways to manage and reduce the less urgent demand for health care, while also reducing the risk of unnecessary exposure in a health care setting.

Planning considerations for these services during a pandemic include the following:

- Telephone lines might have to operate 24/7;
- toll free lines should be provided along with measures (if possible) to ensure access for persons in rural and remote areas who might have limited internet or telephone service;
- High user volumes can be expected, so business continuity and surge capacity planning for additional equipment and staff are needed to meet demand and prevent staff burnout. A tool for estimating call volume during a pandemic may be useful in planning;
- Protocols and standard operating guidelines should be established for call centres and updated regularly, and "just-in-time" training provided for call centre staff;
- Apps and on-line tools for self-assessment and self-monitoring in different languages should be developed and widely promoted;
- Call data and website visits should be tracked electronically and analyzed on an continuing basis to improve operations; and
- Assessment tools should be validated [6, 11].

Digital contact tracing

Several digital CT smartphone applications are available to the public to warn the users of potential exposure to the COVID-19 case and generate data that facilitates in the early identification of hotspots, complementing the manual tracing operations [11]. Digital CT uses electronic information to detect the potential exposures to infection. Several countries (i.e., South Korea, China) use data collection system (security camera footage, cell phone location data and financial transaction). [11] In the USA, certain Bluetooth-based applications are accepted in the digital tracing process [12].

The newly introduced approach in the pandemic controlis the app-based CT for instance the ones developed by a pan-European initiative and a joint Google and Apple collaboration. [13] App-based CT showed the effectiveness of CT applications in identifying exposure with the use of individual applications due to these novel smartphone technologies [14].

In India, a tracking app that uses the smartphone's GPS and Bluetooth features to track COVID-19 cases has been used. With Bluetooth, the application determines the risk if one has been in a close proximity (within six feet) of a COVID–19 infected person, by scanning through a database of known cases across India. Using location information, the application determines whether the location is similar to the infected area based on the data available. The benefit of this app is to spread awareness of COVID–19 and to connect essential COVID–19-related health care services to the general population in India [15].

Yasaka et al. proposed CT based on ''contact points'' using smartphone application that may create ''checkpoints'' by generating a QR code. This QR code may be scanned by the other applications when joining their checkpoints. When used with the checkpoints' information, this application creates transmission graphs that estimate the infection risk [16].

Secure contact tracing might be a powerful tool to decrease the rate of COVID-19 transmission. The Swiss Federal Office of Public Health developed a centralized system as part of an international consortium (EPFL and ETH Zurich) such as DP-3T (Decentralized Privacy-Preserving Proximity Tracing). DP-3T is a decentralized, secure, privacy-preserving proximity tracing system based on the Bluetooth Low Energy standard [17, 18].

Getting the information on contacts

Getting information on contacts from the lab-confirmed case

CT should begin as soon as a case is confirmed, and the epidemiologist/medical officer should interview the case. Details should be filled in the COVID-19 case investigation form. All with a confirmed case anytime between two days before the onset of symptoms and the date of isolation (or maximum of 14 days after the symptom onset in the case) should be determined. Each contact should be identified and recorded by the epidemiologist/medical officer on the contact list form. If the case had no symptoms (i.e., asymptomatic case), a contact person is defined as someone who had contact with the case within a time frame ranging from two days before the sample collection to 14 days after the sample was taken. Based on the information collected, the epidemiologist/medical officer should classify each contact as a high-risk or a low-risk and record this in special form as explained above. Furthermore, cases may have contacts in multiple countries, in that case, the details of contacts living in different countries should be shared with the health authorities of the respective country state. However, tracking contacts located in a country is the responsibility of that particular country [6, 8].

Preparation of contact line-list by front line health worker conducting contact tracing

Every health care worker should be appropriately trained on the filling of the form (paper-based or app-based system), health and safety precautions and reporting of the symptomatic case under the supervision/coordination of the supervisor. Each form should contain the COVID-19 surveillance ID number, date of contact with the case, name, age, sex, address and phone number, pre-filled for each contact assigned to the contact tracer (if details are available). The front-line health care worker conducting contact tracing will fill each row (one row for each contact) until the completion of 14 days following the last exposure for each contact. The results/outcomes should be reported regularly i.e., on weekly basis. The contact tracing form will be carried by the front-line health worker conducting CT until the completion of contact tracing (14 days from the last exposure for each contact). The master contact line list should be shared regularly i.e., on weekly basis to the district, state and national level for regular data analysis [6, 7-8].

End of contact tracing

Contacts may be released from the daily follow-up after the completion of the 14-day follow-up after the date of the last exposure with the lab-confirmed case without developing COVID-19 compatible symptoms or if they remain negative for COVID-19 laboratory test. The front-line health care worker conducting CT should record the completion of the 14-day follow-up period on the reporting format and should communicate this information to the supervisor/coordinator by submitting the CT format form for the record purpose. If a contact leaves the country, it is important that they immediately alert the health authorities of the respective country state. Once the destination of travel (including any other transit locations) has been determined, the supervisors must begin the notification process. However, tracking contacts located in a country is the responsibility of that country [6, 7-8].

Health and safety precautions

Member of RRT are called upon to investigate the potential outbreak and super-spreader event.

