CASE 1

Artificial Intelligence in Primary Care: Implementing New Technology into Existing Systems

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"We'll be in touch soon," Noor Grewal says as she exits her last virtual meeting of the day. She takes her red pen and circles next Friday's date on her agenda. Noor is a public health liaison officer with a background in public health and health informatics at the province's Digital Health Bureau (see Exhibit 1). She is currently working on a project to increase the capacity of electronic medical records (EMRs) to address public health concerns. Her last meeting was with Damon Miller, the Director of Strategy and Planning in the Department of Health Analytics. He just informed Noor that she has one week to recommend which artificial intelligence tool will be integrated into the Digital Health Bureau's certified EMRs, with the goal of improving existing systems with new technologies that can rapidly begin combatting public health challenges in primary care. He was eager to hear which company the team would be contacting to begin the integration process. Unfortunately, Noor does not yet have an answer for him. She is hoping her upcoming meetings with industry representatives will bring her closer to a decision. In the meantime, she takes a deep breath as she starts going through her pile of notes for this project.

BACKGROUND

On May 18, 2020, the province announced funding to help several health organizations develop projects focused on improving telemedicine. This increase in funding was in response to the COVID-19 pandemic that has wreaked havoc on global health systems. With an increased focus on COVID-19, the province is worried about the lack of attention on health promotion and chronic disease prevention and how this might have negative and long-term effects on population health outcomes. The province recognizes the opportunity to improve health outcomes through better collaboration between primary care and public health. Primary care is the health care system's gatekeeper and is an effective system for understanding community needs in an effort to prevent diseases and protect the well-being of the provincial population. However, because people have been limiting nonessential trips outside their home for the past few months to prevent community spread of COVID-19, the way primary care is being delivered has changed, and more people are opting to use telemedicine instead.

Telemedicine can be described as the use of information technology to assist in the delivery of health care across geographical, time, and social barriers (Perednia & Allen, 1995). Although it is better than having no access to care, telemedicine cannot completely replace in-person visits. Many health care services, from physical examinations that require direct patient contact to routine immunizations, must be provided in person. However, because the threat of COVID-19 continues and hesitancy to be in public places persists, the use of telemedicine will likely remain important and if successful, continue to be an integral part of primary care post-pandemic. As a

result, the province is investing in increasing the capacity of telemedicine to support primary care public health functions.

The Digital Health Bureau is one of the many organizations to have received funding because its employees are experts in EMRs and digital health tools. The group is accustomed to making the most of its limited resources, and the sudden influx of funding has led to a sense of urgency and excitement within the organization. To decide how to use the funds, a series of internal meetings were held with department directors. In the end, the Digital Health Bureau has assigned its Department of Health Analytics the authority to carry out the project to incorporate artificial intelligence tools into certified EMRs because of its experience in analyzing EMR data and using them to improve existing technologies. To discuss the project further, Damon called for a meeting with his department.

Digital Health Bureau

Health care providers and organizations independently obtain health information systems from EMR vendors and other information technology companies. Not all health care workers and management teams are experienced users of information technology, and the Digital Health Bureau addresses this deficiency to ensure the best available technology is used in the province's health systems. The Digital Health Bureau supports health care providers and hospitals in adopting EMRs and other digital health solutions to support their practices. The organization has established a strong reputation with provincial stakeholders through its list of certified EMRs and digital health tools to guarantee patient safety and provider satisfaction. Consultations are offered to health care providers who need training and resources and have not adequately adopted virtual care and digital health tools into their practice. With the additional funding provided by the province during the COVID-19 pandemic, the Digital Health Bureau can commit to promoting the use of technology by health care providers so that they can effectively support their patients during the pandemic.

