Rapid Synthesis

Identifying Remote-monitoring Technologies to Enable Existing Level of Care

6 July 2022

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Rapid Synthesis:
Identifying Remote-monitoring Technologies to Enable Existing Level of Care
60-day response

6 July 2022

McMaster Health Forum

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Timeline

Rapid syntheses can be requested in a three-, 10-, 30-, 60- or 90-business-day timeframe. This synthesis was prepared over a 60-business-day timeframe. An overview of what can be provided and what cannot be provided in each of the different timelines is provided on McMaster Health Forum's Rapid Response program webpage (www.mcmasterforum.org/find-evidence/rapid-response).

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Conflict of interest

The authors declare that they have no professional or commercial interests relevant to the rapid synthesis. The funder played no role in the identification, selection, assessment, synthesis or presentation of the research evidence profiled in the rapid synthesis.

Merit review

The rapid synthesis was reviewed by a small number of policymakers, stakeholders and researchers in order to ensure its scientific rigour and system relevance.

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KEY MESSAGES

Questions

- How can remote-monitoring and associated technologies enable people to stay in their homes or existing level of care?

Why the issue is important

- The adoption of technologies for remote patient monitoring and other virtual-care services are increasingly becoming an important part of the solution to address new and ongoing challenges across health systems in Canada, especially during the recovery stage of the COVID-19 pandemic.
- In May 2020, the Government of Canada announced an investment of $240.5 million to increase access to virtual-care services and digital tools to support Canadians' health and well-being.
- From this funding, $150 million is earmarked for provinces and territories to expand virtual health services across five priority areas, which includes remote patient-monitoring technologies.

What we found

- We identified two guidelines, 62 systematic reviews and other types of reviews (e.g., rapid, scoping, narrative, or integrated reviews), and two protocols for systematic reviews as being highly relevant to the question.
- For at-home diabetes management, the evidence we found suggests that remote-monitoring technologies (RMTs) for glucose monitoring do not provide additional clinical benefits, but they do provide major advantages for patients, such as access to quality health information and increased comfort in avoiding multiple finger pricks per day, making informed decisions, and increasing feelings of security and autonomy.
- In terms of remote monitoring for patients with cardiac conditions, we found inconsistencies in the evidence on whether RMTs made a difference in healthcare utilization by these patients, but identified several advantages of RMTs, including faster clinical decision-making, reduced incidence of hospital readmissions, self-monitoring assistance for patients living in rural areas, and support for medically unstable patients as they transition to stability.
- We also found evidence that indicates that telephone interventions were effective in improving medication adherence and reducing inpatient days of people with mental health issues, and the use of RMTs was associated with fewer emergency-department visit and, readmissions, and improved quality of life during post-operative recovery.
- While the use of wearable technology during the COVID-19 pandemic evolved over time from tracking patient symptoms to detecting airborne pathogens, the evidence we identified suggests that wearable devices can be supported further by integration with other technologies, and/or training and education of primary users for increased digital literacy.
- In terms of cost-effectiveness, the evidence we found indicates that cost outcomes of RMTs are associated with the size of the eligible population, the cost of monitoring equipment, and the size of the predicted market share of the monitoring technology, and that remote monitoring programs may be economically preferable for specific chronic conditions where only one or two vital signs need to be monitored (e.g., hypertension).
- Considering the challenges of using RMTs that were identified in the evidence, including susceptibility to privacy breaches of digital data, difficulty of patient self-management, added long-term workload commitment for care providers, and limited internet access, potential facilitators for implementing remote-monitoring programs may include increased access to the required technologies, quality of the technology, cost-effectiveness, and patient knowledge, involvement and convenience of use.
- We also conducted a jurisdictional scan of experiences from Australia, the United Kingdom (U.K.), and the states of New York and California in the United States (U.S.), as well as all Canadian provinces and territories, with using RMTs to enable people to manage their care at home, and investing in digital infrastructure to increase access to RMTs.

- In Australia, health tech start-up, CareMonitor, and video consulting company, Attend Anywhere, are using technology to coordinate multidisciplinary clinical-care pathways for remote patient management and provide videoconferencing platforms for telehealth consultations, respectively.
- Efforts have been made in the U.K. to scale up digital infrastructure and expand the capacity for RMTs, including the launch of a remote monitoring procurement dynamic purchasing system (DPS) to help streamline the procurement process for National Health Service (NHS) England, and a collaborative initiative of five integrated care systems in London that have come together to develop and coordinate their digital-transformation plans.
- NHS Scotland recently awarded a three-year contract to Inhealthcare, a virtual healthcare provider agency, to support the scaling up of RMTs across Scotland, and California Telehealth Resource Center developed a remote patient monitoring toolkit to help California providers and patients optimize remote patient monitoring for better, more equitable care.
- In terms of financial supports for the development and implementation of RMTs, NHS England allocated 200 million British pounds in its 2022-23 priorities and operational planning guidance to further develop RMT virtual wards, and Medicaid programs in both California and New York provide reimbursement for patients with certain chronic conditions that utilize RPM services that are ordered and billed by physicians or other qualified health professionals.
- In Canada, in response to the COVID-19 pandemic, the Government of Canada invested $200 million and established bilateral agreements with provinces and territories to accelerate the development of virtual-care solutions for Canadian residents.
- Several RMT initiatives are underway in Canadian provinces and territories, and policy work has been undertaken to support the ongoing development and monitoring of RMT and virtual-care services in Canada, such as the federal government's Policy Framework for Virtual Care and evaluations of the impact of virtual-care services provided during the pandemic.

QUESTION

How can remote-monitoring and associated technologies enable people to stay in their homes or existing level of care?

WHY THE ISSUE IS IMPORTANT

Remote patient monitoring (RPM) is the delivery of healthcare services to people outside of conventional clinical settings (e.g., at home) using telecommunication technology. RPM could involve asynchronous and/or synchronous transmission of health data, evaluation, and appropriate follow-up between a person and their healthcare provider through a variety of technologies (e.g., videoconferencing, blood-pressure monitors, online portals). For example, RPM could be used by health providers to observe a person's physiological (e.g., blood pressure) and behavioural (e.g., medication adherence) information from a distance. Through RPM, people who are receiving care can become active participants in the management of their health through a variety of technologies.(3; 4)

There are potential benefits to RPM such as an improvement in health outcomes, access to care, and the reduction of healthcare-delivery costs. A recent realist review from 2021 found that six factors may influence successful implementation: 1) targeting populations at high risk; 2) accurately detecting a decline in health; 3) providing responsive and timely care; 4) personalizing care; 5) enhancing self-management; and 6) ensuring collaborative and coordinated care.(4)

The adoption of RPM and other virtual-care services are increasingly becoming an important part of the solution to address new and ongoing challenges across health systems in Canada, especially during the recovery stage of the COVID-19 pandemic. In May 2020, the Government of Canada announced an investment of $240.5 million to increase access to virtual-care services and digital tools to support Canadians' health and well-being. From this funding, $150 million is earmarked for provinces and territories to expand virtual health services across five priority areas, which includes remote patient monitoring technologies.(2)

The rapid synthesis requested by the AGE-WELL National Innovation Hub APPTA synthesizes current research evidence about how remote-monitoring and associated technologies could enable people to stay in their homes or existing level of care.

Box 1: Background to the rapid synthesis

This rapid synthesis mobilizes both global and local research evidence about a question submitted to the McMaster Health Forum's Rapid Response program. Whenever possible, the rapid synthesis summarizes research evidence drawn from systematic reviews of the research literature and occasionally from single research studies. A systematic review is a summary of studies addressing a clearly formulated question that uses systematic and explicit methods to identify, select and appraise research studies, and to synthesize data from the included studies. The rapid synthesis does not contain recommendations, which would have required the authors to make judgments based on their personal values and preferences.

Rapid syntheses can be requested in a three-, 10-, 30-, 60- or 90-business-day timeframe. An overview of what can be provided and what cannot be provided in each of these timelines is provided on the McMaster Health Forum's Rapid Response program webpage (www.mcmasterforum.org/find-evidence/rapid-response).

This rapid synthesis was prepared over a 60-business-day timeframe and involved four steps:

1) submission of a question from a policymaker or stakeholder (in this case, the British Columbia Ministry of Health);
2) identifying, selecting, appraising and synthesizing relevant research evidence about the question;
3) drafting the rapid synthesis in such a way as to present concisely and in accessible language the research evidence; and
4) finalizing the rapid synthesis based on the input of at least two merit reviewers.

WHAT WE FOUND

From our searches (see Box 2 for our search strategy), we identified 69 relevant documents, which included five guidelines, 62 systematic reviews (including rapid, scoping, narrative, and integrated reviews) and two protocols for systematic reviews. We assessed each for relevance and categorized them as high, medium, or low relevance to the question. From this, we identified two guidelines, 35 systematic reviews, five rapid reviews, and two protocols for systematic reviews as being highly relevant to the question.

In addition, we conducted a jurisdictional scan to identify experiences from Australia, the United Kingdom (U.K.), and the states of New York and California in the United States (U.S.), as well as all Canadian provinces and territories, with using remote monitoring technologies (RMTs). We outline in narrative form below our key findings from the highly relevant evidence documents and from the jurisdictional scan.

Additional details on insights from the research evidence are provided in Table 1. Additional details from the identified highly relevant evidence documents are provided in Appendix 1. We provide hyperlinked titles of the evidence documents assessed as being of medium or low relevance to the question in Appendix 2.

Box 2: Identification, selection and synthesis of research evidence

We identified research evidence (systematic reviews and primary studies) by searching (on 19 January 2022) Health Systems Evidence (www.healthsystemsevidence.org) and PubMed. In Health Systems Evidence, we searched for overviews of systematic reviews, systematic reviews and economic evaluations, and costing studies using the health-system delivery arrangements topic filter for Skill mix-Multidisciplinary teams and combined it with the topic filter for primary care. Due to the high number of results retrieved, we limited the search to reviews published in 2016 or later. In PubMed, we searched for (primary care) AND (inter-professional OR interprofessional OR multidisciplinary OR interdisciplinary OR multi-disciplinary OR inter-disciplinary) AND (team) AND (1) AND (2) with publication date limit of 2016-current.

The results from the searches were assessed by one reviewer for inclusion. A document was included if it fit within the scope of the questions posed for the rapid synthesis.

For each systematic review we included in the synthesis, we documented the focus of the review, key findings, last year the literature was searched (as an indicator of how recently it was conducted), methodological quality using the AMSTAR quality appraisal tool (see the Appendix for more detail), and the proportion of the included studies that were conducted in Canada. For primary research (if included), we documented the focus of the study, methods used, a description of the sample, the jurisdiction(s) studied, key features of the intervention, and key findings. We then used this extracted information to develop a synthesis of the key findings from the included reviews and primary studies.

Key findings from the research evidence

The highly relevant guidelines, systematic reviews, rapid reviews, and other types of documents were categorized using the framework presented in Table 1, which summarizes the number and type of documents that were relevant to each category. We provide more detailed findings from these documents in the narrative summary below and in Table 2 that follows, which is organized based on the purpose or goal(s) of the remote-monitoring technologies being used, namely helping people manage their care needs at home for as long as possible, and helping those who are already in residential facilities avoid moving to a more intensive level of care.(1-26) In addition, we identified several documents that focused on patient perceptions and cost-effectiveness of remote-monitoring technologies, and on barriers and facilitators for the use of remote-monitoring technologies.(27-34)

Table 1: Number and type of highly relevant evidence documents identified

Organizing framework categories		Guidelines (n=2)	Systematic reviews (n=35)	Rapid reviews (n=5)	Protocols (n=2)
What types of remote-monitoring technologies can be used?	Non-invasive and automatic (e.g., wearable devices)	2	14	2	1
	Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)	2	28	3	2
	Multicomponent	0	14	1	0
Who can use remote-monitoring technologies?	Older adults	0	7	1	0
	Frail older adults	0	1	1	0
	Caregivers	0	7	2	1
	People with one or more chronic conditions (e.g., cardiovascular disease, diabetes, Alzheimer's, multimorbidity)	2	29	2	2
In what health-system sectors can remote-monitoring technologies be used?	Home and community care	2	22	4	0
	Primary care	2	9	2	0
	Acute/specialty care	0	7	2	0
	Long-term care	0	1	1	0
	Rehabilitation	0	1	1	0
	Public health	0	0	0	0
For what purpose or goal(s) can it be used?	Help people manage their care needs at home for as long as possible	2	26	5	0
	Help with those who are already in residential facilities avoid moving to a more intensive level of care	0	1	0	0
	Enable patient- and caregiver-friendly care in long-term care and allow residents to avoid hospital admission	0	1	1	0
	Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts	0	14	4	1
	Enhance safety (e.g., falls prevention)	0	2	0	1
	Reduce or prevent the use of unnecessary care	0	1	1	0
How can the use of remote-monitoring technologies be supported?	Integration with other technologies (e.g., electronic health records or virtual-care technologies)	0	2	1	0

	Training and education (including for enhanced overall digital literacy)	0	3	2	0
	Financial supports	0	2	1	0
	Other infrastructure supports	0	1	2	0

Helping people manage their care needs at home for as long as possible

We identified several evidence documents that examined remote monitoring for adults with chronic conditions. A 2018 medium-quality systematic review that we found indicated that research on the use of remote-monitoring tools for patients with chronic conditions may not be comprehensive, and we also identified multiple studies that explored the use of RMTs for management of diabetes and cardiac conditions.(1)

Diabetes management at home was the key focus of one clinical practice guideline, a health technology assessment, and four systematic reviews that we found. A 2021 clinical guideline from the American Association of Clinical Endocrinology concluded that advanced diabetes technology that is non-invasive, automatic, and patient-engaged can be integrated safely and effectively into the care of persons with diabetes, alongside a personalized approach to self-management.(5) A 2019 Canadian health technology assessment (HTA) examined the clinical effectiveness of using glucose monitors for insulin-dependent patients with Type 1 and Type 2 diabetes. The HTA found no significant differences between glucose-monitoring methods (e.g., finger prick glucose tests, continuous glucose monitors, flash glucose monitors, and hybrid insulin delivery systems) for hemoglobin A1c levels or number of hypoglycemic events requiring assistance for children and adults with Type 1 diabetes. There was limited evidence identified to draw conclusions about efficacy for Type 2 diabetes patients and for Type 1 diabetes in a pregnant population. Health professionals interviewed for the HTA felt that the major advantage of the glucose-monitoring devices was the quality of the information available to both the patient and their healthcare provider, and patients found continuous glucose monitors to be an effective tool in managing their glucose levels, that led to increased comfort in not having to perform multiple finger pricks a day, improvements in sleep, and increased confidence in making informed life decisions (e.g., taking vacation time). The current evidence suggests that while glucose-monitoring technologies provide no additional clinical benefits compared to finger prick blood-glucose tests, they do provide non-clinical benefits such as added comfort, convenience, and flexibility in diabetes management.(6)

The most recent systematic reviews we identified on diabetes management at home generally had similar findings as above and noted that RPM made little to no difference in clinical outcomes of diabetes patients. A 2020 overview of systematic reviews that looked at the effectiveness of RPM (e.g., smartphones and websites) on clinical outcomes and healthcare utilization found that RPM made little to no difference on hemoglobin A1c levels in patients with diabetes, or in hospitalizations, emergency stays, and mental health component of health-related quality of life. The authors concluded that the insignificant reductions may be related to the need for accompanying behaviour-change interventions, and the use of RPM as a single-component intervention rather than as part of multicomponent interventions.(3) A high-quality 2018 systematic review assessed the effectiveness of telehealth interventions on glycemic control in adults with Type 2 diabetes and reported that the greatest improvement was seen in telephone interventions, followed by an internet blood-glucose monitoring system, and interventions involving transmission of self-monitored blood glucose (SMBG) using a mobile phone or telehealth unit.(7)

We also found that earlier systematic reviews had more supportive findings for using RMTs for diabetes management. A medium-quality review from 2014 that focused on SMBG for people with Type 2 diabetes described seven key elements of RPM interventions: 1) education for patients; 2) education for providers; 3)

use of a structured SMBG profile; 4) SMBG goals; 5) SMBG data to generate feedback; 6) evidence of feedback provided to patients; and 7) evidence of interactive communication and shared decision-making strategies between patients and provider. The review found that interventions that used more SMBG elements were found to improve hemoglobin A1C levels.(8) Additionally, a low-quality review conducted in 2007 assessed the effectiveness of home telemonitoring of patients with diabetes and found that diabetes telemonitoring resulted in significant decreases in glucose levels and foot complications, and that patients responded positively to home telemonitoring due to an increased feeling of security and autonomy.(9)

Several reviews examined the effectiveness of remote-monitoring technologies for people with cardiac conditions, including chronic obstructive pulmonary disease (COPD), hypertension and heart failure. A high-quality systematic review conducted in 2021 assessed the effectiveness of telehealth interventions for reducing exacerbations, improving quality of life, reducing service utilization, and death among people with chronic obstructive pulmonary disease (COPD), and concluded that remote monitoring plus usual care may not be beneficial overall compared to usual care alone. It concluded that given that there is no evidence of harm, telehealth interventions may be beneficial as an additional health resource depending on individual needs based on professional assessment.(10) In addition, one medium-quality systematic review conducted in 2018 assessed the effectiveness of non-invasive, automatic, and patient-engaged technologies, such as text messaging, automated messaging system, and behaviour change phone calls for adults that had a stroke, hypertension, and/or HIV. The review concluded that remote patient monitoring was more effective with patients of low literacy, those early in their disease trajectory, and those who had experienced stressful life events.(11)

A 2022 overview of systematic reviews looked at the impact of remote monitoring for adults with chronic diseases on healthcare utilization, including hospitalization, hospital stay, consultations, outpatient visits and follow-up, and emergency department visits, and concluded that RMTs may result in little to no difference in utilization among adults with cardiovascular disease, COPD, or asthma in addition to outpatient visits and follow-up.(12) However, another overview of systematic reviews from 2017 found that RPM involving telemonitoring and home telehealth were generally effective in reducing heart failure, rehospitalization, healthcare utilization, and mortality for cardiovascular disease. The authors identified that integral components of telemonitoring should include physiological monitoring of blood pressure, heart rate, weight, and electrocardiogram (ECG).(13) Additionally, two systematic reviews of high and medium quality, both conducted in 2009, focused on patients with heart failure and reported that RMTs reduced the overall incidence of hospital readmissions.(14; 15)