Asymptomatic carriers usually easily transmit the virus to others. The antibodies that are most important in SARS-CoV-2 are IgG antibodies that are found in the blood and saliva. IgG is elevated 10-14 days after a person is infected. A positive antibody test is a proof that the person had SARS-CoV-2 infection.

A contact is an individual who has been exposed to a case so that they had an opportunity to acquire the infection. A high-risk sub-

population is a segment of the population that has characteristics that increase the risk of infection or severe disease.

The incubation period is an interval between the moment of invasion by an infectious agent and the first sign(s)/symptom(s) of the disease. In the case of SARS-CoV-2, the incubation period is on average 4-5 days but may be up to 14 days.

The infectious period is a time during which a case can transmit a disease to others. It starts two days before someone develops signs/symptoms.

During isolation a case is separated from others.

Polymerase chain reaction (PCR) test is a diagnostic test that identifies virus in the body. SARS-CoV-2 has RNA sequences that are unique and specific to the virus, that is, no other virus or organism has these sequences. The SARS-CoV-2 PCR test assesses for parts of these sequences. If they are present, the test is positive. It is important to recognize that this is not a culture, these tests just assess for the presence of SARS-CoV-2 RNA. PCR tests for SARS-CoV-2 are usually done from swabs taken from the back of the throat or nose.

The reproductive number of people one infectious person will infect if everyone that person has contact with is susceptible.

Respiratory droplets are particles of respiratory secretions that are exhaled and typically consist of water-like fluid. If someone is infected with SARS-CoV-2, their respiratory droplets are proven to contain SARS-CoV-2 virus. Respiratory droplet particles cannot float in the air, they will drop to the ground by gravity. Therefore, after a person exhales them, they fall within 3-4 feet. These particles are defined as >5 microns in diameter. In health care settings and enclosed settings with a high likelihood of getting an infections it is important to implement infection prevention and control strategies including adequate nonpharmaceutical measures as masks wearing especially in under vaccinated populations with high-risk populations as in nursing homes where high numbers of frail persons live with comorbidities and weakened immune system [1, 2, 6, 7-8].

Healthcare professionals' management

In CT settings, additional human resources are required at all medical levels. The pandemic organization committee should estimate service requirements according to the disease burden and the demographics of the region. It is essential to evaluate the language skills and other attributes to be able to relocate from their current roles and settings.

The focus is to expand the number of medical and nursing personnel with administrative, research and educational assignments to perform the necessary clinical duties Furthermore, he regulatory national body may ask students or retired persons to meet increased need for health care.

Steps in health and safety of RRTs in the COVID-19

1. Preparing for mission (Personal and team preparation)
2. Travel
3. Accommodation and food
4. Working in the field
5. Health monitoring
6. Managing contacts from COVID019
7. Return and follow up [6, 7-8]

Team preparation

Team composition including staff well-being officer – a clear division of tasks and responsibilities. Assign one team member to monitor the health and safety of team members during the mission and the observance of IPC protective measures.

Collect existing information and conduct an initial risk assessment of the setting – community transmission level.

Review task and potential risks and select adequate PPE and alcohol-based hand rub in sufficient quantities and brief team members about protective measures for health and safety.

Team preparation includes conducting medical briefing that includes:

- Update first-aid kits including personal thermometer and personal prophylaxis measures;
- Medical clearance – personnel with underlying medical conditions, pregnant women and age above 60 should not be requested to travel to COVID-19 outbreak settings;
- Seasonal flu vaccination for RRT members well in advance, according to local recommendations (i.e., malaria prophylaxis as applicable to the local situation);
- Provide adequate security briefing;
- Planning of safe transport and safe accommodation.

The general recommendations are to choose safe transport, avoid crowded vehicles and public transport. Thus, to use natural aeration (open windows) while travelling by car, or air-condition without recirculation. It is mandatory to wear face masks in enclosed places or when physical distancing is not possible.

The additional recommendations are to observe other safety rules such as road safety, speed limits, the technical condition of the vehicle, seat belts, life jackets in boats, helmets for motorcycles and bicycles [6, 7-8].

Conclusions

The current coronavirus pandemic 2019 (COVID-19) represents a major public healthcare crisis with epidemiologic models predicting hazardous consequences. The major concern is a high mortality rate. Contact tracing with the use of smartphone apps is a powerful approach to control and reduce the lethal outcomes of the COVID-19 pandemic. In the modern era, the use of smartphone technology has its limitations due to the potential exposure of personal information such as location.

A detailed case investigation and content tracing are vital skills in the healthcare system necessary to decrease and control the spread of COVID-19 in the local community.

The current COVID-19 pandemic represents a major public healthcare crisis with epidemiologic models predicting hazardous consequences. The major concern is a high mortality rate, especially in certain high-risk populations as nursing homes residents. CT with the use of smartphone apps is a powerful approach to control and reduce the lethal outcomes of the COVID-19 pandemic. In the modern era, the use of smartphone technology has its limitations due to the potential exposure of personal information such as location.

Strong coordination is important for the implementation and monitoring of CT for COVID-19. Increase knowledge and understanding of programme managers and implementers on the importance of putting the community at the centre of CT while empowering them to do so need to be done. Often it is necessary to engage community leaders and other community liaisons to assist with this investigation. Effective integration of community engagement principles and process into CT strategies and implementation will build and promote trust and ultimately reduce the transmission of COVID-19 and saved lives in the whole population [6, 7-8].

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