COVID-19 and Telemedicine

On March 11, 2020, the World Health Organization declared the outbreak of COVID-19, a coronavirus-associated acute respiratory disease, a pandemic (Portnoy et al., 2020). This is the third spillover of an animal coronavirus to humans that has caused a major pandemic in the past 20 years, after severe acute respiratory syndrome and Middle East respiratory syndrome (Gates, 2020). The declaration of a pandemic by the World Health Organization led to immediate changes by the world's health care systems to prevent overburdening hospitals with COVID-19 patients. Strategies included early diagnosis, isolating positive cases, and quarantining all positive case contacts (Ohannessian et al., 2020). The pandemic also caused a disruption in routine primary care for the general public, leading to a shift toward telemedicine (Ohannessian et al., 2020). This shift was intended to decrease unnecessary travel to clinics and hospitals for minor health concerns and to limit the spread of disease to health care workers and to patients in waiting rooms (Ohannessian et al., 2020). Essentially, telemedicine proved to be an effective tool for people with low-risk diseases or concerns about COVID-19 to receive health support and care, while minimizing their exposure to seriously ill patients (Portnoy et al., 2020). Less than two months after the COVID-19 pandemic began, Canadian clinicians transformed primary care, with 94% of clinicians using telephone-based care and 49% reporting greater use of video and email consultations (Wong, 2020).

Public Health Concerns in Primary Care

Starfield (1998, p. 8–9) defined primary care at the health service system level as care "that provides entry into the system for all new needs and problems, provides person-focused (not disease-oriented) care over time, provides care for all but very uncommon to unusual

conditions, and coordinates or integrates care provided elsewhere or by others." Primary care can contribute to public health through its continuity of care and through patient-provider relationships that create opportunities for disease prevention and early detection (Harris, 2016). However, COVID-19 created a backlog of care needs in Canada; at the beginning of the pandemic, 85% of chronic care and 92% of wellness checks and preventive care appointments were limited because of the pandemic (Wong, 2020). This created a significant challenge for primary care providers in addressing chronic disease management and providing preventive care services. In addition, primary care providers had to continue to provide sexual health services that were time sensitive, such as contraception, abortions, and testing for sexually transmitted diseases. During the COVID-19 pandemic, immunization requirements were not enforced by public health officials, which may have created a surge in vaccine-preventable illnesses such as measles and whooping cough (Zafar, 2020). Physicians and public health officials were concerned about a loss of herd immunity due to delayed and missed vaccinations, and this could have had deadly consequences globally (Zafar, 2020).

DEPARTMENT OF HEALTH ANALYTICS MEETING

Damon met with his department to explain the funding from the province and the reasons why they were chosen to carry out the project. The province communicated the need to have a tangible solution to support public health functions in primary care, and the Department of Health Analytics team has experience in integrating new digital health tools into existing EMRs. The Department of Health Analytics is a strong advocate for the future of technology-driven health and has been busy promoting the use of artificial intelligence in health care. The availability of large amounts of structured and unstructured health data, further accelerated by the increasing use of EMRs, is promising for the use of artificial intelligence in primary care. Large volumes of data can be processed using algorithms to obtain insights for assisting primary care providers with diagnoses, risk assessments, and administrative tasks, etc. (Jiang et al., 2017). The adoption of EMRs has been increasing in Canada, with 86% of primary care physicians using EMRs in 2019 compared with 73% in 2015 (Canadian Institute for Health Information, 2020). Canadian primary care physicians who use multiple EMR functions also reported greater satisfaction than their colleagues who did not use additional digital tools (Canadian Institute for Health Information, 2020).

Damon let his team know that this project provides an opportunity to incorporate artificial intelligence tools into their organization's certified EMRs. Electronic medical record integration is decided to be a fast route to deliver change but achieving this will involve many steps. First, the team must determine the public health-associated challenges faced by primary care providers using telemedicine. Then, they must determine whether there are existing artificial intelligence tools that can help mitigate the challenges identified by primary care providers. Finally, the team must choose the best available tool and begin integrating it into the certified EMRs for immediate use by primary care providers. As the public health liaison officer for the department, Noor is tasked with serving as the bridge between the artificial intelligence industry and the Digital Health Bureau and must report her recommendation about the best tool available.

FOCUS GROUP TO DETERMINE THE CHALLENGES

First on Noor's list was to determine the pressing public health challenges in primary care. She started by conducting a preliminary literature search to determine which problems had been discussed in detail. She found that the greatest concerns involved issues such as vaccine hesitancy, the high prevalence of chronic conditions, and the increase in emerging infectious diseases. She soon realized the scope of this search was too broad and that few articles were published on these issues because the COVID-19 pandemic had emerged so recently. She

decided a focus group would help meet her immediate goal of determining the public health challenges present during the pandemic. It would also contextualize the information she was finding in the literature. Using videoconferencing technology, Noor was able to host a focus group with primary care providers who work in a variety of solo practice and family health team settings across the province, making sure to include both rural and urban providers and those who ranged in experience and age. After receiving the transcript and completing her analysis of the focus group discussion, she was able to narrow the public health challenges down to two major issues.