A rapid review from 2021 examined remote-monitoring programs for cardiac conditions in Canada and reported that healthcare providers described the benefits of remote patient monitoring as aiding in faster clinical decision-making, and that acceptability and uptake of remote-monitoring technologies could be enhanced by improving technological literacy and by offering more technical supports to patients and caregivers.(16) A low-quality review conducted in 2009 focused on ways in which telemonitoring can be utilized to assist patient self-monitoring for signs and symptoms of heart failure, and concluded that telemonitoring may be effective to assist patients living in rural or remote areas who lack access to specialist care to self-monitor heart failure signs and symptoms. Additionally, the review noted that it could be used to initially support medically unstable patients as they transition to stability, at which point they could be switched to alternative telemonitoring modalities that require less equipment such as telephone touchpads or internet-based interventions.(17) As noted in a low-quality realist review from 2021 that identified factors of RPM interventions related to acute care, RPM interventions have the potential to reduce acute care use for patients when they are targeted to appropriate populations and disease states, designed well, and implemented with patients and providers in mind.(4)

We also identified reviews that evaluated RMTs for tracking and managing care for people with mental health issues, human immunodeficiency virus (HIV), multidrug-resistant tuberculosis (MDR-TB), and COVID-19. Two systematic reviews of low- and medium-quality conducted in 2018 assessed RMT for the purpose of

helping those with mental health issues manage their care needs at home. The medium-quality review included older adults with mental health issues and their caregivers and found that interventions with telephone support from the medical team, including phone calls and short text-message prompts about medication, were effective in improving medication adherence, while also reducing severity of mania symptoms and reducing inpatient days. The authors noted that patient preferences should be accommodated to determine whether computer-based methods will be effective for them.(18) Similarly, the low-quality systematic review concluded that RMTs appear feasible and acceptable, and may be a promising intervention for improving mental healthcare, but additional experimental studies are needed.(19)

A 2020 low-quality scoping review evaluating mobile-health technologies in management of patients undergoing chronic dialysis concluded the mobile-health interventions showed neutral to positive results in chronic dialysis patient management.(20) Another low-quality review from 2007 assessed the role of medical information systems in tracking patients with either HIV or multidrug-resistant tuberculosis (MDR-TB), to ensure they are promptly started on high-quality care while reducing loss to follow-up. The review concluded that effective information systems in low- and middle-income countries should play an increasing role in monitoring HIV and MDR-TB projects, and that focus should be on tracking patients from initial diagnosis to initiating effective treatment.(21)

In reference to the use of RMTs to monitor COVID-19 symptoms, we found only one 2021 systematic review of low quality that assessed wearable devices to monitor early symptoms of COVID-19 for post-discharge monitoring, to avoid hospital readmission or to intervene early to mitigate health impacts. The review found that at the beginning of the pandemic, wearable technology was primarily utilized to track patient symptoms related to fever, high heart rate, cough, and oxygen level. As the pandemic progressed, applications of wearable devices expanded to include wearable sensors that detect airborne pathogens, and for the screening, tracking, and prevention of COVID-19. The authors suggest that use of wearable devices can be supported further by integration with other technologies and/or training and education for primary users (e.g., older adults) for increased digital literacy.(22) In addition, we found a rapid review that aimed to assess the clinical utility and cost-effectiveness of medical devices that support remote monitoring, and how these devices have been used by patients who have been diagnosed with COVID-19. However, the authors did not identify relevant literature pertaining to the research question.(23)

A recent medium-quality meta-analysis conducted in 2021 focused on remote monitoring in post-operative settings and whether its use is associated with post-operative recovery. It reported that the use of mobile health, whether through wearable devices or patient-engaged technologies such as smartphones for remote patient monitoring, was associated with fewer emergency department visits, readmissions, and improved quality of life after surgery.(24) Lastly, a rapid review from 2013 examining applications of e-health and remote-monitoring for rural residents in Australia, Canada, and the U.S., concluded that e-health has the potential to address clinical needs, meet social and cultural needs, and contribute to overcoming workforce shortages in rural and remote areas. Moreover, the authors recommended e-health in rural areas should be introduced alongside changes in management principles, which include a communication strategy to engage clinicians and patients, community consultation, and training.(25)

Help with those who are already in residential facilities avoid moving to a more intensive level of care

Out of all the evidence we identified, only one recent low-quality systematic review was found that explored how RPM can be used to help those who are in residential facilities avoid moving to a more intensive level of care. The review aimed to identify advances in aging-in-place technology and assistive-technology devices for older adults, and to determine the level of evidence on RPM, telecare, smart homes, and artificially intelligent monitoring systems. Several of the included studies focused on developing technological solutions for specific groups of older adults such as Alzheimer's patients living in nursing homes or independent adults living at home alone. Additionally, the review highlighted that artificial intelligence applications for elderly care and algorithms could improve the accuracy and progress of analytical techniques so that remote monitoring systems may work at a faster rate.(26)

Patient perceptions and cost effectiveness of remote-monitoring technologies

We also found evidence that focused on examining patients' perceptions of RMTs. A rapid review from 2022 explored continuous multi-parameter remote automated monitoring (CM-RAM) technologies to capture biophysical data of patients for clinical teams. The authors found that CM-RAM was generally acceptable among patients in home, community care, and hospital settings due to comfort, non-intrusiveness and feeling of safety.(27) A medium-quality systematic review conducted in 2014 examined older adults' perceptions of patient-engaged and multicomponent technologies created to be proactive in preventing falls. The technologies included personal wearable emergency alarms, home automation systems, videoconferencing, robotics, and game consoles. Overall, older adults perceived these technologies as positive in terms of their usability, reliability, and increased comfort and confidence of use. The review concluded that training, education and tailoring for individual needs are ways in which the technologies can be further supported for enhanced use.(28)

In terms of cost evaluations for the use of RMTs, we identified a medium-quality systematic review of economic evaluations conducted in 2016 that aimed to identify the costs associated with remote-monitoring programs for older adults with chronic conditions, such as COPD, congestive heart failure, diabetes, and hypertension. The review found that monitoring a single vital sign cost less than monitoring for multiple vital signs, and remote-monitoring programs for respiratory diseases or multiple conditions were associated with higher costs than programs for hypertension or congestive heart failure. Therefore, remote-monitoring programs may be preferable for specific chronic conditions from an economic perspective.(29) In addition to examining clinical effectiveness, an HTA examined cost-effectiveness and the budget impact of using glucose monitors for diabetes patients, and recommended flash glucose monitors as the most cost-effective option. It also suggested in its budget-impact analysis that cost outcomes are sensitive to the size of the population eligible for public funding of glucose monitors, the costs of the glucose monitors, and the size of the predicted market share of each glucose monitoring technology. The assessment also suggested that funding for flash glucose monitors should be provided based on functional, not clinical, need.(30) We also identified a protocol for a systematic review that is anticipated to be completed by January 2023 and will assess the use and cost-effectiveness of RMTs to monitor and record the motor symptoms of people living with Parkinson's disease.(31)

Barriers and facilitators of the use and/or implementation of remote-monitoring technologies

A medium-quality systematic review conducted in 2017 focused on weighing facilitators against barriers for implementing telemedicine and found that the most prevalent barriers included lack of evidence, difficulty of patient self-management, added long-term workload commitment for care providers, gaps in program design, and lack of evidence on implementation. The review reported that potential mitigation strategies and/or facilitators for implementation and uptake of remote-monitoring technologies can include increased access to the technology or telemedicine, quality of the technology, patient knowledge, involvement, and convenience of use, and cost-effectiveness.(32)

A recent systematic review aimed to improve sensor-based defence and attack mechanisms to ensure patient privacy when using mobile health. It also identified several challenges related to sensors and their use for security, such as susceptibility to social engineering attacks to retrieve passwords, usability issues with providing complete authentication to access data, data collection and analysis, and high intra-class variation and imitation threat of physiological biometrics.(33) A medium-quality systematic review published in 2017 identified barriers for engagement of remote-monitoring technologies in general, irrespective of the purpose or goal of the technology in use, which included technical malfunctions and limited internet access or connection, lack of knowledge or familiarity with the technology, inadequate tailoring to the disability status of participants, financial costs, and privacy concerns. The review suggests that measures to design remote-technology systems should involve the primary users, such as older adults and caregivers, to facilitate the acceptability, feasibility, and uptake of the technology.(34)

Key findings from the jurisdictional scan of other countries

Our jurisdictional scan of experiences from other jurisdictions found that most remote monitoring programs and initiatives focused on helping people manage their care needs remotely at home rather than in residential facilities or care homes, and on scaling up digital infrastructure to enable remote patient monitoring.

Helping people manage their care needs remotely at home

CareMonitor, a health tech start-up in Sydney, Australia, coordinates complex clinical pathways through a real time, multidisciplinary remote monitoring and telehealth platform that allows healthcare providers to plan and manage patient care electronically. Features of the platform include remote health monitoring of vital signs through Bluetooth-enabled devices, decision-support tools for allocating care pathways, workflow tools like automated patient reminders and task assignments, and Push health-assessment questionnaires and educational content for patients. In addition, Melbourne-based video consulting company, Attend Anywhere, provides remote videoconference technology to facilitate healthcare consultations between healthcare providers and patients across Australia and the United Kingdom, and the Australian Digital Health Agency provides links to healthcare providers who offer telehealth consultations through video or the phone. Meanwhile, California Telehealth Resource Center developed a remote patient monitoring toolkit to help California providers and patients optimize remote patient monitoring for better, more equitable care.

Scaling up digital infrastructure to enable remote patient monitoring

Plans are underway in the U.K. to scale up digital infrastructure to enable remote patient monitoring for people with long-term conditions living at home or in care homes. England's NHSX, a joint unit between the National Health Service (NHS) and the wider digital economy (e.g., the United Kingdom's Government Digital Service and other government units), is working with seven NHS regions in England to scale digitally enabled healthcare projects at home for people with long-term conditions, including both physical and mental health. In London, five integrated care systems (i.e., different virtual and digital-health agencies and organizations) have come together to develop and coordinate their digital transformation plans to improve the digital infrastructure of care homes, and establish remote monitoring technologies to help recognize the deterioration of residents' health.

NHS England has also made efforts to procure systems for remote-monitoring platforms. A remote-monitoring procurement dynamic purchasing system (DPS) was launched in September 2020 to help streamline the process for NHS England and social-care organizations to select and use the right remote-monitoring platform for patients based on needs. In addition, the Spark DPS, run by the Crown's Commercial Services, will enable buyers such as commissioners within NHS England and NHS Improvement, social-care organizations, Clinical Commissioning Groups, Primary Care Networks, NHS Trusts and NHS Special Health Authorities to complete the procurement process in a quick, efficient manner.

NHS Scotland recently awarded a three-year contract to Inhealthcare, a virtual healthcare-provider agency, to support the scaling up of RMTs to enable patients across Scotland to record information from home and relay readings to NHS teams for analysis to manage COVID-19 and chronic illnesses.

We also identified several examples of financial supports being deployed for the development and implementation of remote-monitoring technologies. As of June 2020, five digital-health initiatives were awarded funding in Wales as part of a 150,000 British pounds call to action for new and innovative ways to use digital technology in response to COVID-19. NHS England's 2022-23 priorities and operational planning guidance sets out plans to adopt new models of care that leverage the full potential of digital technologies, including the allocation of up to 200 million British pounds to be made available to further develop virtual wards that utilize RMT to treat patients at home who would otherwise need hospital treatment.

The 2021-22 California Spending Plan provides $33.1 million General Fund for health programs that include adding a telehealth service that uses remote-monitoring devices to send physiological data on patients to clinicians (as a covered benefit in the Medi-Cal program). On an ongoing basis, the benefit is projected to result in net General Fund savings in the low millions of dollars due to newly negotiated rebates on the monitors and the reduction in costs for standard blood glucose monitors.

Effective 1 July 2021, remote physiologic monitoring (RPM) was implemented in California for fee-for-service and managed-care beneficiaries with full scope Medi-Cal or pregnancy-only coverage, and RPM services became reimbursable for patients ages 21 and older when ordered by and billed by physicians or other qualified health professionals (QHP). Beginning January 2022, the spending plan expanded coverage of continuous glucose monitors to Medi-Cal beneficiaries with Type I diabetes over age 21.

New York Medicaid program covers and reimburses for remote patient monitoring for the following conditions: congestive heart failure, diabetes, chronic obstructive pulmonary disease, wound care, polypharmacy, mental/behavioral problems, technology-dependent care (i.e., continuous oxygen, ventilator care). New York has private payer policies that includes some level of telehealth coverage or reimbursement, and as of 8 March 2022, New York continues to have an emergency declaration in place with state telehealth and licensure flexibility.

Key findings from the jurisdictional scan of Canadian provinces and territories

Our jurisdictional scan of experiences in Canadian provinces and territories with remote monitoring technologies identified several programs that have enabled Canadian residents to manage care at home. In addition, we identified several examples of remote-monitoring programs developing during the COVID-19 pandemic and new financial supports for remote monitoring.

Helping people manage their care at home

British Columbia (B.C.) has several remote-monitoring programs that use technologies to facilitate patient consultation and management. Island Health expanded its existing remote-monitoring program through a $42 million dollar investment from the provincial government to develop the Hospital at Home model which provides eligible patients with appropriate devices, a tablet, and a virtual call bell to facilitate daily in-person visits, virtual visits, and medication management. In addition, a collaboration between BC Cancer, the Office of Virtual Care at the Provincial Health Services Authority, and the Ministry of Health in October 2021 led to the implementation of a remote patient-monitoring service using the TELUS Home Health Monitoring platform to remotely monitor cancer patients receiving chemotherapy and radiation therapy, using a heart-rate monitor, electronic thermometer, tablet, pedometer, and scale. Additionally, the Fraser Health Authority Cardiac Services Program partnered with the BC Alliance on Telehealth Policy and Research in 2017 to expand the Virtual Cardiac Rehabilitation Program, a remote patient monitoring approach for patients with ischemic heart disease that offers a heart-rate monitor, blood-pressure monitor, weekly education sessions, one-on-one meetings with a nurse, exercise specialist, and dietitian, and monthly group chat sessions.

Saskatchewan has a pilot chronic obstructive pulmonary disease (COPD) Home Health Monitoring Program to help patients measure and submit health details daily from home via a program app accessible through a non-invasive device, such as a phone, tablet, or computer.

In April 2021, OntarioMD and the Ontario Ministry of Health piloted a virtual program for high-risk patients in Northern Ontario who have lung, heart, and other chronic conditions using the Insights4Care (i4C) Program, which enables healthcare providers to identify patients for a referral to remote monitoring or the provincial telehomecare program.

According to a jurisdictional scan on remote patient monitoring conducted in 2018, Québec had a home telemonitoring solution for elderly clients with cystic fibrosis, hypertension, uncontrolled diabetes, and

COPD that provides one-hour training of patients by a nurse on documenting health parameters using a touchscreen device with built-in alerts that are monitored by nursing case managers. The scan also described the Telehealth Coordination Center Health Monitoring Services that provided telehomecare services for clients in Québec with one or more complex and/or chronic conditions using an online app and a tablet to enable a multidisciplinary team of health professionals to provide regular follow-ups using a self-management approach and secure communications.

In Prince Edward Island (PEI), a Remote Patient Monitoring (RPM) program for patients with heart failure from 2015 to 2017 proved to be beneficial to participants in that it led to significant decreases in the number of emergency visits post-program, the total number of acute-care admissions for heart failure patients, the total length of stay in acute care, the number of primary-care visits, and an increase in participant quality of life, knowledge of the disease condition, and patient satisfaction. Patients in the program were given an RPM kit (blood pressure cuff, weight scale, and pulse oximeter) and training on how to use the monitoring equipment. They were then monitored remotely by family physicians and nurse practitioners for 12 weeks for heart failure and eight weeks for COPD through an analog phone line, Wi-Fi or 3G/4G network, and an integrated Clinical Information System (CIS).

Additionally in PEI, a glucose monitoring program was launched on 1 June 2022 that provides glucose-sensor technology to eligible PEI residents conveniently at their local pharmacy at a subsidized cost. Specific criteria must be met to be eligible and only specific glucose sensor supplies are eligible for coverage under the program. To avoid interruption of coverage, eligible residents must renew their benefits annually, and coverage is provided based on household income and the existence of private insurance.

A publicly funded provincial government program in New Brunswick called The New Brunswick Extra-Mural Program provides primary healthcare services to people in their homes and communities, including remote patient-monitoring services.

In 2018-19, the government of Newfoundland and Labrador announced that it would expand the use of the Health at Home program to enable patients to check, record and transmit their personal health indicators (e.g., blood pressure or blood sugar levels) and reduce travel time through the use of remote-monitoring technology. In that same year, rural communities on the Northern Peninsula gained access to remote-monitoring technology through a partnership with Labrador-Grenfell Health and Canada Health Infoway that allowed healthcare providers to receive accurate health measurements from patients while in their homes.

Participants in Yukon's Chronic Conditions Support Program record their heart health vitals (e.g., blood pressure, heart rate, oxygen saturation levels) and reply to clinical symptom surveys using a 'Connected Health Kit' from Cloud DX that includes an android tablet, a wrist blood pressure cuff, Bluetooth body weight scale, and Bluetooth pulse oximeter to connect to the tablet.

Development and financial support for remote-monitoring programs during the COVID-19 pandemic

We found that the COVID-19 pandemic brought about the development of a wide variety of remote-monitoring programs and initiatives as well as financial supports from the federal, provincial, and territorial governments of Canada. At the federal level, the Government of Canada made an investment of $200 million in May 2020 to help provinces and territories accelerate their efforts to provide virtual-care solutions for their residents, $50 million of which was given to Canada Health Infoway to support the provinces and territories with implementation of new remote patient-monitoring initiatives. Bilateral agreements were established with each of the provinces and territories with details about how the funding should be used to support the implementation of secure information-sharing and remote monitoring platforms.

In May 2020, the B.C. government scaled up remote patient-monitoring technologies as a virtual-care priority during the COVID-19 pandemic with the support of the federal government's $18 million dollar investment under the British Columbia Virtual Care Action Plan.

In response to the pandemic, an initiative called the Alberta Central Zone Primary Care Network (PCN) Home Health Monitoring Project used remote monitoring technologies to enable teams of PCN physicians and nurses to monitor the health status of patients with chronic health conditions at home through a secure online monitoring system. Participants in the project were able to use their own medical devices (e.g., blood pressure cuffs, weigh scales, glucometers, pulse oximeters and thermometers) or devices provided by their PCN team.

