A New Dimension of Health Care: The Benefits, Limitations and Implications of Virtual Medicine

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ABSTRACT

Background: Virtual medicine has been rapidly evolving over the past several decades. However, obstacles such as data security, inadequate funding and limited technological resources have hindered its seamless incorporation into the health care system. The recent pandemic has induced a widespread adoption of virtual care practices to remove the need for physical meetings between patients and health care practitioners.

Purpose: This literature review aims to examine the current state of virtual medicine amid the COVID-19 pandemic and evaluate the benefits, limitations and implications of continuing technological advancements in the future.

Findings: Most of the available literature suggests that the recent adoption of virtual medicine has allowed practitioners to cut down on costs and secondary expenses while maintaining the quality of medical care services. Due to the growing consumer demand, researchers predict that virtual medicine may be a viable modality for patient care post-pandemic. However, concerns surrounding patient security and digital infrastructure threaten the ability of virtual medicine to provide quality and effective health care. Additionally, rural virtual medicine programs face challenges in expanding services due to the scarcity of information and communication technology specialists and inadequate funding. Comprehensive legislation and governance standards must be implemented to ensure proper data security and privacy. Additional funds may also be required to train staff, reform current digital software and improve the quality of service. The proliferation of advanced technologies and improvements in current platforms will enable more providers to render virtual medical care services.

Keywords: COVID-19, Virtual Medicine, E-health, Telehealth, Telemedicine

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INTRODUCTION

In recent years, technological advancements have revolutionized health care. Examples of health care technology ranging from electronic health records to the development of several imaging technologies have helped improve patients comfort and increase precision among physicians¹. Patients now have access to better diagnostic tools and cutting-edge treatments, granting them an enhanced quality of life¹. In the wake of the recent pandemic, physicians have shifted from in-person health care practices to virtual care options to mitigate the spread of COVID-19. COVID-19 denotes the novel Coronavirus Disease 2019.

Virtual medicine is a broad term that encompasses the remote interaction between patients and health care workers using information and communication technologies. This term encompasses the use of telehealth and telemedicine services as well as the implementation of mobile health technologies². This paper will examine both asynchronous and synchronous modalities of virtual medicine, as well as touch upon various remote patient monitoring tools currently being used for medical surveillance and data collection. The review aims to evaluate the benefits and limitations of virtual care implementation in response to COVID-19. As well as provide considerations for health care systems and providers using virtual medicine services, to ensure it remains a viable modality to patient care post-pandemic.

COVID-19 AND VIRTUAL MEDICINE UPTAKE

COVID-19 is a new strain of virus that causes serious respiratory infections in humans. The virus can spread through small respiratory droplets from the nose or mouth and can be transmitted through close contact or physical touch of contaminated surfaces⁶. Common symptoms include shortness of breath, fatigue, gastrointestinal malfunction, high temperature, and persistent cough. According to the World Health Organization symptoms may appear immediately after being exposed or take as long as ten days⁶. A large majority of people who test positive for the virus experience few to no symptoms. People suffering from mild symptoms recover within two weeks of isolation while severe cases may require hospitalization and, in some cases, lead to death⁷. Currently, there is no cure for COVID-19⁸. Veklury (Remdesivir) is the only anti-viral drug that has received Food and Drug Administration (FDA) approval. The FDA and Health Canada have also issued approval for the Pfizer, AstraZeneca and Moderna vaccines. Additional vaccines and treatments are currently under investigation. Over the past few months, the government of Canada has imposed several legislative and health measures to minimize the spread of COVID-19. This includes the

implementation of physical distancing measures, restriction of non-essential travelling, mandating face masks, encouraging proper hand hygiene and other measures to minimize community transmission⁹. Provinces across Canada have now implemented strict lockdowns rules, while essential businesses are still open citizens are expected to maintain two-meter interpersonal distance and wash hands frequently to mitigate transmission⁶.