Challenge One: Tracking Delays in Preventive Care Delivery

At the start of the pandemic, most primary care clinics were only open for urgent health concerns and procedures that required an in-person visit. Regular physical examinations and wellness visits were postponed until further notice. As a result, patients were not receiving their routine vaccinations and preventive screenings. Some physicians mentioned more patients had inquired about their vaccination records, possibly because of the increased focus on vaccinations in the media. Thus, primary care physicians expressed concerns about the backlog of preventive care services that would have to be addressed as the demand for care surged when clinics reopened. Primary care physicians would have to optimize clinical workflow as they identified which patients were due for preventive care visits. This required tracking which services were delayed in order to guarantee patients were followed up in a timely manner. Survey data at the start of the pandemic supported the focus group findings as 17% of practices were predicting staff layoffs and 23% of clinicians had been missing work because of illness and/or self-quarantine (Wong, 2020). Another 13% of clinicians reported burnout in their practice was at its highest level and 32% reported that financial stress in their practice was at its highest level (Wong, 2020). This indicated the importance of optimizing workflow because financial and health constraints were impacting everyday functioning in medical clinics. As the pandemic went on, physicians continued to be overwhelmed by telemedicine consultations and urgent clinic visits and did not have additional time to manually check which preventive care services each patient was missing. However, clinicians needed to prioritize patients who were most in need of vaccinations and screenings when scheduling appointments. It was important to ensure that infectious disease herd immunity was maintained and that no new outbreaks of vaccine-preventable diseases emerged. For example, a child needing a measles vaccine would be considered a high priority patient, whereas a healthy, low-risk patient requiring routine cancer screening would be placed further down the priority list.

Challenge Two: Reduced Quality in Monitoring Chronic Diseases

During regular in-office visits, primary care physicians check patient vital signs such as pulse rate, respiratory rate, blood pressure, and body temperature (Harries et al., 2009). These measures are an integral component of patient management because they provide an immediate sense of underlying pathology, they indicate how a patient responds to treatment through regular monitoring, and they permit tracking changes in a patient's condition (Harries et al., 2009). With the increase in virtual visits during the pandemic, physicians were unable to accurately assess their patients' vital signs. This created challenges for monitoring changes in patient health, particularly for chronic disease management, early disease detection, and new chronic disease prevention. Physicians were worried that missing important health changes in their patients would allow diseases to progress and would increase hospitalization risks, both of which would add stress to the already overwhelmed acute care system. Some patients were able to remotely provide their own vital signs using their own machines or devices, but it was hard for clinicians to assess the margin of error of these devices and whether patients were using them correctly. The variability in the methods of vital sign measurement added a margin of

error that could not be easily determined, making the data in patient progress charts and case files unreliable for monitoring long-term changes in patient health.

SEARCH FOR ARTIFICIAL INTELLIGENCE TOOLS

Now that Noor has narrowed down the focus group findings to the two main issues faced by primary care providers during the pandemic, it was time to find out whether there were any artificial intelligence tools that could help mitigate those problems. Noor conducted an environmental scan to identify such tools with uses in primary care. She was surprised to see the large number of tools that were created to help primary care providers reduce burnout and increase direct time with their patients. Many virtual assistants and tools focused on providing administrative help to primary care providers; however, for this project, she had to focus on tools that could directly solve the challenges she had identified. Noor was able to find two tools with this capability so she conducted a web-based search to find more information about them. She summarized the information from her online searches:

Tool 1: Prioritize AI Inc. for Optimal Preventive Service Delivery
Description: Prioritize AI Inc. analyzes data within EMRs to identify and prioritize which patients are high risk and due for preventive services such as cancer screening and routine vaccinations. The tool helps determine which health-related events, such as the community spread of communicable diseases, pose the greatest risk to population health. This helps primary care physicians and their staff book in-clinic appointments based on these risks.