On 7 May 2020, the Saskatchewan Health Authority (SHA) announced a partnership with Telus Health to expand the home health monitoring system to help patients with chronic conditions avoid hospitalization and emergency-room visits during the pandemic, and on 26 January 2021, SHA announced the further expansion of the program to include patients who had tested positive for COVID-19 and were self-isolating.

The province of Manitoba has faced several barriers in the past in developing a remote monitoring program, including funding implications at the federal and provincial level, lack of proficiency with technology, a general preference amongst the population for in-person healthcare, access to the internet, concerns surrounding the *Personal Health Information Act*, and considerations for the development of a remuneration model for remote activities. Taking advantage of the federal government's investment, the Manitoba government issued a request for proposals in December 2020 to support remote home monitoring for COVID-19 patients discharged from hospital that would build upon a Virtual Outpatient COVID Monitoring initiative to supply in-home biometric health devices to COVID-19 patients, and collect their health status information centrally for review by health professionals.

At the onset of the pandemic, Seamless Mobile Health Inc. (Seamless MD) pivoted its chronic disease management technology to a COVID-19 remote monitoring tool with the support of the National Research Council of Canada Industrial Research Assistance Program (NRC IRAP), that provided alerts in real time and recommendations for next steps (e.g., continue isolation or seek medical attention) for patients and employees of Ontario healthcare institutions after the completion of a daily symptom survey. Additionally, as part of the Fall Preparedness Plan 2020 and the Digital First for Health Strategy, the Ontario government invested $9.5 million to expand remote patient-monitoring programs delivered by healthcare organizations, including Ontario Health Teams, with a plan to connect patients with a virtual healthcare provider for routine checkups, symptom monitoring, referrals to specialists, and any further follow-up.

Non-severe COVID-19 cases in Nova Scotia were monitored using non-invasive devices through a pilot project of the Nova Scotia Virtual Action Plan, and the COVID Community Virtual Care Team (CCVCT) provided 24-hour phone support and monitoring for people who tested positive for COVID-19 and were at high risk for hospitalization. Patients were being provided with portable pulse oximeters to monitor oxygen levels at home, twice daily, until they are determined to be in recovery. In addition, the Department of Health and Wellness provides financial supports to assist with the cost of personal alert-assistance services by providing a reimbursement of up to $480 per year to certain low-income seniors aged 65 and older and adults aged 19 and older with acquired brain injury.

In Newfoundland and Labrador, initiatives are underway to support health providers in accessing, sharing and storing patient data from remote monitoring technologies, including MyCCath, a web-based referral system for cardiac catheterization services, an e-ordering solution in the province's electronic health record (HEALTHe NL) for diagnostic services, and the Telepathology Network which will enable all healthcare providers across the province to share and store digital pathology images electronically as well as other related data on a secure computer system.

The Yukon government used funding from its bilateral agreement with the federal government to develop the 1Health initiative that will give Yukoners access to modern health technologies, including a patient portal that will enable virtual visits with health providers, secure message exchange, and provide patients with direct access to their health information. In Nunavut, the federal government's Rapid Adoptions Virtual Care Fund

allocation of $1 million in funding led to a series of projects that expanded access to virtual care and remote monitoring supports for residents in the province.

Lastly, we identified policy work that highlighted the need for ongoing development and monitoring of virtual-care services in Canada. The federal government's Policy Framework for Virtual Care emphasizes that long-term adoption of virtual-care services within Canada's publicly funded health systems will require patient- and community-centred approaches, provider remuneration/incentive structures, appropriateness, safety and quality of care, licensure, provider change management, and equity in access to care. In addition to this, evaluations of the impact of virtual-care services provided during the pandemic in provinces and territories are supported by the Centre of Digital Health Evaluation (CDHE) and Women's College Hospital in partnership with Infoway, the Canadian Institute for Health Information (CIHI), and the Canadian Agency for Drugs and Technologies in Health.

Table 2: Overview of evidence with using remote-monitoring and associated technologies to enable people to stay in their homes or existing level of care

Purpose or goal(s) of the remote-monitoring technologies being used	Key findings and features from evidence of remote-monitoring and associated technologies
Help people manage their care needs at home for as long as possible	*Remote-monitoring technologies for patients with diabetes* • A 2021 guideline on the use of advanced technology by clinicians, diabetes-care teams, healthcare professionals, and other stakeholders in the management of persons with diabetes mellitus, and the American Association of Clinical Endocrinologists (AACE) task force concluded that advanced diabetes technology can be integrated safely and effectively into the care of persons with diabetes, alongside a personalized approach to self-management (6) • A 2019 Canadian provincial health technology assessment provided the following findings and recommendations on using glucose monitors for insulin-dependent patients with Type 1 and Type 2 diabetes: o For children and adults with Type 1 diabetes, no significant differences were found between glucose monitoring methods (e.g., finger prick glucose tests, continuous glucose monitors, flash glucose monitors, and hybrid insulin delivery systems) for hemoglobin A1c levels or number of hypoglycemic events requiring assistance o There was limited evidence to draw conclusions about efficacy for Type 2 diabetes patients and for Type 1 diabetes in a pregnant population o Health professionals interviewed for the assessment felt that the major advantage of the glucose-monitoring devices was the quality of the information available to both the patient and their healthcare provider o Patients found continuous glucose monitors to be an effective tool in managing their glucose levels that led to increased comfort in not having to perform multiple finger pricks a day, improvements in sleep, and increased confidence in making informed life decisions (e.g., taking vacation time) o The current evidence suggests that while glucose-monitoring technologies provide no additional clinical benefits compared to finger prick blood glucose tests, they do provide non-clinical benefits such as added comfort, convenience, and flexibility in diabetes management (1) • A recent overview examining the effectiveness of remote patient monitoring (RPM) on patients with chronic conditions on clinical outcomes and healthcare utilization found that: o RPM interventions made little to no difference on HbA1c levels in patients with diabetes and on systolic blood pressure in patients with hypertension o RPM interventions did not make a difference in hospitalizations, emergency stays, and mental health component of health-related quality of life o insignificant reductions may be related to the need of behaviour change interventions and the use of RPM as a single-component intervention rather than integrating it into multicomponent interventions (3) • A 2018 systematic review analyzed the impact of telehealth remote patient monitoring on glycemic control in patients with Type 2 diabetes and concluded that while current evidence suggests that telehealth is effective in controlling

	HbA1c levels in people with Type 2 diabetes, there is still a need for better quality primary studies and reviews of randomized controlled trials (7) • A medium-quality review from 2014 focused on self-monitoring of blood glucose (SMBG) for people with Type 2 diabetes described seven key elements of RPM interventions: 1) Education for patients 2) Education for providers 3) Use of a structured SMBG profile 4) SMBG goals 5) SMBG data to generate feedback 6) Evidence of feedback provided to patients 7) Evidence of interactive communication and shared decision-making strategies between patients and provider • The review concluded that interventions that used more SMBG elements were found to improve hemoglobin A1C levels (8) • A low-quality review conducted in 2007 assessed the effectiveness of home telemonitoring of patients with diabetes and found that diabetes telemonitoring resulted in significant decreases in glucose levels and foot complications, and that patients responded positively to home telemonitoring due to an increased feeling of security and autonomy (9) *Remote monitoring technologies for patients with cardiac conditions* • A 2021 systematic review assessing the effectiveness of telehealth interventions for remote monitoring and consultations for people with chronic obstructive pulmonary disease (COPD) concluded remote monitoring plus usual care provided through a remote device and followed up by a health professional may not be beneficial overall compared to usual care alone o Given that there is no evidence of harm, telehealth interventions may be beneficial as an additional health resource depending on individual needs based on professional assessment (10) • One medium-quality systematic review conducted in 2018 assessed the effectiveness of non-invasive, automatic, and patient-engaged technologies, such as text messaging, automated messaging system, and behaviour-change phone calls for adults who had a stroke, hypertension, and/or HIV o The review concluded that remote patient monitoring was more effective with patients of low literacy, those early in their disease trajectory, and those who had experienced stressful life events (11) • A recent overview on remote patient monitoring (RPM) and resource use in specialized health services concluded that RPM may result in little to no difference on hospital utilization among adults with cardiovascular disease, chronic obstructive pulmonary disease, or asthma in addition to outpatient visits and follow-up (12) • Another overview of systematic reviews from 2017 found that RPMs involving telemonitoring and home telehealth were generally effective in reducing heart failure, rehospitalization, healthcare utilization, and mortality for cardiovascular disease o The authors identified that integral components of telemonitoring should include physiological monitoring of blood pressure, heart rate, weight, and electrocardiogram (ECG).(13)

	• Two systematic reviews conducted in 2009 of high- and medium quality focused on patients with heart failure and reported that RMTs reduced the overall incidence of hospital readmissions (14; 15)
	• A recent health technology rapid review examined remote-monitoring programs for cardiac conditions in Canada and reported:
	  o Healthcare providers described the benefits of remote patient monitoring (RMP) as aiding in faster clinical decision-making to identify and address health concerns earlier
	  o Acceptability and uptake of remote-monitoring technologies could be enhanced by improving technological literacy, and offering more technical supports to patients and caregivers
	  o Limited evidence about the effectiveness of RMP, and that further evaluation is needed regarding populations in rural or remote settings, are of low socio-economic status, and are racialized or Indigenous (16)
	• A low-quality review conducted in 2009 focused on ways in which telemonitoring can be utilized to assist patient self-monitoring for heart failure signs and symptoms and concluded that telemonitoring may be effective to assist patients living in rural or remote areas who lack access to specialist care to self-monitor heart failure signs and symptoms
	  o The review noted that it could be used to initially support medically unstable patients as they transition to stability, at which point they could be switched to alternative telemonitoring modalities that require less equipment such as telephone touchpads or internet-based interventions (17)
	• A systematic review from 2018 aimed to assess the benefits of using electronic, mobile and telehealth tools for vulnerable patients with chronic disease and explore the mechanisms by which these tools have an impact on patient self-efficacy and self-management
	  o The review found that research involving these tools with vulnerable groups is not comprehensive and that the use of social networks or other eHealth mechanisms to link patients and provide opportunities for vicarious experience could be further explored in relation to vulnerable groups (1)
	• A 2021 realist review aimed to identify factors influencing the effectiveness of remote patient-monitoring interventions for acute care and concluded that RPM interventions have the potential to reduce acute-care use when they are targeted to appropriate populations and disease states, designed well, and implemented with patients and providers in mind (4)
	
	Remote-monitoring technologies for other health conditions
	• A 2018 systematic review examining the application and effectiveness of telehealth interventions to support severe mental illness management concluded that interventions with telephone support from the medical team including phone calls and short text message prompts about medication was effective in improving medication adherence, while reducing severity of mania symptoms and reducing inpatient days (18)
	• A recent systematic review examined remote measurement-based care (RMBC) as a technology to measure patients' psychiatric symptoms outside a clinical context, and concluded that RMBC appears feasible and acceptable and may be a promising intervention for improving mental health care, but additional experimental studies are needed (19)

	• A recent scoping review evaluating mobile health technologies in management of patients undergoing chronic dialysis concluded the mobile health interventions showed neutral to positive results in chronic dialysis patient management (20) • An older systematic review from 2007 examining information systems for patient follow-up and chronic management of HIV and tuberculosis in resource poor areas concluded that effective information systems must play an increasing role in monitoring those two diseases as patient enrolment scales up in resource-poor areas (21) • A 2021 systematic review assessed wearable devices to monitor early symptoms of COVID-19 for post-discharge monitoring to avoid hospital readmission or intervene early to mitigate health impacts o The review found that at the beginning of the pandemic, wearable technology was primarily utilized to track patient symptoms related to fever, high heart rate, cough, and oxygen level o As the pandemic progressed, applications of wearable devices expanded to include wearable sensors that detect airborne pathogens and for the screening, tracking, and prevention of COVID-19 o The authors suggested that use of wearable devices can be supported further by integration with other technologies and/or training and education for primary users (e.g., older adults) for increased digital literacy (22) • A rapid review that aimed to assess the clinical utility and cost-effectiveness of medical devices that support remote monitoring for patients diagnosed with COVID-19 did not identify relevant literature pertaining to the research question (23) • A recent medium-quality meta-analysis conducted in 2021 focused on remote monitoring in post-operative settings and whether its use is associated with post-operative recovery o It reported that the use of mobile health, whether through wearable devices or patient-engaged technologies such as smartphones, for remote patient monitoring was associated with fewer emergency-department visits, readmissions, and improved quality of life after surgery (24) • An older rapid review examining applications of e-health and remote-monitoring for rural residents in Australia, Canada, and the U.S. concluded that e-health has the potential to address clinical needs, meet social and cultural needs, and contribute to overcoming workforce shortages in rural and remote areas, and the authors recommend e-health in rural areas should be introduced alongside changes in management principles, which include a communication strategy to engage clinicians and patients, community consultation, and training (25)
Help with those who are already in residential facilities avoid moving to a more intensive level of care	• A 2019 systematic review aimed to identify advances in aging-in-place technology and assistive technology devices for older adults, and to assess the effectiveness of remote patient monitoring, telecare, smart homes, and artificially intelligent monitoring systems, and found: o There was a preference amongst researchers who focused on smart homes for novel sensor systems and ultrasonic transmitters and receivers, while those researchers who focused on remote monitoring preferred telemedicine equipment and custom wearable devices o Artificial intelligence apps for elderly care and algorithms could improve the accuracy and progress of analytical techniques so that remote monitoring systems will work faster (26)

Patient perceptions and cost-effectiveness of remote-monitoring technologies	• A medium-quality systematic review conducted in 2014 examined older adults' perceptions of patient-engaged and multicomponent technologies, including personal wearable emergency alarms, home automation systems, videoconferencing, robotics, and game consoles, created to be pro-active in preventing falls o Overall, older adults perceived these technologies as positive in terms of their usability, reliability, and increased comfort and confidence of use o The review concluded that training, education and tailoring for individual needs are ways in which the technologies can be further supported for enhanced use (28) • A 2022 rapid review explored continuous multiparameter remote automated monitoring (CM-RAM) technologies to capture biophysical data of patients for clinical teams, and found that CM-RAM was generally acceptable among patients in home, community care, and hospital settings due to comfort, non-intrusiveness and feeling of safety (27) • A medium-quality systematic review of economic evaluations conducted in 2016 aimed to identify the costs associated with remote-monitoring programs for older adults with chronic conditions, such as chronic obstructive pulmonary disease (COPD), congestive heart failure, diabetes, and hypertension o The review found that monitoring a single vital sign cost less than monitoring for multiple vital signs, and remote monitoring programs for respiratory diseases or multiple conditions were associated with higher costs than programs for hypertension or congestive heart failure, and therefore, remote monitoring programs may be preferable for specific chronic conditions from an economic perspective (29) • In addition to examining clinical effectiveness, the 2019 Canadian health technology assessment that we found examined cost effectiveness and the budget impact of using glucose monitors for diabetes patients, and recommended flash glucose monitors as the most cost-effective option and suggested in its budget impact analysis that cost outcomes are sensitive to the size of the population eligible for public funding of glucose monitors, the costs of the glucose monitors, and the size of the predicted market share of each glucose monitoring technology o The assessment also suggested that funding for flash glucose monitors should be provided based on functional, not clinical, need (30) • A protocol for a systematic review that is anticipated to be completed by January 2023 is assessing the use and cost-effectiveness of RMTs to monitor and record the motor symptoms of people living with Parkinson's disease(31)
Barriers and facilitators of the use and/or implementation of remote-monitoring technologies	• A medium-quality systematic review conducted in 2017 focused on weighing facilitators against barriers for implementing telemedicine and found that the most prevalent barriers included lack of evidence, difficulty of patient self-management, added long-term workload commitment, gaps in program design, and lack of evidence on implementation o The review reported that potential mitigation strategies and/or facilitators for implementation and uptake of remote monitoring technologies can include increased access to the technology or telemedicine, quality of the technology, patient knowledge, involvement, convenience of use, and cost-effectiveness (32) • A medium-quality systematic review conducted in 2018 identified barriers for engagement of remote-monitoring technologies in general, that included technical malfunctions and limited internet access or connection, lack of

	knowledge or familiarity with the technology, inadequate tailoring to the disability status of participants, financial costs, and privacy concerns o The review suggests that measures to design remote-technology systems should involve the primary users, such as older adults and caregivers, to facilitate the acceptability, feasibility, and uptake of the technology (34) • A recent systematic review aimed to improve sensor-based defence and attack mechanisms to ensure patient privacy when using mobile health, and provided several challenges related to sensors and their use for security, such as: o Susceptibility to social engineering attacks to retrieve passwords o Usability issues with providing complete authentication to access data o Data collection and analysis o High intra-class variation and imitation threat of physiological biometrics (33)

Table 3: Experiences from other countries with using remote-monitoring and associated technologies to enable people to stay in their homes or existing level of care

Country	Description of remote-monitoring technologies and associated technologies
Australia	*Helping people manage their care at home* • According to the Australian Government, advancements in telehealth, telemedicine, mobile health (mHealth), and remote patient monitoring (RPM) systems in Australia are enabling the decentralization of health care • The Australian Digital Health Agency provides links to healthcare providers who offer telehealth consultations through video or the phone • CareMonitor, a Sydney-based health tech start up, coordinates complex clinical pathways through a real time, multidisciplinary remote-monitoring and telehealth platform that allows healthcare providers to plan and manage patient care electronically o Features of the platform include remote health monitoring of vital signs through Bluetooth enabled devices, decision support tools for allocating care pathways, workflow tools like automated patient reminders and task assignments, and Push health-assessment questionnaires and educational content for patients • Melbourne-based video consulting company, Attend Anywhere, provides remote videoconference technology to facilitate healthcare consultations between healthcare providers and patients across Australia and the United Kingdom o An Attend Anywhere platform provides a central secure gateway for consultations to take place by providing an Attend Anywhere Button for patients to enter the consultation waiting area, wait for the healthcare provider to enter their private waiting area, and meet with the healthcare provider over a web-based videoconference platform called Web Real-Time Communications (Web RTC)
United Kingdom	*Scaling up digital infrastructure to enable remote patient monitoring* • England's NHSX, a joint unit between the NHS and the wider digital economy (e.g., the United Kingdom's Government Digital Service and other government units), is working with seven NHS regions in England to scale digitally enabled healthcare projects at home for people with long-term conditions, including both physical and mental health