The COVID-19 pandemic has had a crippling impact on the national and regional health care system. Many outpatient and inpatient services have been suspended and resources have been reallocated to COVID-19 prevention³. Additionally, some of the largest hospitals in Ontario have been nearing or exceeding full capacity. This overcrowding has forced allied health care workers to provide support in hallways and conference rooms¹³. Moreover, it has encouraged many clinicians to make virtual consultations and use technological resources to minimize contact with patients⁴. These changes have allowed physicians to recalibrate demand and capacity for in-person visits; allowing them to re-shift their attention towards patients who require surgical intervention⁵. As clinics start to reopen, leveraging telemedicine for pre-operative counselling or primary consultations can help alleviate the burden from doctors, as this responsibility is generally delegated to nurses or physician assistants. This can help reduce the backlog of operations and allow physicians to maintain continuity of care⁵. Timely provision of care has become the focus of our resources today¹². Researchers estimate that over half of clinical care appointments will be conducted virtually post-pandemic⁴.

HISTORY OF VIRTUAL MEDICINE

Current Technology and Virtual Medicine Software

The widespread adoption of virtual medicine has been hindered by the lack of reliable network connections and the dearth of medical technology that can support virtual medicine¹. However, recent technological advancements along with the global pandemic have accelerated the spread of medical technology and the adoption of virtual practices²⁵. Advanced telecommunication and information technologies have helped transform the health care system by reducing human errors, improving clinical outcomes, providing efficient ways to track and store data, along with others¹¹. Today, electronic health technologies are extremely advanced and efficient, allowing them to act as substitutes for skilled workers. These scientific instruments are commonly used for diagnostic imaging, remote patient monitoring, and teleconferencing. Examples of health technologies include mobile health applications, emails, self-serve devices, personal monitors, among others³. These technologies and

Figure 1 Historical timeline of virtual medicine. This figure was constructed using Microsoft PowerPoint, a program commonly used to make slideshow presentations. This model outlines years of technological innovation and federal legislation that have made telehealth possible today (1924-2020). The evolution of virtual healthcare demonstrates the progress our society has made to date. Virtual medicine must continue to evolve before it can become the backbone of our healthcare system.

software are particularly beneficial for citizens who live in rural areas or have pre-existing medical conditions which limit travel⁴⁸. Additionally, the use of such platforms has helped minimize physical contact between patients and health care workers during the COVID-19 pandemic¹³. A list of virtual medicine software and platforms currently used worldwide are summarized in **Table 1**.

Remote patient monitoring (RPM) is another sector of virtual health care that involves the use of technology to monitor patient health outside of a traditional clinical setting. It allows patients to seek support at home. There are two types of monitoring devices normally used in virtual medical services: devices that measure common physiological parameters such as blood pressure, and those which transmit patient data to their

Telehealth Software	Function
AMC Health (Advanced Monitored Caregiving Inc., New York, United States)	AMC offers advanced telemedicine software that is used in conjunction with FDA approved medical devices. This includes a Bluetooth device that allows biometric data to be transmitted between the patient and caregiver ²⁶ .
Doxy.me (Doxy.me LLC, Rochester, New York)	Doxy.me is a cloud-based telemedicine solution used for video conferencing, texting, file transfers and patient queue management. This software is designed to help health care professionals diagnose and treat patients virtually. It allows practitioners to maintain the history of patient visits and monitor their improvement through the analytics module ²⁶ .
VITASENIOR-MT (Vita.IPT, Tomar, Portugal)	VITASENIOR-MT is a telemedicine platform used primarily for the elderly population. The system is composed of 3 components: a wireless network (WSN), VITABOX and cloud. The program contains biometric sensors which are used to collect data about a patient's body including blood pressure, oximetry and heart rate. Once the necessary data is accumulated, it is sent to the cloud where associated doctors can access patient information on any web browser ²⁶ .
NEMESIS (Nemesis Labs Inc. Mohali, Punjab)	NEMESIS is an artificial intelligence (AI) enabled telemedicine platform. The system is used to obtain and visualize electrocardiogram (ECG) signals and transmit them to other medical stations. It allows physicians to track and store patient data as well as monitor billing issues. The program is primarily used for video conferencing and email correspondence between specialists and their respective clients ²⁶ .
The Ontario Telemedicine Network (OTN) (Ontario Telemedicine Network, Toronto, Ontario)	The Ontario Telemedicine Network developed an integrated tele-home care service that provides daily monitoring and weekly assistance for patients with Chronic Obstructive Pulmonary Disease (COPD) ⁵⁹ .