How it works: This is an automated system that utilizes natural language processing to extract relevant data from patient medical files and also uses deep neural networks to generate predictions regarding the risk of communicable and chronic diseases. Priority lists are then built to rank patients most at risk for developing communicable diseases (i.e., measles), followed by chronic conditions (i.e., cancer). Highest ranking patients from each list are analyzed to build a final priority list for use during appointment booking.

Algorithm development: To develop the algorithm, risk factors for each disease were assessed by gathering health data from patients and using statistical methods to compare disease-specific epidemiological data to determine which diseases had the higher incidence rate of posing a greater risk to population health. Patient health data included demographics, lifestyle factors (exercise, smoking, alcohol use), physiological data (weight, height, glucose level, cholesterol level, blood pressure), and personal and family medical history (Magnuson & Fu, 2014). Epidemiological data and research studies were then used to estimate the probabilities of patients developing different communicable and chronic diseases. An epidemiologist was consulted throughout the algorithm development and all other development phases were completed by information technology experts in the company.

Privacy policy: The company states personal information is used for continual tool improvement and development. Information may be accessed by foreign government agencies under applicable laws because Prioritize AI Inc. collaborates with global information technology companies to develop the tool. All data are stored using a cloud-based service and appropriate security measures are in place to ensure patient confidentiality.

Tool 2: Video Vitals Inc. for Vital Sign Monitoring
Description: Video Vitals Inc. can transform video camera-equipped devices such as laptops and smartphones into vital sign measurement tools. Video Vitals Inc. technology can be used to measure heart rate, blood pressure, and respiratory rate by scanning a 10 s video of a person's

face. Physicians benefit from this tool during their video consultations with patients because it allows them to acquire accurate vital sign measurements, which leads to improved monitoring for changes in health conditions.

How it works: When starting a video consultation, patients are instructed to sit still and breathe normally for 10 s. The tool outlines the facial area and counts down from 3 s to tell the patient when the recording will begin. This technology uses the light reflecting from the patient's face to measure their vital signs. After 2 min, the patient's vital signs are recorded and filed and the physician can then view and discuss the results during the video consultation.

Algorithm development: The company uses a patent-pending technology called VidCor, which combines signal processing with deep neural networks to measure a patient's heart rate, blood pressure, and respiratory rate. The system was initially tested at a family medicine clinic in New Jersey on 100 volunteers who agreed to have their vital signs measured to help develop the tool. The patients were Caucasian, aged 18 to 85, and equally split between men and women. After the doctor measured the patient's vital signs using office instruments such as a stethoscope and blood pressure cuff, a data scientist hired by Video Vitals Inc. entered the room and recorded a 10 s video of the patient's face. The measurements from the video were compared with the doctor's measurements and the margins of error recorded. Once the margin of error of the three vital signs was consistently below 2%, the algorithm was finalized.

Privacy policy: The company uses its advanced encryption processes to protect personal health information from unauthorized disclosure and access. When information sharing with third parties is required to improve the technology, it is disclosed in aggregate and only if patients consent to share this information. Before a physician uses this tool with a patient for the first time, the patient is offered an opportunity to opt out of sharing any personal health information. The company also says it protects patient privacy by only using facial detection capabilities and not any facial recognition software.