	• An example of one of the seven NHS regions includes London, in which five integrated care systems (i.e., different virtual and digital-health agencies and organizations) have come together to develop and coordinate their digital transformation plans to improve the digital infrastructure of care homes and establish remote monitoring technologies to help recognize the deterioration of residents' health • As of September 2020, the launch of a remote monitoring procurement dynamic purchasing system (DPS) will help streamline the process for England's National Health Service (NHS) and social-care organizations to select and use the right remote monitoring platform for patients based on needs • The Spark DPS, run by the Crown's Commercial Services, will enable buyers such as commissioners within NHS England and NHS Improvement, social-care organizations, Clinical Commissioning Groups, Primary Care Networks, NHS Trusts and NHS Special Health Authorities to complete the procurement process in a quick, efficient manner • Last updated 22 February 2022, NHS England's 2022-23 priorities and operational planning guidance sets out plans to adopt new models of care that leverage the full potential of digital technologies, and includes plans for up to 200 million British pounds to be made available to further develop virtual wards, which utilize remote monitoring technology to treat patients at home who would otherwise need hospital treatment • As of 25 June 2020, five digital-health initiatives have been awarded funding in Wales as part of a 150,000 British pounds call to action for new and innovative ways to use digital technology in response to COVID-19 by a panel including NHS Wales, Welsh Government, and digital-health industry representatives • NHS Scotland announced a three-year contract to Inhealthcare, a virtual healthcare provider agency, to support the scaling up of remote monitoring services across Scotland ○ Inhealthcare will provide technologies to enable patients to record information from home and relay readings to NHS teams for analysis to manage COVID-19 and chronic illnesses

United States (California)	*Scaling up digital infrastructure to enable remote patient monitoring*
	• Effective July 1, 2021, remote physiologic monitoring (RPM), also known as remote patient monitoring, was implemented for fee-for-service and managed care beneficiaries with full scope Medi-Cal or pregnancy-only coverage
	  ○ RPM services are provided for established patients ages 21 and older and are reimbursable when ordered by and billed by physicians or other qualified health professionals (QHP)
	• California Telehealth Resource Center developed a remote patient-monitoring toolkit to help California providers and patients optimize RPM for better, more equitable care
	• The 2021-22 California Spending Plan includes US$33.1 million General Fund for health programs ($94.8 million total funds) in 2021-22 to add remote patient monitoring that includes a telehealth service that uses remote monitoring devices to send physiological data on patients to clinicians (as a covered benefit in the Medi-Cal program)
	  ○ Beginning January 2022, the spending plan expands coverage of continuous glucose monitors to Medi-Cal beneficiaries over age 21 with Type 1 diabetes
	  ○ On an ongoing basis, the benefit is projected to result in net General Fund savings in the low millions of dollars due to newly negotiated rebates on the monitors and the reduction in costs for standard blood glucose monitors (finger pricks)

United States (New York)	*Scaling up digital infrastructure to enable remote patient monitoring* • New York Medicaid program covers and reimburses for remote patient monitoring for the following conditions: congestive heart failure, diabetes, chronic obstructive pulmonary disease, wound care, polypharmacy, mental/behavioural problems, technology-dependent care (i.e., continuous oxygen, ventilator care) • New York has private payer policies that includes some level of telehealth coverage or reimbursement o As of March 8 2022, New York continues to have an emergency declaration in place with state telehealth and licensure flexibility

Table 4: Experiences from Canadian provinces and territories with using remote-monitoring and associated technologies to enable people to stay in their homes or existing level of care

Province/territory	Description of remote-monitoring technologies and associated technologies

Pan-Canadian	*Development and financial support for remote-monitoring programs during the COVID-19 pandemic*
	• At the onset of the COVID-19 pandemic, the National Research Council of Canada Industrial Research Assistance Program (NRC IRAP) supported Seamless Mobile Health Inc. (Seamless MD) to pivot its chronic disease management technology to a COVID-19 remote monitoring tool that would require patients to complete a daily symptom survey remotely, and then would provide a recommendation for next steps (e.g., continue isolation or seek medical attention)
	  o Employees of healthcare institutions can also be remotely monitored using this tool to determine whether they should continue isolating or return to work
	  o Seamless MD provides a centralized dashboard and alerts in real time to the patient's healthcare provider or the employer
	  o The remote monitoring tool has been used by St. Joseph's Homecare in Ontario and SE Health, one of Canada's largest home-care agencies
	• In May 2020, the Government of Canada announced that an investment of $200 million would be made to help provinces and territories to accelerate their efforts to provide virtual-care solutions for their residents, including secure information-sharing and videoconferencing platforms, and remote patient-monitoring tools
	  o $50 million of this investment was given to Canada Health Infoway to support the provinces and territories with implementation of new related initiatives
	• According to the government's Policy Framework for Virtual Care, evaluations of the impact of virtual-care services in provinces and territories during the COVID-19 pandemic and for the longer term will be supported by the Centre of Digital Health Evaluation (CDHE) and Women's College Hospital in partnership with Infoway, the Canadian Institute for Health Information (CIHI), and the Canadian Agency for Drugs and Technologies in Health (16)
	  o Through these supports, a pan-Canadian approach through a digital-health evaluation framework will be established as well as a network to enable knowledge translation and conduct evaluations of new digital-health investments
	• The Policy Framework described several "pillars" for the long-term adoption of virtual-care services within Canada's publicly funded health systems: patient- and community-centred approaches, provider remuneration/incentive structures, appropriateness, safety and quality of care, licensure, provider change management, and equity in access to care

British Columbia	*Helping people manage their care at home*
	• Through a $42 million dollar investment from the provincial government, Island Health expanded its existing remote monitoring program to develop the Hospital at Home model, which provides remote patient monitoring, daily in-person visits, virtual visits, and medication management to any acute-care patients who meet the eligibility criteria
	  ○ Patients are provided with appropriate devices, a tablet, and a virtual call bell
	• In October 2021, a collaboration between BC Cancer, the Office of Virtual Care at the Provincial Health Services Authority, and the Ministry of Health led to the implementation of a remote patient-monitoring service using the TELUS Home Health Monitoring platform for cancer patients receiving chemotherapy and radiation therapy for head, neck, or lung cancer
	  ○ Patients are remotely monitored for temperature, heart rate, weight, physical activity, and treatment side effects
	  ○ Patients receive a heart-rate monitor, electronic thermometer, tablet, pedometer, and scale
	• In 2017, the Fraser Health Authority Cardiac Services Program partnered with the BC Alliance on Telehealth Policy and Research to expand the Virtual Cardiac Rehabilitation Program, a remote patient-monitoring approach for patients with ischemic heart disease that was trialed as a research intervention
	  ○ The expansion of the program aimed to provide remote patient-monitoring services for cardiovascular disease patients
	  ○ Patients involved would receive a heart-rate monitor, blood-pressure monitor, weekly education sessions, one-on-one meetings with a nurse, exercise specialist, and dietitian, and monthly group chat sessions
	
	Development and financial support for remote-monitoring programs during the COVID-19 pandemic
	• In May 2020, the Government of Canada agreed to support the province in the development and scale up of remote patient-monitoring technologies as a virtual-care priority during the COVID-19 pandemic under the British Columbia Virtual Care Action Plan, an $18 million dollar investment from the federal government that will build on the province's existing virtual-care initiatives
	• The TELUS Home Health Monitoring platform is a collaboration between the Provincial Health Services Authority and TELUS that provides remote patient monitoring for patients, including tracking vital signs, symptoms or general health, and has been utilized for COVID-19 patients, those with chronic conditions, and those on surgical waitlists

Alberta	*Development and financial support for remote-monitoring programs during the COVID-19 pandemic*
	• As of March 2021, an initiative called the Alberta Central Zone Primary Care Network Home Health Monitoring Project, uses teams of Primary Care Network (PCN) nurses and physicians to remotely monitor care for patients with chronic health conditions within the context of minimizing risk of exposure to COVID-19 and easing stresses on the health system
	  ○ The initiative uses remote monitoring technologies, such as blood pressure cuffs, weigh scales, glucometers, pulse oximeters and thermometers, for patients to monitor their health status at home, and the measurements are stored in an online system monitored by their health team
	  ○ The initiative is a collaboration between the Government of Alberta, Alberta Health Services (AHS), Alberta Central Zone Primary Care Networks (PCNs), Boehringer Ingelheim (2) Ltd., TELUS Health, Alberta Innovates (Alberta's largest research and innovation agency), and Health Cities (a not-for-profit organization that works with clinicians and companies to develop new models of care)

	○ As of July 2020, two Alberta Central Zone Primary Care Networks (PCNs) have successfully trialed the home health-monitoring initiative, and the current phase includes an expansion to six additional central Alberta PCNs
Saskatchewan	*Helping people manage their care at home* • The COPD Home Health Monitoring Program is a pilot program to help patients manage care at home ○ Patients measure and submit health details daily via a program app accessible through a non-invasive device, such as a phone, tablet, or computer ○ The program loans non-invasive devices, such as pulse oximeters, to patients who need them *Development and financial support for remote-monitoring programs during the COVID-19 pandemic* • On May 7, 2020, the Saskatchewan Health Authority announced the expansion of home health monitoring to help patients with chronic conditions avoid hospitalization and emergency-room visits during the COVID-19 pandemic ○ The Saskatchewan Health Authority and eHealth Saskatchewan partnered with Telus Health to expand the Home Health Monitoring system to help clinicians remotely monitor and support patients via a digital-health dashboard and identify patients in need of immediate care ○ Remote patient monitoring is largely being used to monitor lung transplant patients, chronic obstructive pulmonary disease, and support community paramedicine • On January 26, 2021, the Saskatchewan Health Authority announced the expansion of the home-monitoring program to include patients who have tested positive for COVID-19 and are self-isolating • On April 20, 2021, the Government of Saskatchewan announced a bilateral agreement with the Government of Canada that would help to invest in, and expand the use of, virtual healthcare services including: videoconferencing technologies, remote patient monitoring, eHealth, and an auto-dialer system
Manitoba	*Development and financial support for remote-monitoring programs during the COVID-19 pandemic* • The adoption of remote care due to COVID-19 has caused a change in the health system to implement more remote care • In December 2020, the Manitoba government issued a request for proposals to support remote home monitoring for COVID-19 patients discharged from hospital, and for Manitobans managing chronic conditions in the community ○ Remote monitoring solutions would build upon a Virtual Outpatient COVID Monitoring initiative that provides services to patients with COVID-19 who have been discharged ○ Remote monitoring will support patients with COVID-19, chronic obstructive pulmonary disease, and congestive heart failure, with the potential expansion of the service to those with Type 2 diabetes and other chronic conditions ○ The remote monitoring solution would supply in-home biometric health devices, such as thermometers, pulse oximeters, scales, spirometers, and blood-pressure monitors, to support patients in monitoring their health status, and the information will be collected centrally for review by health professionals to monitor results and communicate with patients ○ This would reduce the need for hospital admissions and support faster discharge of patients • An environmental scan conducted in 2021 found that Manitoba did not have a remote-monitoring program, although a program is currently in development ○ Common barriers to implementation included general funding implications from the federal and provincial level, program approach, connectivity and infrastructure considerations, program dissemination considerations at the regional level,

	concerns surrounding the *Personal Health Information Act*, and considerations for the development of a remuneration model for remote activities o Barriers also included a general preference for in-person healthcare, adequate patient management strategies, lack of proficiency with technology, and access to program essentials such as the internet o Facilitators that would contribute to the implementation of a remote-monitoring program include the adoption of a patient-centred approach to care, development of culturally sensitive program tools, and consideration of the development of resources for caregivers o Access to funding for staff to improve patient support, widespread availability of high-speed internet, and the use of electronic medical record metrics would also facilitate the implementation of a remote monitoring program
Ontario	*Helping people manage their care at home* • In April 2021, OntarioMD and Ontario Ministry of Health piloted a remote patient-monitoring program for high-risk patients in Northern Ontario who have lung, heart, and other chronic condition,s through an existing Insights4Care Program (which enables healthcare providers to identify patients for a referral to remote monitoring or the provincial telehomecare program) *Development and financial support for remote-monitoring programs during the COVID-19 pandemic* • Ontario Telemedicine Network (OTN) works to maximize access to specialized care, reduce pressure on hospitals, and modernize consumer access to care • As part of the Fall Preparedness Plan 2020 and the Digital First for Health Strategy, the government invested $14.5 million to support the expansion of virtual care, which includes an investment of $9.5 towards remote patient-monitoring programs delivered by healthcare organizations including Ontario Health Teams o The proposed implementation plan would involve patients connecting with a virtual healthcare provider for routine checkups, symptom monitoring, referrals to specialists, and any further follow-up o The Ministry of Health and Ontario Health are reviewing needs-based application for reviewing virtual-care investment proposals
Québec	*Helping people manage their care at home* • According to a jurisdictional scan conducted in 2018, a home telemonitoring solution established by Jardins-Roussillon Health and Social Services Centre has served elderly clients with cystic fibrosis, hypertension, uncontrolled diabetes, and COPD that lead to a significant reduction in the number of hospitalizations and ER visits, and shorter hospital stays o Through the program, the patient received one-hour of training by a nurse as to how to document health parameters using a touchscreen device, and nursing case managers consult the data and compliance with their individually prescribed care plan o Built-in alerts are automatically generated and pushed out to both the patient and case manager when data falls outside thresholds • The Telehealth Coordination Center Health Monitoring Services aims to provide telehomecare services for clients with one or more complex and/or chronic conditions o Monitoring services are accessed with an online app, and a tablet can also be provided to be used by patients to access telehomecare

	○ A healthcare professional or case worker explains how to access the service and then the professionals analyze patient responses and determine appropriate treatment ○ Advantages included a regular follow-up by a multidisciplinary team of health professionals, a customer approach focused on self-management, potential decrease in complications and emergency visits, and secure communications and confidentiality
New Brunswick	*Helping people manage their care at home* • The province is receiving $5.3 million through a bilateral agreement with the Government of Canada to support remote patient-monitoring technologies • The New Brunswick Extra-Mural Program is a publicly funded provincial government program delivered by Extra-Mural/ Ambulance New Brunswick Inc., that provides primary healthcare services to people in their homes and communities, including remote patient-monitoring services
Nova Scotia	*Help people manage their care at home* • The Department of Health and Wellness provides financial supports in the form of a reimbursement of up to $480 per year to low-income seniors aged 65 and older and adults aged 19 and older with acquired brain injury to assist with the cost of personal alert-assistance services (including falls alert pendants or wrist devices) ○ Additional eligibility requirements include those who live alone, require long-term home-care services, use mobility devices, and have a recent history of falls *Development and financial support for remote-monitoring programs during the COVID-19 pandemic* • The COVID Community Virtual Care Team (CCVCT) provides 24-hour phone support for people who tested positive for COVID-19 ○ Patients who are at high risk for hospitalization or who have recently been discharged from emergency departments are referred to the CCVCT by public health or clinical care units ○ Portable pulse oximeters are provided to patients to monitor oxygen levels at home, twice daily, until they are determined to be in recovery • The Nova Scotia Virtual Care Action Plan was launched as a pilot project to monitor non-severe COVID-19 cases at home ○ Non-invasive devices are to help patients self-manage care at home and provide regular updates about health status to healthcare providers
Prince Edward Island	*Help people manage their care at home* • A report by Canada Health Infoway evaluates the benefits of the Remote Patient Monitoring (RPM) program in PEI ○ After being referred to the program, patients were given an RPM kit and training on how to use the monitoring equipment ○ Patients were monitored remotely for 12 weeks for heart failure and eight weeks for chronic obstructive pulmonary disease (COPD) ○ Heart failure and COPD symptoms and vitals were monitored using a blood-pressure cuff, weight scale, and pulse oximeter ○ Clinical information is transmitted to health care providers through an analog phone line, Wi-Fi, or 3G/4G network ○ RPM nurses interacted with patients for support, advice and coordination of resources, and provided self-management education

	○ Family physicians and nurse practitioners received regular letters with monitored trends for their patients ○ To optimize monitoring, RPM was integrated within existing Health PEI Clinical Information System (CIS) ○ Benefits included a 45% decrease in number of emergency visits post-program; a decrease in total number of acute-care admissions for heart failure patients; a 74% decrease in the total length of stay in acute care; a 19% decrease in the number of primary-care visits; a 38% decrease in MLFH score whereby a lower score reflects improved quality of life; and increased knowledge of the disease condition ○ 92% of participants were highly satisfied with the RPM services they received • On 1 June 2022, the PEI government made a glucose sensor program available to eligible PEI residents that provides glucose sensor technology conveniently at their local pharmacy at a subsidized cost ○ Only specific glucose-sensor supplies are eligible for coverage and the number of sensors provided are based on the wear time of the selected glucose-sensor supplier ○ The out-of-pocket cost to those who are eligible is based on household income and the existence of private insurance ○ Benefits for the program last up to a maximum of one year and must be renewed annually by 30 June
Newfoundland and Labrador	*Helping people manage their care at home* • In 2018-19, the government of Newfoundland and Labrador announced that it would expand the use of the Health at Home program, which helps to reduce the need for travel for thousands of patients and their families by using remote patient-monitoring technology to enable patients to check, record and transmit their personal health indicators (e.g., blood pressure or blood sugar levels) ○ The government also planned to collaborate with the Newfoundland and Labrador Centre for Health Information to develop electronic ordering processes for diagnostic imaging procedures and expand telehealth services into new settings • Eastern Health announced in June 2019 that rural communities on the Northern Peninsula and in Labrador would gain access to remote-monitoring technology through a partnership with Labrador-Grenfell Health to allow healthcare providers to receive accurate health measurements from patients while in their homes ○ This initiative was supported by the province's Department of Health and Community Services and Canada Health Infoway *Development and financial support for remote-monitoring programs during the COVID-19 pandemic* • Work is underway in several government programs for improving remote access to care: ○ An e-ordering solution in the province's electronic health record, HEALTHe NL, is being developed for diagnostic services ○ MyCCath is a web-based referral system for cardiac catheterization services that has been deployed provincially through HEALTHe NL to help expedite referrals for cardiac procedures • Another collaborative initiative of the province and Canada Health Infoway is the Telepathology Network which will enable all healthcare providers across the province to share and store digital pathology images electronically, as well as other related data on a secure computer system • On 6 August 2021, the Government of Canada announced a bilateral agreement with the province to invest over $4.5 million to expand virtual healthcare services, including remote-monitoring technologies
Yukon	*Help people manage their care at home* • Yukon offers virtual health monitoring for chronic conditions through the Chronic Conditions Support Program

	○ After being assessed for suitability, the client will be supplied with a 'Connected Health Kit' from Cloud DX that includes an android tablet, a wrist blood pressure cuff, Bluetooth body weight scale, and Bluetooth pulse oximeter to connect to a tablet and record the client's vitals ○ The client will record their blood pressure, heart rate, body weight, oxygen saturation levels on the Cloud DX software platform and reply to clinical symptom surveys *Development and financial support for remote-monitoring programs during the COVID-19 pandemic* • An online self-assessment tool to help Yukoners determine if they need to be tested for COVID-19 is now available ○ The screening tool asks a series of questions and takes users through steps to help determine whether they should call the HealthLine at 811 or take other actions • 1Health initiative will give Yukoners access to modern health technologies, including a patient portal, which provides them with direct access to their health information ○ The patient portal will enable virtual visits with and between providers, secure message exchange, remote client monitoring and telehealth services
Northwest Territories	*Development and financial support for remote-monitoring programs during the COVID-19 pandemic* • On May 2020, the federal government committed $3.11 million to the Northwest Territories to support virtual care and remote patient monitoring • Northwest Territories entered into a Bilateral Agreement with Canada to deploy virtual-care solutions and remote-monitoring technologies to ensure Canadians can continue to access high-quality care during COVID-19
Nunavut	*Development and financial support for remote-monitoring programs during the COVID-19 pandemic* • On May 2020, the government committed $3.11 million to Nunavut to support virtual care and remote patient monitoring • The federal government's Rapid Adoptions Virtual Care Fund allocation of $1 million in funding to Nunavut led to a series of projects that expanded access to virtual-care supports for residents in the province, including messaging and videoconferencing platforms and remote patient monitoring • Nunavut entered into a Bilateral Agreement with Canada to deploy virtual-care solutions to ensure Canadians can continue to access high-quality care during COVID-19 ○ It was agreed to allocate funds provided by Canada under this Agreement toward remote patient-monitoring technologies

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APPENDICES

The following tables provide detailed information about the systematic reviews and primary studies identified in the rapid synthesis. The ensuing information was extracted from the following sources:

- systematic reviews - the focus of the review, key findings, last year the literature was searched, and the proportion of studies conducted in Canada; and
- primary studies - the focus of the study, methods used, study sample, jurisdiction studied, key features of the intervention and the study findings (based on the outcomes reported in the study).