Table 1 A list of telemedicine platforms and software. A list of a few popular telemedicine platforms and their respective function. Telemedicine platforms enable doctors to interact with patients online and provide remote clinical health care. They are particularly beneficial for practitioners who treat dispersed rural populations and for patients with pre-existing health conditions who are bound by travel restrictions.

respective health care provider. Due to COVID-19, the FDA has issued an Emergency Use Authorization form (EUA) to increase the availability of technology and monitoring tools for citizens. The purpose of this policy is to limit patient contact with physicians and allied health care workers, as well as ease the burden on health care facilities that are experiencing increasing demand²⁷. There has also been a recent surge in the use of medical devices for self-monitoring as summarized in **Table 2**. These devices enable citizens to track occupational health and fitness. RPM tools such as smartwatches, a continuous glucose monitor along with others decrease the need for communication with caregivers, which is especially useful for patients exhibiting only mild symptoms²⁸. While there are many concerns and legal debates regarding the increasing number of health applications developed for medical assistance, both patients and physicians benefit from these applications by virtually monitoring post-surgical recovery and providing daily medication reminders to increase treatment efficacy²⁹.

The demand for digital medical solutions has been

accelerated by the need for new diagnostic methods in the current COVID-19 pandemic. This has resulted in mobile health apps becoming an increasingly popular intervention in the field of virtual medicine. Institutions have mHealth apps that allow patients to pay bills, schedule appointments, access lab results, and receive virtual care. This allows patients to obtain more individualized control over their health care³². A recent study by Kim et al. (2020) investigated the efficacy and safety of mHealth apps. Thirty-seven patients were enrolled in a 12-week course and provided with a Neofit device. Neofit is a wearable device used to track physiological parameters such as heart rate, the number of calories burned, the number of macronutrients consumed and sleep. This data is stored on an application linked to the patient's smartphone. Following mHealth-dependent care, researchers saw a significant improvement in physical fitness, body composition, and physical activity³³. Companies like Apple and Google continue to develop and offer mobile applications to monitor diabetes, pregnancy, weight loss, chronic illnesses and much more as summarized in **Table 3**. Some of the most popular applications

Remote Patient Monitoring**Function****Devices**

Fitbit (Healthy Metrics Research Inc., San Francisco, California)	Fitbits are a type of smartwatch that acts as an activity tracker. This accessory can track your steps, heart rate, weight, quality of sleep and number of burned calories ³⁰ .
Digital blood pressure cuffs	This device is used to measure patients' blood pressure levels. The cuff is constructed with an inflatable rubber bladder which is wrapped around the arm. The pressure meter then indicates the cuffs pressure ³⁰ .
Glucometer	A small portable device that is used to measure the concentration of glucose in a patient's blood. These machines are commonly used by diabetic patients ³⁰ .
Pulse Oximeters	The purpose of this device is to monitor oxygen saturation levels in the blood. It presents patients with a reading of oxygen levels and pulse rate. Physicians recommend this device to patients who have a history of heart failure, chronic obstructive pulmonary disease, and anaemia ³⁰ .
ECG Consoles	A form of equipment commonly used by surgical patients to monitor their hearts' electrical activity post-discharge ³¹ .

Table 2 Common examples of remote patient monitoring technologies. Below is a list of a few non-invasive remote-monitoring devices being currently used to facilitate patient monitoring while reducing patient-physician contact and minimizing exposure to the virus.

created include Fitbit, Apple Heart Study, Bluestar and Alivecor Kardia mobile²⁹. Digital technologies have also been widely used for pandemic management and support. Countries have been developing tools to help facilitate surveillance, testing, and contact tracing to provide citizens with visual depictions of spread and regular updates about new health care policies³. A list of some applications currently offered for smartphones and devices are summarized in **Table 3**.