LOOKING THROUGH A HEALTH EQUITY LENS

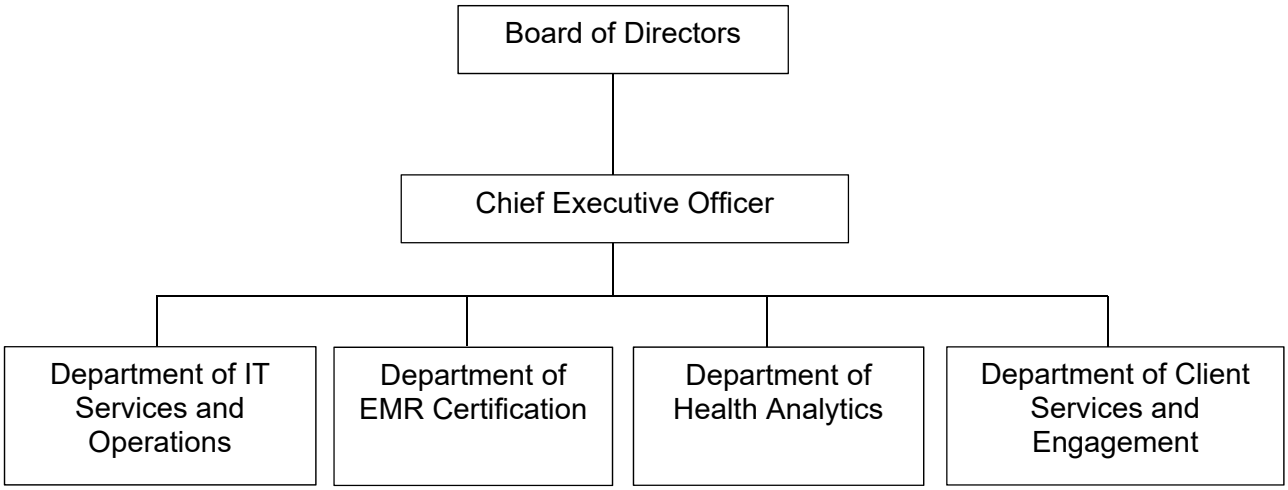
During her break, Noor scrolls through her Twitter timeline and notices posts from companies describing their commitment to anti-Black racism. The demonstrations sparked by the killing of George Floyd in Minneapolis inspired a global dialogue about racism, and the medical community was also called upon to take action in addressing systemic racism and its link to health disparities among Black people (Keshavan, 2020). Seeing this, Noor realizes she must consider how the artificial intelligence tools will address ethical and health equity issues arising from their use in primary care. To examine these applications through a critical lens, Noor truly needs to leverage her background in public health and health informatics. Noor understands she needs to learn more about the tools, so she books meetings with representatives from Prioritize AI Inc. and Video Vitals Inc. Before attending the meetings, Noor must first create a list of criteria that are important to consider during the decision-making process and then use these criteria to create a list of questions for the company representatives.

MAKING A DECISION

Noor watches an online webinar while she is sitting on her couch drinking her morning coffee. One of the speakers, a health equity researcher, mentions that "big data technologies can cause societal harms beyond damages to privacy" (Barocas & Selbst, 2016), leading Noor to think about the recommendations she has to make by the end of the day. After critically evaluating the results of her environmental scan and the findings from the meetings with the company representatives, Noor has made a decision regarding the best available tool for EMR integration. She knows Damon and the team are excited to finally implement an artificial

intelligence tool into the province's EMR systems, and she wonders whether they will be happy with her recommendation.

EXHIBIT 1
Digital Health Bureau Organizational Chart



Source: Author created.

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INSTRUCTOR GUIDANCE

Artificial Intelligence in Primary Care: Implementing New Technology into Existing Systems

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BACKGROUND

The Digital Health Bureau has received funding from the province to develop projects focused on improving telemedicine. The Department of Health Analytics has been instructed by the Digital Health Bureau to use the funding to improve the use of electronic medical records in response to the COVID-19 pandemic. Noor Grewal, a public health liaison officer, has been tasked with determining the best option for electronic medical record integration to address key public health needs in primary care. Currently, the Department of Health Analytics is focused on advocating for the use of artificial intelligence in health care and wants to use this funding opportunity to integrate an artificial intelligence-enabled tool into the province's certified electronic medical record systems. Noor has narrowed down the top concerns in primary care and searched for artificial intelligence tools that have the potential to solve the identified problems. She has a meeting to provide her recommendations to Damon Miller, the Director of Strategy and Planning, in one week. This case highlights the importance of setting decision-making criteria and critically evaluating all evidence before making a decision that has the potential to impact the health of the entire population of the province.

OBJECTIVES

1. Recognize the potential to promote public health in primary care settings.
2. Propose a list of questions and criteria that would be important in facilitating the decision-making process.
3. Practice making decisions under time constraints and with incomplete information.
4. Apply a systems-thinking approach to discuss the challenges associated with implementing new technologies.

DISCUSSION QUESTIONS

1. What are the advantages of using artificial intelligence in primary care?
2. What criteria would be important to consider from a health equity lens before integrating artificial intelligence tools into electronic medical records?
3. In what cases would personal health information be used for purposes outside of a patient's immediate care and treatment?
4. What are Noor's responsibilities as a public health practitioner in making the decision after meeting with company representatives?

KEYWORDS

Artificial intelligence; decision-making criteria; electronic medical records; information technology; preventive care