For the appendix table providing details about the systematic reviews, the fifth column presents a rating of the overall quality of each review. The quality of each review has been assessed using AMSTAR (A Measurement Tool to Assess Reviews), which rates overall quality on a scale of 0 to 11, where 11/11 represents a review of the highest quality. It is important to note that the AMSTAR tool was developed to assess reviews focused on clinical interventions, so not all criteria apply to systematic reviews pertaining to delivery, financial or governance arrangements within health systems. Where the denominator is not 11, an aspect of the tool was considered not relevant by the raters. In comparing ratings, it is therefore important to keep both parts of the score (i.e., the numerator and denominator) in mind. For example, a review that scores 8/8 is generally of comparable quality to a review scoring 11/11; both ratings are considered "high scores." A high score signals that readers of the review can have a high level of confidence in its findings. A low score, on the other hand, does not mean that the review should be discarded, merely that less confidence can be placed in its findings and that the review needs to be examined closely to identify its limitations. (Lewin S, Oxman AD, Lavis JN, Fretheim A. SUPPORT Tools for evidence-informed health Policymaking (STP): 8. Deciding how much confidence to place in a systematic review. *Health Research Policy and Systems* 2009; 7 (Suppl1):S8).

All of the information provided in the appendix tables was taken into account by the authors in describing the findings in the rapid synthesis.

Appendix 1: Summary of highly relevant findings from systematic reviews and other types of reviews about remote-monitoring technologies and associated technologies that enable people to stay in their homes or existing level of care

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

Guidelines	American Association of Clinical Endocrinology clinical practice guideline: The use of advanced technology in the management of persons with diabetes mellitus (5)
	
	• What types of remote-monitoring technologies can be used?
	  o Non-invasive and automatic (e.g., wearable devices)
	  o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  o People with one or more conditions
	  ▪ Diabetes
	• In what health-system sectors can remote-monitoring technologies be used?
	  o Home and community care
	  o Primary care
	• For what purpose or goal(s) can it be used?
	  o Help people manage their care needs at home for as long as possible
		The aim of this clinical practice guideline by the American Association of Clinical Endocrinology (AACE) is to provide evidence-based recommendations for the use of advanced technology by clinicians, diabetes-care teams, healthcare professionals, and other stakeholders in the management of persons with diabetes mellitus.
		
		AACE conducted literature searches and a task force of medical experts convened by the AACE Clinical Practice Guidelines Oversight Committee and AACE Board of Directors developed recommendations based on a review of clinical questions, expertise, and a discussion to achieve unanimous consensus for each of the recommendations.
		
		The recommendations are intended to address key topics and relevant questions for determining the evidence behind the efficacy and safety of devices standards for clinicians and other healthcare professionals to use advanced diabetes technology in the management of persons with diabetes. The AACE task force concluded that advanced diabetes technology can be integrated safely and effectively into the care of persons with diabetes, alongside a personalized approach to self-management.
			Published 1 June 2021	Not applicable	Not applicable

	Glucose monitoring technologies for the management of insulin-dependent diabetes (30) • What types of remote-monitoring technologies can be used?	This guideline provides literature search findings and recommendations from a Canadian provincial health technology assessment on the clinical effectiveness, patient perspectives, cost-effectiveness, and the budget impact of using glucose monitors, such as continuous glucose monitors, flash glucose monitors, and hybrid closed loop insulin delivery systems to help manage glucose levels in insulin-dependent patients with Type 1 or Type 2 diabetes.	Published June 2019	Not applicable	4/10

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	○ Non-invasive and automatic (e.g., wearable devices) ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) • Who can use remote-monitoring technologies? ○ People with one or more conditions ▪ Diabetes • In what health-system sectors can remote-monitoring technologies be used? ○ Home and community care ○ Primary care • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible	The following methods were used to gather and synthesize the available evidence and recommendations by the Health Technology Assessment unit at University of Calgary and the Health Technology Assessment Office of British Columbia, Canada: 1) systematic review of the clinical validity of using time in range as a surrogate marker; 2) systematic review and grey literature review of health technology assessments; 3) systematic review on clinical effectiveness of continuous glucose monitors for the management of glucose levels in patients with insulin dependent diabetes (Type 1 and Type 2); 4) review of guidelines and best practice recommendations; 5) systematic review of patient perspectives literature; 6) environmental scan across Canada; 7) key informant interviews and patient focus groups; 8) implementation scenarios; and 9) budget impact analysis. The following recommendations were derived from the assessment: • The current evidence suggests that glucose monitoring technologies, including continuous glucose monitors, flash glucose monitors, and hybrid closed loop insulin delivery systems, provide no additional clinical benefits compared to finger prick blood glucose tests, but provide non-clinical benefits such as added comfort, convenience, and flexibility in diabetes management. Therefore, it is recommended for funding to include flash glucose monitors, the most cost-effective option assessed • Funding for flash glucose monitors be provided based on functional, not clinical, need • Reviewing glucose monitoring technologies again when compelling new evidence of their clinical benefits becomes available Additionally, some of the key findings were as follows: • A systematic review and a series of network meta-analyses were conducted on the comparative clinical effectiveness of finger prick glucose tests, continuous glucose monitors, flash glucose monitors, and hybrid insulin delivery systems for the management of insulin-dependent diabetes. For children and adults with Type 1 diabetes, no significant differences were found between glucose monitoring methods for HbA1c or number of hypoglycemic events requiring assistance. Due to limited evidence, no conclusions about efficacy could be drawn for Type 2 diabetes and for Type 1 diabetes in a pregnant population			

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
		• Health professionals interviewed felt the major advantage of the glucose-monitoring devices was the quality of the information available to both the patient and their healthcare provider • Patients found continuous glucose monitors to be an effective tool in managing their glucose levels, such as increased comfort in not having to perform multiple finger pricks a day, improvements in sleep, and increased confidence in making informed life decisions (e.g., taking vacation time) • Budget impact analysis suggests cost outcomes are sensitive to size of the population eligible for public funding of glucose monitors, the costs of the glucose monitors, and the size of the predicted market share of each glucose monitoring technology			

Systematic reviews	Remote patient monitoring and resource use in the specialized health service: An overview of systematic reviews (12)
	
	• What types of remote-monitoring technologies can be used?
	  o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  o People with one or more conditions
	  ▪ Cardiovascular disease
	• In what health-system sectors can remote-monitoring technologies be used?
	  o Home and community care
	  o Primary care
	• For what purpose or goal(s) can it be used?
	  o Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts
		The review describes RPM as technological devices with the ability to be followed up by healthcare services at home. The review found six systematic reviews that studied the effects of RPM of adults with chronic diseases on healthcare utilization (e.g., hospitalization, hospital stay, consultations, outpatient visits and follow-up, emergency-department visits).
		
		The authors found that there was little to no difference in hospitalization and emergency-department visits for adults with cardiovascular disease. However, they did find that it may reduce hospitalization for adults with asthma and length of stay for adults with chronic obstructive pulmonary disease. Overall, the review concluded that RPM may result in little to no difference on utilization among adults with cardiovascular disease, chronic obstructive pulmonary disease, or asthma, in addition to outpatient visits and follow-up. The authors acknowledged that future high-quality research may change their results.
			Published 12 January 2022	Not applicable	Not reported

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	Mobile health technology for remote home monitoring after surgery: A meta-analysis (24) • What types of remote-monitoring technologies can be used? o Non-invasive and automatic (e.g., wearable devices) o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) • In what health-system sectors can remote-monitoring technologies be used? o Acute/specialty care • For what purpose or goal(s) can it be used? o Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts	This meta-analysis examined how mHealth has been used for remote patient monitoring in post-operative settings and whether its use has been associated with differences in post-operative recovery. The authors specified that mHealth for remote patient monitoring has previously been used to maintain communication between patients and their clinical team after hospital discharge, to increase the likelihood of early identification of complications, and decrease morbidity and mortality rates post-discharge. mHealth was defined as any tablet computer or smartphone that was able to collect and transmit health-related patient data to their clinical team wirelessly, including devices that recorded physiological data or patient-reported outcomes. The review included 45 studies that primarily involved mHealth for remote patient monitoring for orthopedic (n=11) and hepatobiliary/oncological procedure patients (n=7). The review found that the types of mHealth devices utilized most frequently for remote patient monitoring post-discharge included smartphones (n=30), tablet computers (n=5), pedometers/ accelerometers (n=9), and vital-signs monitors including blood pressures (n=7), oxygen saturation (n=7), and heart-rate monitors (n=5). Most devices collected data daily (n=25). Twenty-two of the studies collected actively reported data (defined as direct patient input) related to pain, nausea, quality of life, and adherence. Other studies reported indirect outcomes (defined as passively reported) including vital signs (n=11), step counts (n=9), and lab testing (n=2). Lastly, some studies had mHealth technology that enabled users to submit photos of their surgical wound (n=12). The authors found that the use of mHealth for remote patient monitoring was associated with fewer emergency-department visits, readmissions, and improved quality of life after surgery. As a result, the authors support remote home monitoring using mHealth as feasible and effective for post-operative care.	Published 18 October 2021	8/11 (AMSTAR rating from McMaster Health Forum)	6/45
	The rise of wearable devices during the COVID-19 pandemic: A systematic review (22) • What types of remote-monitoring technologies can be used? o Non-invasive and automatic (e.g., wearable devices) • For what purpose or goal(s) can it be used? o Post-discharge monitoring to avoid hospital readmission or	This review aimed to identify the types of wearable technology that have been used for the remote monitoring of COVID-19 symptoms and the challenges associated with their use. The review focused on wearable devices and unobtrusive sensing technologies that have the capability to monitor early symptoms of COVID-19 and common health conditions. This included telehealth monitoring systems. Seventy articles were included in the review. The authors found that at the beginning of the pandemic, wearable technology was primarily utilized to track patient symptoms related to fever, high heart rate, cough, and oxygen level. As the pandemic progressed, applications of wearables expanded to include wearable sensors that detect airborne pathogens and for the screening, tracking, and	Published 28 August 2021	2/9 (AMSTAR rating from McMaster Health Forum)	Not specified

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	intervene earlier to mitigate health impacts • How can the use of remote-monitoring technologies be supported? o Integration with other technologies (e.g., electronic health records or virtual-care technologies) o Training and education (including for enhanced overall digital literacy)	prevention of COVID-19. In addition, wearable technology incorporated sensors for temperature, pulse oximeters, respiratory rate, cough and lung sound monitoring, electrocardiogram for monitoring of COVID-19 patients, and blood pressure monitoring. Potential barriers associated with the use of wearable technology included technical issues, social interruptions, and regulatory considerations. The authors conclude that consideration of user preferences in the design of wearable devices, the use of fifth generation networking technology (5G), and technological awareness and education for the elderly are solutions to existing challenges.			
	Factors influencing the effectiveness of remote patient-monitoring interventions: A realist review (4) • What types of remote-monitoring technologies can be used? o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) • Who can use remote-monitoring technologies? o People with one or more conditions ▪ Cardiovascular disease • For what purpose or goal(s) can it be used? o Help people manage their care needs at home for as long as possible	This study aims to identify factors of RPM interventions that relate to increased and decreased acute care use, and to) develop recommendations for future RPM intervention design and implementation. The study found 31 factors that have an impact on the effectiveness of RPM innovations on acute-care use. These were synthesised into six theories of intervention success: (1) targeting populations at high risk; (2) accurately detecting a decline in health; (3) providing responsive and timely care; (4) personalizing care; (5) enhancing self-management; and (6) ensuring collaborative and coordinated care. The authors concluded that RPM interventions have the potential to reduce acute-care use when they are targeted to appropriate populations and disease states, designed well, and implemented with patients and providers in mind.	Published 25 August 2021	3/9 (AMSTAR rating from McMaster Health Forum)	Not reported
	Telehealth interventions: Remote monitoring and consultations for people with chronic obstructive pulmonary disease (COPD) (10) • What types of remote-monitoring technologies can be used?	This systematic review assessed the effectiveness of telehealth interventions that allow remote monitoring, consultation, and multicomponent interventions for reducing exacerbations, improving quality of life, and reducing service utilization and death among people with chronic obstructive pulmonary disease (COPD). The review included 29 studies and most remote-monitoring interventions included required participants to transfer measurements using a remote device, and later a health professional review (asynchronous). Only five included interventions transferred data and allowed review by health professionals in real	Published 20 July 2021	10/11 (AMSTAR rating from McMaster Health Forum)	Not reported

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	○ Non-invasive and automatic (e.g., wearable devices) ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) ○ Multicomponent • Who can use remote-monitoring technologies? ○ People with one or more conditions ▪ Other • In what health-system sectors can remote-monitoring technologies be used? ○ Home and community care ○ Primary care • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible ○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts	time (synchronous). No evidence was found on comparison of remote consultations with or without usual care. The authors concluded that remote monitoring plus usual care provided asynchronously may not be beneficial overall compared to usual care alone. The findings showed no difference in fatalities when remote monitoring is provided in addition to usual care. Remote monitoring interventions alone are no better than usual care overall for health outcomes. Multi-component interventions with asynchronous remote monitoring are no better than usual care, but may provide short-term benefit for quality of life and may result in fewer readmissions to hospital for any cause. Lastly, the authors stated that given there is no evidence of harm, telehealth interventions may be beneficial as an additional health resource depending on individual needs based on professional assessment.			
	Managing chronic illnesses with remote patient monitoring in primary healthcare: An overview of overviews (3) • What types of remote-monitoring technologies can be used? ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) • Who can use remote-monitoring technologies?	The review examined the effectiveness of remote patient monitoring (RPM) for patients with chronic conditions on clinical outcomes and healthcare utilization. The authors described RPM as the ability to transmit health data, evaluation, and follow-up between patients and providers that may involve phones, mobile phones, videos, and portable/implantable devices, with information transmitted at least twice a year. The review included 11 randomized controlled trials of patients with diabetes and/or hypertension between aged 50 to 70. Most of the RPM were used in primary health services that included feedback from providers. The authors reported that RPM was used in various ways related to data transmission (e.g., commercial telehealth units, existing landlines) and who assessed the patient (e.g., providers, monitoring centres, or the RPM device). Most of the randomized controlled trials illustrated that patients were followed up if there were any major concerns. Most randomized controlled trials did not	Published 3 July 2020	Not applicable	0/11

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	○ People with one or more conditions ▪ Cardiovascular disease ▪ Diabetes • In what health-system sectors can remote-monitoring technologies be used? ○ Primary care • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible	adequately describe usual care, which made it difficult to compare to the intervention. The review found that RPM made little to no difference on HbA1c levels in patients with diabetes and on systolic blood pressure in patients with hypertension. Additionally, RPM did not make a difference in hospitalizations, emergency stays, and mental health component of health-related quality of life. The authors concluded that the insignificant reductions may be related to the need for behaviour-change interventions, and that RPMs were used as a single-component intervention instead of being integrated into multicomponent interventions. The authors noted that RPMs have the potential to be tailored, but this requires further qualitative research to understand how, why, and when RPMs are most useful.			
	Intervention and evaluation of mobile health technologies in management of patients undergoing chronic dialysis: Scoping review (20) • What types of remote-monitoring technologies can be used? ○ Non-invasive, automatic, and wireless (wearable) • Who can use remote-monitoring technologies? ○ Caregivers ○ People with one or more conditions • In what health-system sectors can remote-monitoring technologies be used? ○ Home and community care • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible	This scoping review identified the gaps in patient outcome assessment of mobile-health (mHealth) technologies in adult patients undergoing chronic dialysis. mHealth technology refers to the "wireless devices and sensors (including mobile phones) that are intended to be worn, carried, or accessed by the person during normal daily activities." Twenty-two studies in seven countries outlined mHealth interventions with the purposes of nutrition or dietary self-monitoring (seven studies), remote biometric monitoring (seven studies), web-based portal (four studies), self-monitoring of in-session dialysis information (three studies), and self-monitoring of lifestyle or behavioural change (one study). Evaluation of the mHealth interventions has demonstrated increased patient satisfaction and user acceptance. A consistent high rating of acceptability was found in studies for self-monitoring of nutrition, in-session dialysis-specific information, RPM, and online portals. One study reported positive feedback from nurses, referring to it as a "time-saving tool" and another study showed improved interaction with patients as a result of mHealth interventions. Using RPM was associated with increased confidence in healthcare activities and reduced negativity toward dialysis. One study reported a significant change in high serum parathyroid hormone, and another study showed differences in unfiltered ultrafiltration rate, duration on dialysis, and blood pressure between intervention and control groups. Four of five studies reported a decrease in calcium and sodium intake, and an increasing dietary self-efficacy. One study showed no significant difference in physical-activity levels when the intervention group was given a fitness tracker with feedback.	Published 3 April 2020	4/9 (AMSTAR rating from McMaster Health Forum)	2/22

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	• How can the use of remote-monitoring technologies be supported? ○ Financial supports	Four studies reported significant cost savings per study day by reduced number of hospital or ER visits and fewer hospital days, reduced frequency of nurse phone calls for medical alerts, reduced outpatient visit claim payments, lower medication cost, reduced use of health resources, and cost savings to healthcare services. This review concluded that mHealth interventions showed neutral to positive results in chronic dialysis patient management.			