The last element of digital technologies and platforms are Electronic Health Records (EHR). Traditionally, medical documents and communications have been confined to paper. Due to recent technological innovations, physicians are now able to confidentially store information on health care platforms such as electronic databases. Not only is this option beneficial for the environment, but it also makes it easier for patients to access their medical records³⁶. This is because EHR platforms enable patients to access their health records whenever they want, from the comfort of their homes. Companies are continually working to create user-friendly interfaces, as the current EHR infrastructure is very limited³⁷. With COVID-19 cases on the rise, it has become imperative for health organizations to construct EMR platforms that allow for rapid updates and interoperability, making data readily accessible to multiple clinicians at a time³.

Current technologies enable specialists to monitor patients, conduct consultations and seek status reports³. Further innovations will allow physicians to conduct in-depth diagnoses and treatments from the

comfort of their own homes².

BENEFITS OF E-HEALTH

The rapid spread of COVID-19 has posed many challenges in health care. To provide support for citizens many clinics and hospitals have begun to develop and implement virtual medicine programs³⁸. The recent employment of virtual medicine has allowed health care to be more accessible for citizens living in rural and isolated communities. With the recent surge in COVID-19 infections and quarantine health policies, virtual medicine is also allowing people to receive necessary assistance from the convenience of their own homes⁴. Independent practices have come to realize the importance of virtual health care policies to avoid loss of revenue and squandering of resources. Effective virtual medicine strategies offer an array of financial benefits for providers such as reduction of resource waste, time optimization and improved appointment compliance³⁹. As this industry continues to evolve, the benefits associated with virtual medicine are outweighing the costs⁴⁰.

Since the implementation of virtual health care practices, hospitals have been able to substantially cut down on costs for both patients and physicians⁴¹. The benefits of virtual medicine are two-fold: it allows health care workers to be more efficient as time-intensive face-to-face meetings can be addressed virtually, and allows citizens to access lower-cost services⁴¹. A study conducted in 2017 found that 80.7% of patients experienced a reduction in travel costs due to the

mHealth Apps	Function
COVID Alert App (Health Canada, Ottawa, Ontario)	The COVID-19 Alert app is composed of a Bluetooth feature that allows your phone to exchange random codes with nearby phones. The purpose of this app is to contain the spread of the novel coronavirus viral infection ³⁴ .
Mobile Angel (Mobile Angel Inc., Denver, Colorado)	Mobile Angle is a telemedicine app used in the clinical management of cancer and COVID-19. It allows healthcare teams to provide proactive care through its real-time monitoring and communication tools. The application also aggregates nationwide symptoms in real-time to help specialists effectively contain spread ³⁴ .
Mobile MIM Radiology App (MIM Software Inc., Cleveland, Ohio)	Mobile MIM Radiology App is an FDA-approved radiology imaging application that permits healthcare professionals to seek remote access to medical images such as MRI, SPECT, X-ray, PET and more. This app also allows clinicians to test intensity values, distance and display measurement lines ³⁵ .
ResolutionMD (Calgary Scientific inc., Calgary, Alberta)	ResolutionMD is an FDA approved Digital Imaging and Communication in Medicine (DICOM) viewing application. It enables physicians to securely view, analyze and share patient images. The software can be integrated into existing electronic medical records, making it easy for specialists to collaborate with other healthcare professionals around the world ³⁵ .
Fujifilm Synapse (Fujifilm Medical Systems Inc., Lexington, Massachusetts)	Fujifilm Synapse is an FDA-approved medical imaging and information management system. The platform contains a Picture Archiving and Communication Systems (PACS) coupled with compression technology which together allows physicians to access high-quality images rapidly. It also has the capacity to process and distribute multiple images all in a single system ³⁵ .

Table 3 Example of Mobile Health Apps (mHealth). A catalogue of some popular mobile health apps and their respective function. Mobile health apps are used to monitor and share health information via mobile technology. The use of these applications allows physicians to monitor symptoms and make diagnoses.

implementation of virtual medicine programs in the department of surgical oncology. Researchers further discovered an increase in patient satisfaction and improved efficacy among health care professionals. The results of this study demonstrate that severe comorbidities can be virtually treated, without sacrificing safety or quality of service⁴². According to a recent analysis, there has been a 30% decrease in ambulatory care visits since the start of COVID-19, which has helped significantly reduce costs associated with face-to-face consultations and travel⁴³.

Medical providers have had to minimize in-person consultations for non-urgent care during COVID-19 and increase the adoption of virtual medicine practices. Patients have been embracing virtual medicine practices and hence researchers predict that it has become a viable modality for patient care. Darren Cargill, the medical director at Hospice of Windsor and Essex County, when asked about his virtual care services said, "We had the capability to do virtual care before, but we dragged our feet, because we thought patients and families wouldn't like it...Now we give patients the option of virtual or in-person visits, and many are choosing virtual. So, we are able to see

more patients and have more frequent contact with patients. About 70 to 80 per cent of our home visits are now virtual"⁴⁷. Citizens are hoping virtual health care will remain a viable option post-pandemic. The outburst of positive responses from citizens has encouraged the government to make the progression of virtual medicine a top priority⁴⁷. A previous study by Morgan et al. (2014) assessed patient's satisfaction with virtual medical services amid a pandemic. Most participants ranked their experience between 3.43 to 3.72 on a 4-point Likert scale. The minimum score of 1 means patients were not satisfied with the quality of health care provided using the virtual medicine system, comparatively a maximum score of 4 means a high degree of satisfaction was achieved. The high scores suggest that virtual medicine interventions are a sufficient alternative method to in-person follow-up visits⁴⁸. Similar conclusions were derived from a recent study conducted in the area of Gastroenterology. A group of researchers administered a survey to GI patients and physicians to evaluate their experiences with virtual consultations. Patients were highly satisfied with their E-health visit and more than 80% of participants agreed to participate in future virtual medicine programs⁴⁹. Overall, virtual medicine is a viable alternative to

traditional medical practices as it can support physical distancing protocols while upholding the standard of care. Several primary care clinicians now have online portals which provide patients with a secure platform to access private medical information and receive speciality care⁵⁰. These networks also allow citizens to request prescription refills, review test results, and schedule appointments all on one webpage. With several user-friendly features, such portals allow patients to request appointment reminders and permit physicians to request follow-up data⁴⁴. Due to the easy monitoring features, E-health has been deemed effective in reducing patient readmission rate by 40%⁵¹. The online tools allow physicians to audit prescription efficacy and ensure that patients are completing the full course of antibiotics post-surgery. These tactics have been particularly useful for treating chronic conditions such as diabetes and hypertension⁵⁰. Dr. Ramanana Appireddy, a neurologist for the Kingston Health Sciences Centre (KHSC), noticed his stroke patients have been more compliant with their treatment due to virtual follow-ups and remote-patient monitoring technologies. These statements were supported by a study conducted at KHSC which demonstrated that virtual follow-ups reduced wait times by 23% and increased patient satisfaction by 94%⁵². Overall, the derivation of virtual health care apps and platforms in response to a disruption of the health care system has helped elevate patient experience and reduce administrative costs⁵³. Further development of virtual medicine policies and programs may help bridge health equity gaps and expand access to health care.

Overall, the most salient benefit that virtual care offers patients and health care workers is convenience. Virtual medicine has made it possible for patients to rapidly access subspecialists who live in different parts of the world⁴². This has helped minimize the risk of inter-hospital infection and avoid oversaturation of health facilities⁴⁴. Additionally, online operations have helped ease the workload of physicians and provided clinicians with more flexible schedules³⁴. The recent pandemic is the catalyst that has demonstrated the effectiveness of virtual health care to citizens. As citizens continue to reap the benefits of virtual health care services, researchers believe virtual medicine may be a feasible option post-pandemic⁴⁶.