	Innovative assisted living tools, remote monitoring technologies, artificial intelligence-driven solutions, and robotic systems for aging societies: Systematic review (26)
	
	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and automatic (e.g., wearable devices)
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	  ○ Multicomponent
	• Who can use remote-monitoring technologies?
	  ○ Older adults
	  ○ Frail older adults
	  ○ People with one or more conditions
	  ▪ Alzheimer's
	  ▪ Other
	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Home and community care
	  ○ Acute/specialty care
	  ○ Long-term care
	  ○ Rehabilitation
		The aim of this review was to identify advances in aging-in-place technology and assistive technology devices for seniors, and to determine the level of evidence on remote patient monitoring, telecare, smart homes, and artificially intelligent monitoring systems. In total, 91 articles were included, with data that was categorized into four themes – technology acceptance and readiness, intelligent algorithm and software engineering, novel patient monitoring and smart home technologies, and robotic technologies. Most articles (85%) were found to have poor reference standards without a critical appraisal, and the majority of publications were qualitative.
		
		In terms of trends in aging-in-place technology research, most studies between 2000 and 2010 were designed to examine older adults' perceptions of technology while studies after 2010 explored new smart home technologies using sensors and the development of assistive robots, AI technologies, and machine learning systems for the elderly. The review revealed that there was a preference amongst researchers who focused on smart homes for novel sensor systems and ultrasonic transmitters and receivers, while those researchers who focused on remote monitoring preferred telemedicine equipment and custom wearable devices.
		
		Several of the included studies focused on developing technological solutions for specific groups of elderly adults such as Alzheimer's patients living in nursing homes or independent adults living at home alone. Some of the technologies explored by researchers included virtual reality, a telediagnosis system for early detection of Alzheimer's disease, a web-based home monitoring system for Parkinson's disease patients, a predictive model for assistive technology adoption for dementia patients, and telepresence robots with sensor network infrastructure to vital signs. The review also highlighted that AI apps for elderly care and algorithms could improve the accuracy and progress of analytical techniques so that remote monitoring systems will work faster.
			Published 29 November 2019	3/9 (AMSTAR rating from McMaster Health Forum)	Not reported

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	• For what purpose or goal(s) can it be used?
	  ○ Help people manage their care needs at home for as long as possible
	  ○ Help with those who are already in residential facilities avoid moving to a more intensive level of care
	  ○ Enable patient- and caregiver-friendly care in long-term care and allow residents to avoid hospital admission
	  ○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts
	  ○ Enhance safety (e.g., falls prevention)				

	Sensor-based mHealth authentication for real-time remote healthcare monitoring system: A multilayer systematic review (33)
	
	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and automatic (e.g., wearable devices)
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	  ○ Multicomponent
	• For what purpose or goal(s) can it be used?
	  ○ Help people manage their care needs at home for as long as possible
		This study aimed to improve sensor-based defence and attack mechanisms to ensure patient privacy when using mHealth, a telemedicine-based remote monitoring system. To achieve this, two layers of review were conducted. First, a search for evidence about security and privacy issues of sensor-based telemedicine applications was conducted to establish a literature taxonomy. Secondly, literature on sensor-based smartphone authentication was reviewed.
		
		Included studies from the first layer of review (n=19) were separated into two categories: 1) sensor-based telemedicine articles and their applications (n=11/19); and 2) telemedicine articles involving three tiers of security and privacy (n=8/19). In the three-tier telemedicine system, Tier 1 referred to users receiving data on their vital signs through wireless sensors, Tier 2 involved user data being sent to a personal gateway (e.g., Smartphone) through a wireless body area network (WBAN) and then to Tier 3, a healthcare provider in a medical institute.
		
		Several sensor-based applications were identified from the first layer of reviews:
		• Tier 1 applications included: TinyECC, which is an algorithm with optimizations for resource-constrained hardware platforms; a system for the secure logging of events in sensor networks; a protocol for ultra-wideband impulse radios that provided multiple layers of security; a proposal for a
			Published 6 January 2019	2/9 (AMSTAR rating from McMaster Health Forum)	0/19 for first layer of review
					
					0/81 for second layer of review

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
		priority-based compressed data aggregation scheme; and the IEEE 802.15.6-based communication system using UP. • One Tier 2 application was found, which was a priority-based health data aggregation (PHDA) scheme with privacy preservation for cloud-assisted WBANs. • Tier 3 applications included architecture for collecting and assessing data from sensor networks that facilitated easy information sharing and had an effective and flexible security mechanism, and a machine-to-machine low cost and secure communication system for e-Health. A total of 81 articles were included in the second layer of reviews on sensor-based smartphone applications and were analysed based on three research categories – defence, attack, and others. • In terms of defence, sensor-based authentication was identified under use of orientation sensors to assess human behaviour patterns (e.g., walking style), use of the fingerprint sensor, use of the touchscreen sensor, and use of the camera sensor. • Under the attack category, display TapLock was used in the included studies as a mobile phone secret key framework. • The other applications were either beyond scope or were not included in the previous categories. The review highlighted specific benefits of smartphone authentication, including the protection of sensitive personal data as more people use smartphones and become vulnerable to privacy and security breaches. Biometrics is generally considered a more reliable authentication measure than non-biometric methods. The review also provided several challenges related to sensors and their use for security. These included susceptibility to social engineering attacks to retrieve passwords, usability issues with providing complete authentication to access data, data collection and analysis, and high intra-class variation and imitation threat of physiological biometrics. Recommendations were made for users, developers for addressing these challenges.			
	Barriers to and facilitators of engagement with remote measurement technology for managing health: Systematic review and content analysis of findings (35)	The aim of this systematic review was to update and extend previous understanding of the barriers to and facilitators of people using remote measurement technology (RMT) approaches to manage their health. The review defined RMT as the use of mobile health technology to measure change in health status in real time. A total of 33 articles published from January 2014 to May 2017 were included. Participants in the studies ranged in age from 8 to 95 and had one or more health conditions, and the studies took place in 10 countries for	Published 7 December 2018	5/10 (AMSTAR rating from McMaster Health Forum)	1/33

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and automatic (e.g., wearable devices)
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	  ○ Multicomponent
	• Who can use remote-monitoring technologies?
	  ○ People with one or more conditions
	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Home and community care
	  ○ Primary care
		one to 13 months. Most of the studies used active RMT (n=17), including smartphone-based systems and wireless monitoring devices, and 10 studies used both active and passive RMT. In total, 27 studies employed quantitative methods with significant variation across studies to identify barriers and facilitators of using RMT systems, and six studies used purely qualitative methods.
		
		The identified barriers and facilitators were categorized into five themes – health status, usability, convenience and accessibility, perceived utility, and motivation. Barriers included change in environment due to health conditions (e.g., moving from home to hospital), poor vision, technical malfunctions (e.g., missing notifications, app freezing), lost or damaged devices, changes to service plans, incompatibility with existing routines, lack of wi-fi or poor internet connection, lack of knowledge or familiarity, forgetfulness, inadequate tailoring to the disability status of participants, financial costs, privacy concerns, and lack of motivation. Facilitators of using RMT systems included clarification of information, the speed of the system, use of larger devices (e.g., tablets), passive or automatic data collection, notifications, incentives for participation, and participants' intrinsic motivation to learn and sustain engagement.
		
		Using the themes of the review, the authors built a model of the most prominent influences on RMT engagement. They indicated that engagement with the model may be strongest when the user is able to use the technology, finds the technology to be useful, and wants to use the technology. Dropout was identified as a clear indicator of issues with engagement, with barriers to usability being identified as the most frequent reason, and barriers to convenience and acceptability being the second most frequent reasons for disengagement.
		
		The authors suggest that improvements are needed in how the impacts of modifiable variables on engagement are measured, and that RMT systems need to be codesigned with those individuals who will be using them so that they can be acceptable and feasible to use over a long period of time. The study's model indicates the inter-relationship between key facilitators of engagement and the person, and RMT factors that could act as a prototype for the development of RMT in the future.			

	Application and effectiveness of telehealth to support severe mental illness management: Systematic review (18)	This review identified the uses and efficacy of remote patient-monitoring (RPM) technology for severe mental illness. The review defines telehealth as telephones, mobile phones, computers, remote sensors, the internet, and other devices which provide immediate real-time information to service users to improve the management of chronic health conditions.	Published 21 November 2018	7/10 (AMSTAR rating from McMaster Health Forum)	0/31

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  ○ Older adults
	  ○ Caregivers
	  ○ People with one or more conditions
	  ▪ Other
	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Home and community care
	  ○ Acute/specialty care
	• For what purpose or goal(s) can it be used?
	  ○ Help people manage their care needs at home for as long as possible
		The review included 31 studies which reported 29 trials evaluating the use of computers to deliver cognitive rehabilitation (15 trials), patient education (three trials), web-based self-management interventions (two trials), and support consultations (one trial). Virtual reality was used to simulate work and social situations (two trials) and to deliver cognitive training (one trial). Telephones were used to prompt users to take medications (three trials), and to report symptoms to their healthcare team (one trial). Remote sensors were used to monitor medication use in one trial. Seventeen trials focused on patients with schizophrenia, nine on people with schizophrenia or schizoaffective disorder or psychotic disorder, and three on people with bipolar disorder.
		
		The authors report that telephone support was effective in enhancing adherence to medication and reducing symptom severity and inpatient days. Telephone support also reduced positive schizophrenia symptoms compared to a control group. Telemonitoring of symptoms led to fewer inpatient days, and better adherence to atypical antipsychotic use.
		
		Eleven of 15 studies measuring the impact of computer-assisted cognitive rehabilitation (CACR) found statistically significant improvements in improving cognitive function. Two of four studies analyzing the effectiveness of CACR on schizophrenia symptoms found a beneficial effect on negative symptoms. Two of five trials of CACR found a beneficial effect on social adjustment and social cognition (defined as awareness of relationship). Others found no effect of CACR on social autonomy, social professional and family functioning, or social cognition. CACR also improved satisfaction with health care in one trial.
		
		Virtual reality was effective in improving work-related behaviour, conversational skills, assertiveness, and cognitive functioning. The effect of telehealth on other outcomes was inconsistent.
		
		The authors concluded that interventions with telephone support from the medical team including phone calls and short text message prompts about medication was effective in improving medication adherence, while reducing severity of mania symptoms and reducing inpatient days. Few studies evaluated the use of remote medication telemonitoring, but web-based self-management, and hand-held devices and were effective in improving some psychosocial and behavioural outcomes. Patient preferences should be accommodated to determine whether computer-based methods will be effective for them.			

	Electronic, mobile and telehealth tools for vulnerable patients with chronic	This review aimed to assess the benefit of using electronic, mobile and telehealth tools for vulnerable patients with chronic disease, and explore the mechanisms by which these tools have an impact on patient self-efficacy and self-management.	Published 29 August 2018	5/9 (AMSTAR rating from	1/18

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	disease: A systematic review and realist synthesis (1)
	
	• What types of remote-monitoring technologies can be used?
	  o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  o People with one or more conditions
	  ▪ Cardiovascular disease
	  ▪ Diabetes
	  ▪ Other
	• In what health-system sectors can remote-monitoring technologies be used?
	  o Home and community care
	• For what purpose or goal(s) can it be used?
	  o Help people manage their care needs at home for as long as possible
		After searching evidence from 2009 to 2018, quality was assessed according to rigour and relevance. Studies with a richer description were synthesized using a realist matrix. Eighteen trials were identified.
		
		Most of the interventions sought to persuade vulnerable patients into believing they "could self-manage their conditions through improved symptom monitoring, education and support, and goal setting. The patients were relatively passive in the interaction, and the level of patient response attributed to their intrinsic level of motivation." Health literacy, which may be confounded with motivation, and eHealth literacy were measured in one and zero studies, respectively.
		
		This paper found that research involving these tools with vulnerable groups is not comprehensive. Aside from intrinsic motivation, health literacy may also influence the reaction of these groups to technology. The interventions primarily used social persuasion when seeking to achieve better self-management. "Efforts to engage patients by healthcare providers were lower than expected. Use of social networks or other eHealth mechanisms to link patients and provide opportunities for vicarious experience could be further explored in relation to vulnerable groups. Future research could also assess health and eHealth literacy and differentiate the specific needs for vulnerable groups when implementing health technologies."
				McMaster Health Forum)	

	Measuring psychiatric symptoms remotely: A systematic review of remote measurement-based care (19)
	
	• What types of remote-monitoring technologies can be used?
	  o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  o People with one or more conditions
	  ▪ Other
		This review examined remote measurement-based care (RMBC) as a technology to measure patients' psychiatric symptoms outside the context of a clinical encounter.
		
		The authors identified 36 studies that measured patients' psychiatric symptoms remotely and provided feedback to treatment providers. Potential studies were excluded for not including a treatment, not tracking psychiatric symptoms, not providing feedback to a provider, not providing quantitative data, not including individuals experiencing psychiatric symptoms, or providing redundant data with included studies. The final sample included 42 studies representing 36 unique samples.
		
		The study found evidence supporting the short-term feasibility and acceptability of RMBC, although long-term sustainability was less clear. Thirteen randomized controlled trials were identified. RMBC was typically implemented as part of a
			Published 28 August 2018	4/10 (AMSTAR rating from McMaster Health Forum)	Not reported

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Home and community care
	• For what purpose or goal(s) can it be used?
	  ○ Help people manage their care needs at home for as long as possible
		multicomponent intervention (e.g., internet-based cognitive behavioural therapy with feedback to provider). Three studies experimentally isolated the clinical effects of RMBC, with two reporting no statistically significant differences between the RMBC and control conditions, and one reporting greater symptom improvement associated with RMBC
		
		The authors concluded the RMBC appears feasible and acceptable, and may be a promising intervention for improving mental health care, but additional experimental studies are needed.			

	Cost-effectiveness analysis of real-time continuous monitoring glucose compared to self-monitoring of blood glucose for diabetes mellitus in Spain (36)
	
	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and automatic (e.g., wearable devices)
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  ○ People with one or more conditions
	  ▪ Diabetes
	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Home and community care
	• For what purpose or goal(s) can it be used?
	  ○ Help people manage their care needs at home for as long as possible
		This review assessed the effectiveness of real-time continuous glucose monitors (RT-CGM) on the reduction of HbA1c levels and severe hypoglycaemic (i.e., which require the assistance of another person) and ketoacidosis events.
		
		The authors re-reviewed the same 91 articles included in their original RPM systematic review, using realist review methodology to identify factors that determine intervention success and failure in various contexts. Inclusion criteria were: randomized controlled trials of at least eight weeks of follow-up; that compared RT-CGM (plus SBGM) to SBGM alone on the reduction of HbA1c levels and/or severe hypoglycaemic events; and patients in experimental and control groups used the same method of insulin delivery (or percentages of patients using the same method were similar)
		
		The study found that real-time continuous glucose monitoring provides a significant reduction of HbA1c for Type 1 diabetes. There were no statistically significant differences in the rate of severe hypoglycaemic events in Type 1 or Type 2 diabetes. In the base case analysis, RT-CGM led to higher QALYs and healthcare costs with an estimated incremental cost-effectiveness ratio of 2,554,723 Euros and 180,553 Euros per QALY for T1DM and T2DM patients respectively. Sensitivity analyses revealed that the study results were robust. The authors concluded the real-time continuous glucose monitoring is not a cost-effective technology when compared to self-monitoring of blood glucose in Spain.
			Published 24 August 2018	6/11 (AMSTAR rating from McMaster Health Forum)	Not reported

	The impact of telehealth remote patient monitoring on glycemic control in Type 2 diabetes: A systematic review and	This review aims to create an evidence base for the effectiveness of telehealth interventions on glycemic control in adults with Type 2 diabetes. Telehealth is described as "the exchange of medical information from one location to another	Published 26 June 2018	9/11 (AMSTAR rating from	Not reported

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	meta-analysis of systematic reviews of randomized controlled trials (7)
	
	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  ○ People with one or more conditions
	  ▪ Diabetes
	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Home care and community care
	• For what purpose or goal(s) can it be used?
	  ○ Help people manage their care needs at home for as long as possible
		using electronic communications or digital technologies." Four systematic reviews reporting 29 unique studies were reviewed.
		
		Six categories of feedback methods were classified: automated message; human calls (interactive telephone calls with a healthcare provider or researcher); human calls only if necessary; human message (personalized feedback via messaging from a healthcare provider); human message plus calls (personalized feedback via messaging from a healthcare provider followed up by an interactive telephone call); and videoconferencing.
		
		Telehealth interventions produced small but significant improvement in HbA1c levels compared with usual care, found in eleven out of 18 included studies. The greatest improvement was seen in telephone interventions, followed by an internet-based blood glucose monitoring system, and interventions involving transmission of self-monitored blood glucose (SMBG) using a mobile phone or telehealth unit. No improvement was seen from automated telephone calls.
		
		While current evidence suggests that telehealth is effective in controlling HbA1c levels in people with Type 2 diabetes, there is still a need for better quality primary studies and reviews of RCTs to confidently conclude.
				McMaster Health Forum)	

	mHealth text and voice communication for monitoring people with chronic diseases in low-resource settings: A realist review (11)
	
	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and automatic (e.g., wearable devices)
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
		This study aimed to fill the gap in the literature by evaluating causal mechanisms in relation to the effectiveness of mHealth interventions to support chronic disease monitoring in low- and middle-income countries. The authors discuss that mHealth has been supported as an approach to chronic disease management, particularly in low-resourced settings. mHealth is defined as an approach that facilitates two-way communication between patients and their health teams and can include wireless devices such as mobile phones and tablets. This review focused on mHealth interventions that facilitated communication between patients and community health workers, nurses, or doctors in low-resourced settings.
		