DISADVANTAGES OF E-HEALTH

Virtual medicine technologies are primarily dependent on electricity and cellular service. In many rural areas, particularly in events of a massive disaster, this basic infrastructure can be inaccessible for extended periods. This requires the use of backup generators and portable equipment with satellite-linked functions⁵³. In addition to system operation costs, a substantial amount of funds must be devoted to staff training¹¹.

Many physicians believe the procurement costs are too high and instead of investing in backup generators and long-life batteries for periods of crisis, the federal government should authorize more funds for hospital construction in rural and isolated areas⁵⁴.

The primary issue concerning information systems and technology is data security and privacy, especially in the cases of sensitive medical information⁵⁸. Ontario currently uses platforms such as ClinicalConnect and ConnectingOntario to share sensitive patient information with health care professionals across the continuum of care⁵⁹. However, these online databases are highly vulnerable to network and privacy breaches. This may raise malpractice liability concerns and cost hospitals millions of dollars in lawsuits⁵⁷. Countries have attempted to implement legislation to protect confidential medical information and have established various cryptographic techniques to avoid centralization of information³⁶. Despite numerous efforts and financial investments, full protection of confidential information is not guaranteed⁶⁰. Therefore, the government must work in collaboration with private companies to raise additional funds for the maintenance of data security.

In recent years there has been a surge in the production of medical devices and apps for self-monitoring³. While the safety and efficiency of these accessories are primarily dependent on user competency, the reliability and validity of these gadgets continue to be questioned²⁹. The use of mHealth apps is growing exponentially in the United States. A previous systematic review investigated the efficiency of mHealth apps for individuals with cognitive impairment³². Results demonstrated that many virtual applications are developed without the involvement of health care and hence contain incorrect or incomplete information. Additionally, patients suffering from physical and cognitive disabilities or low manual dexterity due to old age tend to have a hard time employing these technologies³². Due to the various barriers in the application of these medical devices, most physicians do not recommend self-testing using mobile applications to avoid possible liability. Furthermore, another study explored usability issues pertaining to virtual care monitoring systems²⁹. The researchers found various complexities in the interface. For example, the text was difficult to read for elderly patients and there was an insufficient provision of instructions³².

Amid COVID-19, remote patient monitoring devices have emerged as a powerful modality of providing quality care. While the utility of this technology has helped physicians monitor physiological metrics and conduct follow-up examinations, the accuracy and precision of such devices remain in question⁶¹. These devices have large variations of accuracy with error margins up to 25%⁶². Today many businesses

and government facilities use temperature screening devices to detect possible COVID-19-related fever. This method is highly ineffective because individuals in the incubation period may not express any apparent symptoms³. Wearable sensors and devices are currently also being used for COVID-19 monitoring, some examples include Apple Watch, WHOOP Strap and VivaLNK Vital Scout⁶¹. Current devices lack interoperability and connectivity, which poses two major challenges for health care workers. These complications restrict clinical facilities from being able to transfer patient data between practices and hinders the ability of physicians to integrate patient data into an EHR platform. This presents additional vulnerabilities concerning patient confidentiality and safety. Additionally, wearable health devices generate enormous amounts of data which requires thorough analysis and evaluation before they can be used by physicians to generate meaningful medical results. Once the data has been collected, IT departments need to redirect this information to electronic medical record systems. The health care field currently does not have a sustainable database that can be used to store or analyze such a high capacity of information⁶³. While remote patient monitoring technologies may help assist in early disease detection, further advancements are required before they can be widely adopted.

IMPLICATIONS OF COVID-19 AND NEED FOR E-HEALTH

Financial debt is threatening the viability of a substantial number of private practices and hospitals in rural areas¹¹. Following the pandemic, the medical field will face two major collateral issues: physical and mental exhaustion of health care workers, and a growing backlog of neglected surgical procedures⁴⁰.