		The review included four studies, where patients were all over 18 years of age and had either stroke, hypertension, and/or HIV. Methods of remote patient monitoring included text messaging, automated messaging system, and automated telephone monitoring and behaviour-change phone calls plus home blood-pressure monitoring.
			Published 16 March 2018	5/9 (AMSTAR rating from McMaster Health Forum)	0/4

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	○ People with one or more conditions ▪ Other • In what health-system sectors can remote-monitoring technologies be used? ○ Primary care • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible	The authors found that remote patient monitoring was more effective with those of low literacy, those early in their disease trajectory, and those who had experienced stressful life events. The study concludes that mHealth interventions for chronic disease monitoring can be effective in low-resourced settings.			
	An integrative review of information and communication technology-based support interventions for carers of home-dwelling older people (37) • What types of remote-monitoring technologies can be used? ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) ○ Multicomponent • Who can use remote-monitoring technologies? ○ Older adults ○ Caregivers • In what health-system sectors can remote-monitoring technologies be used? ○ Home and community care • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible	This review studies the characteristics of ICT support of adult carers of older people that have a potential impact on carer outcomes. The authors reviewed 123 articles. The inclusion criteria included published, peer-reviewed articles in English, published in 2005 or thereafter, dealing with informal (not professional) adult carers who provided care, help or support to an older adult with any impairment, disability or disease, living in their own home. The support intervention or services used in the study had to be ICT-based. The study identified characteristics deemed to have a potential impact on or influenced carer outcomes. Thoe who responded to the *who* question, included carers' relationship with the care recipient or their ethnicity. Those that responded to the *what* question involved different targeted outcomes, the individual needs of the carers and the focus on healthcare utilization and costs. Lastly, those that responded to the *how* question concerned the different services or programs offered, and the types of technologies used. The authors found that at the micro-level certain characteristics of the carer, such as their relationship and extent of employment or race/ethnicity, appear to make a difference in the outcomes, and this should be considered in planning and analyzing the effects in future studies. Regarding the meso level, a number of studies offered multi-faceted or multicomponent programs to fit personal requirements and preferences. Due to the differing needs and preferences of carers, this may prove to be a success factor and have a positive impact for carers. This review can inform future studies and highlight the evidence in the area for decision-makers, practitioners, or NGOs working with innovative forms of support for carers of older people.	Published on 5 February 2018	4/9 (AMSTAR rating from McMaster Health Forum)	13/123

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	Adopting telemedicine for the self-management of hypertension: Systematic review (32) • What types of remote-monitoring technologies can be used? o Non-invasive and automatic (e.g., wearable devices) o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) o Multicomponent • Who can use remote-monitoring technologies? o Caregivers o People with one or more conditions ▪ Other • In what health-system sectors can remote-monitoring technologies be used? o Home and community care • For what purpose or goal(s) can it be used? o Help people manage their care needs at home for as long as possible	Telemedicine may reduce visits to physicians for chronic conditions such as hypertension. There is limited research on the effects of using telemedicine in healthcare facilities, despite the potential benefits for patients. This review aimed to weigh the facilitators against the barriers for implementing telemedicine. Methodical searches were used to collect information regarding self-management of hypertension through telemedicine, resulting in 14 studied works from 2010 to 2016. The most common facilitators included "increased access [to telemedicine], increases in health and quality, patient knowledge and involvement, technology growth with remote monitoring, cost-effectiveness, and increased convenience/ease. The most prevalent barriers include lack of evidence, self-management difficult to maintain, no long-term results/more areas to address, and long-term added workload commitment." Overall, this review serves to guide healthcare professionals in incorporating new best practices and methods when introducing telemedicine into their practices. Understanding these facilitators and barriers to implementation, as well as how these factors impact successful implementation in the area of self-management of hypertension, is important."	Published 24 October 2017	5/11 (AMSTAR rating from McMaster Health Forum)	Not reported
	Remote consulting with telemonitoring of continuous positive airway pressure usage data for the routine review of people with obstructive sleep apnoea hypopnoea syndrome: A systematic review (38) • What types of remote-monitoring technologies can be used? o Non-invasive and patient-engaged (e.g., websites,	This review assessed the effectiveness of teleconsultation and telemonitoring in people with obstructive sleep apnoea hypopnoea syndrome who receive continuous positive airway pressure therapy (CPAP) versus face-to-face care. Five randomized controlled trials were identified. Real-time monitoring of CPAP adherence and efficacy was included in three studies; two studies used a home telemonitoring system with telephone support. A combination of teleconsultation and telemonitoring improved continuous positive airway pressure adherence in two trials, while two reported no differences. Satisfaction was reported positively in all five trials, with patients in one trial being more likely to continue the therapy treatment due to the addition	Published 8 October 2017	7/10 (AMSTAR rating from McMaster Health Forum)	1/5

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  ○ Caregivers
	  ○ People with one or more conditions
	  ▪ Other
	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Home and community care
	• For what purpose or goal(s) can it be used?
	  ○ Help people manage their care needs at home for as long as possible
		of teleconsultation/telemonitoring. One study also reported the cost-effectiveness of teleconsultation/telemonitoring.
		
		Two studies found no statistical difference between intervention and control groups in terms of symptom control.
		
		The authors concluded that remote consulting and real-time telemonitoring in CPAP therapy users can offer care that is more convenient, cost effective, and reduces travel time. However, telephonic communication delays and delays in delivery of equipment decrease the quality of the intervention.			

	Barriers to remote health interventions for Type 2 diabetes: A systematic review and proposed classification scheme (34)
	
	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  ○ People with one or more conditions
	  ▪ Diabetes
	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Home and community care
	  ○ Primary care
		The review described remote health as a type of ambulatory care which allows patients to collect data and communicate with their healthcare provider outside of the clinical setting. For the purpose of the included interventions, the review focused on remote health interventions for Type 2 diabetes self-management, which could involve monitoring a patient's daily activity, medication adherence, diet habits, and health vitals.
		
		Most of the studies were conducted in the U.S. with participants identifying as women. The authors categorized RPMs into nine categories: 1) phone-voice; 2) phone-text; 3) mobile device internet or apps; 4) video; 5) email (computer or mobile phone); 6) remote health unit; 7) computer or internet; 8) glucose monitor; and 9) other health devices. Phone-voice technology was the most reported type of RPM used in low- and mid-income countries.
		
		The review found that RPMs reduced the burden of patients' access to education.
		
		The authors identified five categories of barriers related to the use of RPM: patient barriers (e.g., education, technology illiteracy, medication non-adherence, comfortability, low perceived value); technology access barriers (e.g., cost, limited internet); design barriers (e.g., lack of customization, accuracy, unengaging content); provider barriers (e.g., data accessibility, low integration of provider workflow); and system barriers (e.g., scalability challenges, lack of reimbursement, high costs). The lack of data accuracy was found to be the most commonly
			Published 13 February 2017	4/9 (AMSTAR rating from McMaster Health Forum)	0/41

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	• For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible	reported barrier among the studies. Potential mitigation strategies included technology education and tailored strategies.			

	Remote patient monitoring via non-invasive digital technologies: A systematic review (39)
	
	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and automatic (e.g., wearable devices)
	• Who can use remote-monitoring technologies?
	  ○ People with one or more conditions
	  ▪ Other
	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Primary care
	• For what purpose or goal(s) can it be used?
	  ○ Help people manage their care needs at home for as long as possible
	• How can the use of remote-monitoring technologies be supported?
	  ○ Training and education (including for enhanced overall digital literacy)
	  ○ Financial supports
	  ○ Other infrastructure supports
		This review identified key trends associated with remote patient monitoring (RPM) via non-invasive digital technologies over the last decade. The review defines RPM as "an ambulatory, non-invasive digital technology used to capture patient data in real time and transmit health information for assessment by a health professional or for self-management." The review included 62 randomized controlled trials with older adult populations, 20 years of age or older, with only 5% of studies including youth under 20 years old. The patient population included people enrolled in a study where the intervention was consistent with the definition of RPM.
		
		The authors reported that study populations were more likely to utilize multicomponent interventions (26 studies), followed by smartphones/PDAs (12 studies), wearables (11 studies), biosensor devices (seven studies), and computerized systems (six studies). The use of these interventions to monitor chronic conditions was also a trend, including respiratory (23%), weight management (17%), metabolic (18%), and cardiovascular diseases (16%).
		
		The review found that smartphones/PDAs and computerized systems most often used by the patient as the primary recipient of health information, wearable devices most often transmitted data to study researchers, and biosensor devices and multicomponent interventions transmitted data mostly to physicians or nurses.
		
		The authors concluded that most studies reported positive health outcomes including computerized technologies (100%), followed by biosensor devices (86%), multicomponent interventions (81%), and smartphones/PDAs (58%). Only wearable device studies found an even split between positive and neutral outcomes.
			Published 1 January 2017	4/9 (AMSTAR rating from McMaster Health Forum)	4/62

	Remote monitoring of patients with heart failure: An overview of systematic reviews (13)	The overview included reviews describing remote patient monitoring technology as those that focused on applied information and communication technology for mentoring, supporting physical or mental health, and/or monitoring of any vital	Published January 2017	Not applicable	0/19

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  ○ People with one or more conditions
	  ▪ Cardiovascular disease
	• For what purpose or goal(s) can it be used?
	  ○ Help people manage their care needs at home for as long as possible
	  ○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts
		signs (e.g., biometric and/or data related disease information from patients to health providers). A diverse range of RPMs was identified among the 19 systematic reviews. This included telemonitoring, home telehealth, mobile phone-based monitoring, and videoconferencing.
		
		All-cause mortality and heart failure mortality were the most frequently reported outcomes. RPMs involving telemonitoring and home telehealth were generally found to be effective in reducing heart failure, rehospitalization, healthcare utilization, and mortality. It was also found to improve quality of life. There was limited evidence regarding mobile phone-based monitoring and videoconferencing.
		
		The authors identified that integral components of telemonitoring should include physiological monitoring of blood pressure, heart rate, weight, and ECG.			

	Determining the cost of implementing and operating a remote patient-monitoring program for the elderly with chronic conditions: A systematic review of economic evaluations (29)
	
	• Who can use remote-monitoring technologies?
	  ○ Older adults
	  ○ People with one or more conditions
	  ▪ Cardiovascular disease
	  ▪ Diabetes
	  ▪ Multimorbidity
	  ▪ Other
	• For what purpose or goal(s) can it be used?
		This review aimed to fill a gap in the literature by identifying the costs associated with remote monitoring programs for older adults with chronic conditions. Remote patient monitoring was defined as the transferring of healthcare data from patient to provider, primarily to support care and self-management of patients with chronic conditions, promote clinical outcomes and medication compliance, and reduce costs for patients and the healthcare system.
		
		Thirteen studies were included, of which remote patient monitoring was mainly utilized for patients with chronic obstructive pulmonary disease, congestive heart failure, diabetes, and hypertension. Six of the studies focused on elderly patients with a single chronic condition and seven studies focused on monitoring for multiple conditions. Most studies monitored multiple vital signs (n=10).
		
		The authors found that the combined intervention costs of employing remote monitoring technologies (including equipment purchasing, service, and monitoring costs) ranged from US$275-$7,963. In addition, monitoring a single vital sign cost less than monitoring for multiple vital signs. Lastly, remote monitoring programs for respiratory diseases or multiple conditions were associated with higher costs than programs for hypertension or congestive heart
			Published 19 September 2016	6/9 (AMSTAR rating from McMaster Health Forum)	3/13

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	○ Help people manage their care needs at home for as long as possible ○ Reduce or prevent the use of unnecessary care	failure. The authors concluded that some remote patient-monitoring programs may be preferable for specific chronic conditions from an economic perspective.			
	The patient experience of remote telemonitoring for heart failure in the rural setting: A literature review (40) • What types of remote-monitoring technologies can be used? ○ Non-invasive and automatic (e.g., wearable devices) ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) • Who can use remote-monitoring technologies? ○ People with one or more conditions ▪ Other • In what health-system sectors can remote-monitoring technologies be used? ○ Home and community care • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible ○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts	This review aimed to examine the experiences of remote patient monitoring for heart failure patients to inform the development of a telemonitoring service for patients with heart failure living in rural and remote areas. Remote patient monitoring was defined as telehealth that includes the use of remote access communication and information technologies including Bluetooth blood-pressure cuffs, heart-rate monitors, and tablet devices to transmit patient data. The authors specify that remote patient monitoring can be used for heart failure patients living in rural and remote locations to increase the accessibility of specialist heart-failure care. They posit that it can provide timely transfer of accurate patient information to their healthcare team to monitor the patient and promote early detection and intervention for health complications. The authors also support that its use has been associated with improved quality of life, and reduced mortality and hospital admissions for heart failure. Eleven studies were included in the review. The authors found that the inability to operate equipment and understand procedures, stability and severity of a patient's chronic disease, and the impact of remote-monitoring technology on patient identity, autonomy, and daily living affected patient experience and adherence to telemonitoring. The authors concluded that further research is needed to identify which technological supports and education is necessary to integrate remote patient monitoring into clinical practice.	Published 15 December 2015	3/9 (AMSTAR rating from McMaster Health Forum)	Not specified
	Older adults' perceptions of technologies aimed at falls prevention, detection or monitoring: A systematic review (28)	This review provides an overview of older adults' perceptions of information and communication technologies (ICTs) created to be pro-active in preventing falls. ICTs to prevent falls included home automation systems/personal emergency alarms, videoconferencing, robotics, and gaming consoles. Twenty-one studies were included (12 qualitative, three quantitative studies, six mixed methods).	Published 6 June 2014	7/10 (AMSTAR rating from McMaster	2/21

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	  ○ Multicomponent
	• Who can use remote-monitoring technologies?
	  ○ Older adults
	  ○ Caregivers
	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Home and community care
	• For what purpose or goal(s) can it be used
	  ○ Enhance safety (e.g., falls prevention)
	• How can the use of remote-monitoring technologies be supported?
	  ○ Training and education (including for enhanced overall digital literacy)
		Personal wearable emergency alarm home automation systems were deemed beneficial to participants. However, older adults said they may accept a clear image shown after they had fallen in public places of their home, but not in the bedroom or bathroom. Blurred images in private spaces are preferred. Participants stated they liked choice within the device, whereby they could cancel false alarms. Older adults also reported that they used the technology because of a perceived improvement in safety and independence. Usability, reliability, and adaptation to the home were also important factors for long-term use. Higher durability, increased comfort, smaller help buttons, greater range of transmitter, and a light device with different colours were important aspects for participants.
		
		Videoconferencing was also a studied ICT. Participants who exercised at home using iPad teleconferencing said it was convenient and motivating. Social motivation was an important element; participants felt motivated by being part of a training plan group.
		
		One study analyzing robotics reported concerns from families about the robot taking away human contact. However, participants were more positive about the robots than families and staff, as the robots were useful in communication.
		
		Two studies looked at game consoles which identified motivation, chart progress, and feedback as very important. Different difficulty levels and clear audio feedback from physiotherapists increased motivation. Participants also preferred not to see themselves on the screen and instead wanted to see an avatar matching their movements.
		
		The review concluded that positive messages about the benefits of falls technologies to promote healthy active aging is critical. Ensuring technologies are simple, reliable and tailored to individual need is also important.
				Health Forum)	

	A systematic review of internet-based supportive interventions for caregivers of patients with dementi a(41) • What types of remote-monitoring technologies can be used? ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)	It has been identified that internet interventions hold promise for meeting the needs of informal caregivers of people with dementia at reduced costs. This study aimed to provide an overview of the evidence regarding the effectiveness, feasibility, and quality of internet interventions for these informal caregivers. It identified 12 studies which were assessed according to the Cochrane level of evidence and the Cochrane Back Review Group's criteria. The studies varied widely in their intervention types, dosage, duration, and methodological quality. Overall, the level of evidence was low, but the results demonstrated that these internet interventions can improve various aspects of caregiver well-being. These include confidence, depression, and self-efficacy,	Published April 2014	6/10 (AMSTAR rating from McMaster Health Forum)	1/12

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	○ Multicomponent • Who can use remote-monitoring technologies? ○ Caregivers • In what health-system sectors can remote-monitoring technologies be used? ○ Home and community care	provided the interventions comprise multiple components and are tailored to the individual. Caregivers may also benefit from interaction with a coach and/or other caregivers. Overall, while the evidence suggests that internet-based interventions for informal dementia caregivers may improve the well-being of caregivers, it lacks methodological quality. More standardized and randomized controlled studies assessing these interventions are needed to provide stronger statements regarding the effects and most promising elements of supportive internet interventions.			
	Telehealth remote monitoring systematic review: Structured self-monitoring of blood glucose and impact on A1C (8) • What types of remote-monitoring technologies can be used? ○ Multicomponent • Who can use remote-monitoring technologies? ○ People with one or more conditions ▪ Diabetes • In what health-system sectors can remote-monitoring technologies be used? ○ Home and community care • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible ○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts	This review aimed to assess literature on telehealth remote patient-monitoring (RPM) interventions that include key elements of self-monitoring of blood glucose (SMBG) that are essential for improving hemoglobin A1C (A1C) for people with Type 2 diabetes. Interventions with structured SMBG should have seven key elements: education for patients; education for providers; use of a structured SMBG profile; SMBG goals; SMBG data to generate feedback; evidence of feedback provided to patients; and evidence of interactive communication and shared decision-making strategies between patients and providers. The interventions of the 15 included studies took place between three and 12 months. On average, telehealth RPM interventions from these studies included four of the seven elements of structured SMBG. Interventions that used more SMBG elements were found to improve A1C. The identified SMBG elements were categorized into three groups: SMBG protocols, education, and feedback. In terms of education, participant and provider education from identified interventions ranged from a half-day educational program to ongoing access to online content through an internet portal, text messaging, personal health records, or a home telehealth system. The included studies had minimal structured SMBG profiles, and goals for SMBG target ranges were not clearly defined in most studies. However, all studies indicated that feedback between patients and providers or the telehealth RPM system was incorporated via telephone calls, videoconferencing, text messaging, or a telehealth patient portal. The review suggested that more research is needed to evaluate clinical outcomes of people with Type 2 diabetes whot do not use insulin, and more patient-centred outcomes, such as quality of life.	Published March 2014	4/10 (AMSTAR rating from McMaster Health Forum)	0/15
	Remote monitoring after recent hospital discharge in patients with heart failure: A systematic review and network meta-analysis (42)	The review examined the effectiveness of remote patient-monitoring (RPM) strategies on patients with heartFailure, and whether RPM improves outcomes for adults who have recently been discharged from the hospital.	Published 16 May 2013	7/11 (AMSTAR rating from McMaster	2/21

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	• What types of remote-monitoring technologies can be used?
	  o Non-invasive and automatic (e.g., wearable devices)
	  o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  o People with one or more conditions
	• In what health-system sectors can remote-monitoring technologies be used?
	  o Home or community care
	• For what purpose or goal(s) can it be used?
	  o Help people manage their care needs at home for as long as possible
		The authors described RPM approaches as structured telephone support (STS) and home telemonitoring (TM). STS may be delivered via human-to-human contact (12) or human-to-machine (43) (interactive response system) interface, while TM may involve remote patient-initiated transfer of physiological data, and/or automatic data transfer from cardiovascular implanted monitoring devices.
		