During the COVID-19 pandemic, frontline health care workers have been experiencing considerable psychological stress. We must offer strategies to help mitigate the risk to personnel to keep patients safe³⁸. Nation-wide adoption of E-health practices can help reduce referrals and hospitalizations post-pandemic allowing physicians to conduct remote consultations for non-urgent inquiries. This would help make health assistance more efficient and avoid long face-to-face meetings⁶⁴. Current E-health practices need to be modified and further researched to ensure greater efficacy and potency⁶⁵. This means that private manufacturing companies like Think Research need to develop more financial models to help reduce costs associated with E-health interventions and encourage government bodies, as well as stakeholders to invest in virtual medicine technologies⁶⁶. The research currently available on this subject cannot be generalized to all situations and does not provide a specific valuation of costs and benefits⁶⁵.

A recent study conducted in England investigated the effect of COVID-19 on the halt of procedures and management of medical care by the National Health Services (NHS). Researchers estimated a backlog of 400,000 cases per month due to the COVID-19 pandemic⁶⁷. This includes the suspension of all types of surgical operations, general consultations as well as some urgent cancer care cases⁶⁷. Resumption of services will impose a greater burden on health care workers and a corresponding surge in errors⁶⁸. It will also cause an increase in wait times for citizens to see specialists and receive treatment. Prolonged wait times can transform potentially curable injuries into irreversible chronic conditions resulting in death or permanent disabilities. Therefore, necessary strategies must be implemented to reduce waiting time for patients. One possible method includes continued investment in E-health technology and employment of specialized practitioners to address non-urgent requests and consultations⁴⁵. This would help redistribute workload and help avoid long hours for surgeons and surgical health care workers.

We are at the pinnacle of new developments in the digital space. COVID-19 has forced health care practices towards digitalization and has presented researchers with unprecedented opportunities to expand access to virtual care and conduct virtual medicine research⁶⁴. Further improvements in E-health practices can help ameliorate and accelerate virtual medicine practices⁴.

FUTURE OF E-HEALTH

Over the past decade, the Information Technology Association of Canada as well as other private corporations have spent billions of dollars in research pertaining to medical robotics and telesurgery⁷⁰. In 2001, Professor Jacques Marescaux was the first surgeon to successfully perform remote surgery on a patient⁶⁹. Since then the presence of robots in the hospital has grown immensely. Robot-assisted surgeries are currently used in the field of obstetrics, gynaecology, colorectal, and other general surgery. Today, the Da Vinci is the most popular robotic surgical system used in hospitals. This robot has large, rigid arms which makes it difficult to accurately locate the site of exposure. Additionally, it has limited tools and requires a lot of time to set up. Further expansion of this tool and the creation of more advanced robots with enhanced sensory input will allow surgeons to perform more complex procedures, with greater precision⁷⁰. Improvements are also necessary to bridge the gap between *in vitro* testing and *in vivo* feasibility for more reliable performance¹.

Health-tech companies must continue to invest in the development of next-generation virtual medicine tools to enhance health care delivery and make it more

accessible to isolated populations⁴². The next steps may involve increasing funding to help expand virtual health care literacy and training among physicians⁴⁵. Additionally, the improvement of usability and ease of access to technology will require the proliferation of patient-centric virtual medicine tools and the creation of EHR systems that can facilitate data integration and automated decision support⁵⁷. Implementing these next steps will require extensive collaboration and coordination among stakeholders, research institutions and governing bodies.

Overall, COVID-19 has prompted a widespread adoption of virtual medicine allowing physicians to provide support amid social distancing measures and quarantine. Continued reliance on virtual medicine can help reduce emergency department overcrowding, boost productivity and improve overall patient care. The current implementation of virtual medicine in routine health services is being impeded by the fear of security breaches and the absence of concrete research. Therefore, increased collaboration between private corporations and health care workers, along with additional investments from stakeholders is imperative for further adoption. Findings from this review can help provide medical practitioners with insight on how to reform the health care system and modify virtual medicine to increase resilience to future health crises. Envisioning the system that we want for the future, is the first step to building it.

COMPETING INTERESTS

No competing interests declared.

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