		The review included 21 randomized controlled trials of patients diagnosed with heart failure who had been recently discharged home (≤28 days) from an acute-care setting.
		
		The review found that STS human-to-human and TM with medical support provided during office hours showed beneficial trends, particularly in reducing all-cause mortality for recently discharged patients with heart failure. However, these effects were statistically inconclusive.
				Health Forum)	

	The effect of telemedicine in critically ill patients: Systematic review and meta-analysis (44)
	
	• What types of remote-monitoring technologies can be used?
	  o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  o Older adults
	  o People with one or more conditions
	• For what purpose or goal(s) can it be used?
		This review evaluated the impact of telemedicine on patients' outcomes. A total of 865 relevant citations were identified of which 11 observational studies met selection criteria of critically ill adults or children, examining the effects of telemedicine on mortality. Quality and statistical analysis were employed.
		
		The overall quality of studies was moderate according to the Newcastle-Ottawa scale. Meta-analyses identified that telemedicine is associated with lower ICU mortality and hospital mortality relative to care as usual. Those interventions that had continuous patient-data monitoring, with or without alerts, reduced ICU mortality compared to those with remote intensivist consultation only; however, effects were statistically similar. The identified effects were similar in both higher- and lower-quality studies. The reductions in ICU and hospital length of stay were statistically significant, at about -0.62 days and -1.26 days, respectively.
		
		Overall, telemedicine is associated with lower ICU and hospital mortality among critically ill patients. However, given that effects vary among studies and may be overestimated in nonrandomized designs, the optimal telemedicine technology arrangement and dose specific to ICU organization and case mix remains unclear.
			Published 18 July 2012	8/11 (AMSTAR rating from McMaster Health Forum)	Not reported

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts				
	The impact of telemedicine interventions involving routine transmission of blood glucose data with clinician feedback on metabolic control in youth with Type 1 diabetes: A systematic review and meta-analysis (45) • What types of remote-monitoring technologies can be used? ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) • Who can use remote-monitoring technologies? ○ People with one or more conditions ▪ Diabetes • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible	This systematic review of 10 randomized trials involving 609 youth aimed to determine the impact of telemedicine interventions on the management of Type 1 diabetes (T1DM) in youth. No apparent effect of the interventions was found on "hemoglobin A1c (HbA1c), severe hypoglycemia, or diabetic ketoacidosis." There was limited available data on patient satisfaction, quality of life, and cost, which suggested no differences between groups. It is unlikely that the assessed telemedicine interventions had a substantial effect on glycemic control or acute complications. That said, it is still possible that there are other benefits of telemedicine which are not adequately reported, that newer telemedicine strategies may be more effective, and that these interventions may benefit subgroups of youth (i.e., those with poor glycemic control, adolescents, or those living in remote areas).	Published 22 September 2010	7/11 (AMSTAR rating from McMaster Health Forum)	1/10
	A meta-analysis of remote monitoring of heart failure patients (14) • What types of remote-monitoring technologies can be used? ○ Non-invasive and automatic (e.g., wearable devices) ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) ○ Multicomponent	This review examined effectiveness of telemonitoring and related outcomes of patients with chronic heart failure compared to standard patient care: death, hospitalization for all causes, and hospitalization due to heart failure. The review included 20 randomized controlled trials and 20 observational studies. Follow-up care ranged from less than three months to 12 months, and monitoring of heart-failure patients was conducted by a family physician, specialist, home-care service, or was not specified. The authors compared standard in-person care to telephone-monitoring (e.g., structured phone contact with and without home visits) and technology-assisted monitoring approaches that transmits physiological data (e.g., implantable devices, home-monitoring equipment, and telephone monitoring with supports).	Published 27 October 2009	9/11 (AMSTAR rating from McMaster Health Forum)	1/96

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	• Who can use remote-monitoring technologies?
	  o People with one or more conditions
	  ▪ Cardiovascular disease
	• In what health-system sectors can remote-monitoring technologies be used?
	  o Home and community care
	  o Primary care
	  o Acute/specialty care
	• For what purpose or goal(s) can it be used?
	  o Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts
		The authors reported that remote patient monitoring significantly reduced the overall incidence of death and hospitalization from heart failure compared to standard care. The authors also found in measures of mortality, that there was a slightly higher protective effect when using technology-assisted monitoring, compared to telephone monitoring.			

	Evaluating the evidence base for the use of home telehealth remote monitoring in elderly patients with heart failure (15)
	
	• What types of remote-monitoring technologies can be used?
	  o Multicomponent
	• Who can use remote-monitoring technologies?
	  o Older adults
	  o People with one or more conditions
	  ▪ Cardiovascular disease
	• In what health-system sectors can remote-monitoring technologies be used?
	  o Acute/specialty care
	• For what purpose or goal(s) can it be used?
	  o Post-discharge monitoring to avoid hospital readmission or
		The focus of this review was to assess evidence on home telehealth and remote monitoring (HTRM) of patients with heart failure (HF) post-hospitalization. A total of nine studies were included and five of the studies had a two-arm design while four had a three-arm design. Telephone-based interventions without automated monitoring were excluded. In all studies, participants were heterogenous when it came to the number of antecedent hospitalizations for HF, duration of HF, socio-economic status, and New York Heart Association classification. Study duration was generally three to 12 months and the interventions involved daily or weekly monitoring, and case management with a nurse or nurse specialist.
		
		The impact of telemonitoring interventions was found to be positive in more cases than not when it came to healthcare utilization, mortality, and cost. A 27-40% reduction in overall admissions was suggested in six of the nine studies. Three of the nine studies suggested a significant reduction in mortality while three studies suggested a reduction in healthcare utilization costs. Two studies showed significant reduction in emergency-department visits, and two studies suggested a reduction in bed days of care.
		
		Findings of this study indicate that telemonitoring is a promising strategy for improving outcomes of HF patients. However, more research is needed to determine which combination of HTRM interventions would produce better outcomes with cost reductions.
			Published 15 October 2009	7/10 (AMSTAR rating from McMaster Health Forum)	0/9

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	intervene earlier to mitigate health impacts				
	A systematic review of telemonitoring technologies in heart failure (17) • What types of remote-monitoring technologies can be used? o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) o Multicomponent • Who can use remote-monitoring technologies? o People with one or more conditions ▪ Other • In what health-system sectors can remote-monitoring technologies be used? o Acute/specialty care • For what purpose or goal(s) can it be used? o Help people manage their care needs at home for as long as possible o Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts • How can the use of remote-monitoring technologies be supported? o Integration with other technologies (e.g., electronic health records or virtual-care technologies)	This review particularly focused on ways telemonitoring has been utilized to assist patient self-monitoring for heart failure signs and symptoms. The authors support that self-monitoring for heart failure may be a cost-effective alternative to multidisciplinary disease-management programs and may support decreased hospitalization rates and improve outcomes. Fifty-six articles were included. The authors found that 14 interventions included specialized devices that enabled patients to enter their signs, symptoms, weight, blood pressure, and heart rate, which was transmitted via telephone line to a monitoring station. Patients' nurse or physician were then engaged, and necessary follow-up could be initiated. Twelve initiatives utilized mobile or telephones, where patients could enter their data which was monitored by health professionals. Lastly, four interventions used website-based telemonitoring modalities which enabled patients to submit their data into a website that was monitored by healthcare professionals. Twenty-one interventions included a combination of telemonitoring modalities, most commonly adding in devices for nurse telephone calls. The authors concluded that telemonitoring may be effective to assist patients living in rural or remote areas who lack access to specialist care to self-monitor heart failure signs and symptoms. Additionally, it could be used to initially support medically unstable patients as they transition to stability, at which point they could be switched to alternative telemonitoring modalities that require less equipment such as telephone touchpads or internet-based interventions.	Published 22 April 2009	2/9 (AMSTAR rating from McMaster Health Forum)	Unclear/ 56
	Information systems for patient follow-up and chronic management of HIV	This study assessed the role of medical information systems in tracking patients with either HIV or multi-drug resistant TB to ensure they are promptly started on high-quality care while reducing loss to follow-up. A literature search and	Published 22 October 2007	2/9 (AMSTAR rating from	Not reported

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	and tuberculosis: A life-saving technology in resource-poor areas (21)
	
	• What types of remote-monitoring technologies can be used?
	  ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	  ○ Multicomponent
	• Who can use remote-monitoring technologies?
	  ○ People with one or more conditions
	  ▪ Other
	• In what health-system sectors can remote-monitoring technologies be used?
	  ○ Home and community care
	  ○ Primary care
	  ○ Acute/specialty care
	• For what purpose or goal(s) can it be used?
	  ○ Help people manage their care needs at home for as long as possible
	  ○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts
		personal knowledge was used by the authors. Six HIV and MDR-TB treatment projects in Africa and Latin America described the functionality for tracking patients and detecting those lost to follow-up.
		
		Preliminary findings found "benefits in tracking patients who have not been prescribed appropriate drugs, those who fail to return for follow-up, and those who do not have medications picked up for them by healthcare workers. There were also benefits seen in providing access to key laboratory data and in using this data to improve the timeliness and quality of care. Follow-up was typically achieved by a combination of reports from information systems along with teams of community healthcare workers. New technologies such as low-cost satellite internet access, personal digital assistants, and cell phones are helping to expand the reach of these systems."
		
		While effective information systems in developing countries are a relatively recent innovation, they must play an increasing role in monitoring HIV and MDR-TB projects as they scale up in patient enrolment. A particular focus should be on tracking patients from initial diagnosis to initiating effective treatment and then monitoring them for treatment break or loss to follow-up. More quantitative evaluations are needed.
				McMaster Health Forum)	

	Home telemonitoring of patients with diabetes: A systematic assessment of observed effects (9) • What types of remote-monitoring technologies can be used? ○ Multicomponent • Who can use remote-monitoring technologies?	In this systematic review, diabetes home telemonitoring and its effects at the informational, clinical, structural, behavioural, and economic levels are explored. The review defines telemonitoring as the employment of information technology, including audio, video, and other telecommunication technologies, to monitor patients from a distance. Studies that focused on remote diagnosis and consultation as well as telemonitoring in settings other than home were excluded. A total of 17 studies were included with the experiments occurring between three and 15 months in different countries between 1995 and 2005.	Published April 2007	1/9 (AMSTAR rating from McMaster Health Forum)	2/17

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	○ People with one or more conditions ▪ Diabetes • In what health-system sectors can remote-monitoring technologies be used? ○ Home and community care • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible ○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts	The review points out that technologies used in experiments evolved over time around the telephone systems that emerged, giving way to advanced technologies in diabetes home telemonitoring and hand-held devices for disease management in the 2000s. Significant impacts were identified at the clinical, behavioural, and structural levels. At the clinical level, the review found that diabetes telemonitoring resulted in significant decreases in glucose levels and foot complications. Good receptiveness to home telemonitoring by patients due to an increased feeling of security and autonomy was consistently reported at the behavioural level. At the structural level, some studies reported a reduction in annual clinic visits, hospital admission rates, and length of stay for patients with systematic monitoring. Economic evaluations of the impacts of telemonitoring were still in theearly stages at the time of this review, and the authors recommended that more development of cost-benefit research is needed.			
Rapid reviews	Beyond wellness monitoring: Continuous multiparameter remote automated monitoring of patients (27) • What types of remote-monitoring technologies can be used? ○ Non-invasive and automatic (e.g., wearable devices) • In what health-system sectors can remote-monitoring technologies be used? ○ Home and community care ○ Acute/specialty care • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible ○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts	This article described work to-date about the types of continuous multiparameter remote automated monitoring (CM-RAM) technologies, features, and potential for patient home and clinical use. CM-RAM devices were defined as single integrated devices capable of continuous and simultaneous collection of biophysical data, that can be transmitted to clinical support teams. The authors reported that CM-RAM was most often used in hospital settings to monitor vital signs, such as heart rate, respiratory rate, and blood pressure. The authors were unable to provide conclusions about the clinical benefits of CM-RAM. The authors found that CM-RAM was generally acceptable among participants in home and community care settings. Patients in hospital and home settings reported acceptability due to comfort, non-intrusiveness and feeling of safety. In one study, patients in home settings were less likely to express willingness to use CM-RAM if devices did not also provide them with real-time feedback.	Published 01 February 2022	Not applicable	0/38

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	CADTH health technology review: Remote monitoring programs for cardiac conditions (16)
	
	• What types of remote-monitoring technologies can be used?
	  o Non-invasive and automatic (e.g., wearable devices)
	  o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	  o Multicomponent
	• Who can use remote-monitoring technologies?
	  o Caregivers
	  o People with one or more conditions
	  ▪ Cardiovascular disease
	• In what health-system sectors can remote-monitoring technologies be used?
	  o Home and community care
	  o Primary care
	  o Acute/specialty care
	  o Long-term care
	  o Rehabilitation
	• For what purpose or goal(s) can it be used?
	  o Help people manage their care needs at home for as long as possible
	  o Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts
	• How can the use of remote-monitoring technologies be supported?
		This review examined key program mechanisms influencing patient outcomes, patient and caregiver views and experiences, and ethical considerations of remote-monitoring programs (RMP) for chronic cardiovascular conditions and cardiac rehabilitation in Canada. The authors describe RMP as the formal, organized programs offered by healthcare organizations, or a health authority, that use technology to collect and transmit patient health data.
		
		In the realist review analysis, the authors reported that the integration of remote-monitoring technology (RMT) was more likely to be adopted if it was perceived to be highly unintrusive in patients' daily habits and homes, provided daily supports for self-care such as feedback about personal health status and symptom interpretation, and if RMT was seen as complementary to in-person care.
		
		When examining the views and experiences of RMT use, the authors found that technological challenges and people's housing arrangements (e.g., lack of electrical or phone outlets, lack of physical space for large equipment) acted as barriers to participation in RMP.
		
		The review reported that healthcare providers described the benefits of RMP as aiding in faster clinical decision-making to identify and address health concerns earlier. Challenges with remote technology use included the lack of technical or organizational integration in healthcare delivery, such as increased caseload and time needed for consultations.
		
		The authors suggested that acceptability and uptake of RMT could be enhanced by improving technological literacy and offering more technical supports to patients and caregivers. The report also suggested that providers could be supported by integrating RMP with electronic health records.
		
		The authors concluded that there is limited evidence about the effectiveness of RMP, and that further evaluation is needed regarding populations in rural or remote settings, of low socio-economic status, and are racialized or Indigenous. The authors suggest that decision-makers and providers should consider the infrastructure (e.g., reliable internet access) and financial impacts, and potential supports for informal caregivers such as training and education.
			Last updated: 3 September 2021	Not applicable	13/121

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	○ Integration with other technologies (e.g., electronic health records or virtual-care technologies) ○ Training and education (including for enhanced overall digital literacy) ○ Financial supports ○ Other infrastructure supports				
	Remote-monitoring medical devices for COVID-19: Clinical utility and cost-effectiveness (23) • For what purpose or goal(s) can it be used? ○ Help people manage their care needs at home for as long as possible ○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts ○ Reduce or prevent the use of unnecessary care	This review aimed to identify the clinical utility and cost-effectiveness of medical devices that support remote monitoring, and how these devices have been used by patients who have been diagnosed with COVID-19. The authors did not identify relevant literature.	Published 16 July 2020	Not applicable	Not reported
	CFHealthHub for managing cystic fibrosis during the COVID-19 pandemic (46) • What types of remote-monitoring technologies can be used? ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) • Who can use remote-monitoring technologies? ○ People with one or more conditions ▪ Other	This review aims to provide an overall assessment of the evidence regarding the CFHealthHub technology, its effectiveness, feasibility, and cost-effectiveness as a digital platform to help adults with cystic fibrosis (CF) manage their condition and monitor their medication use. The CFHealthHub platform is a multifaceted intervention co-created by people with CF and clinical teams in CF centres, aimed to create a digital-health learning system for behaviour change of people with CF and clinical teams. The intervention also aims to improve the way that CF centres deliver care. It comprises of the following: • eFlow nebulisers that include sensors to record the time, date, and duration of each use, in which the data will be transmitted to the CFHealthHub server; • CFHealthHub server, managed by Manchester University, United Kingdom; • CFHealthHub's online portal and application which is accessed by clinics and patients and presents real-time data from the nebulisers; additionally, the app	Published 10 July 2020	Not applicable	0/3

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	• In what health-system sectors can remote-monitoring technologies be used?
	  o Home and community care
	  o Primary care
	• For what purpose or goal(s) can it be used?
	  o Help people manage their care needs at home for as long as possible
		has educational content and evidence-based behaviour-change tools to support people with CF; and
		• CFHealthHub is part of a digital learning health system that continually captures data to inform clinical teams about the quality of CF care.
		The CFHealthHub platform has three main purposes:
		1) to support behavioural change that will improve adherence to their recommended medicines and promote patient activation;
		2) to help clinicians to support people with CF to build good self-care habits, by giving them accurate data on medication adherence; and
		3) to allow CF centres to track use of medicines, and seek support if medicines adherence rates are lower than average for their centre.
		
		The review summarizes the findings from three studies related to the effectiveness of this technology, including one feasibility study for a randomized controlled trial and two economic studies. The review noted key uncertainties around the evidence or technology are that RCTs of CFHealthHub have not yet been published, so there is currently no comparativeness evidence showing its effectiveness. Clinical experts in the field of cystic fibrosis and patient organizations were invited to comment on the technology, and noted that they expect the benefits of CFHealthHub to be improving medicines adherence and may lead to certain system benefits, such as reducing hospital admissions, reducing the need for intravenous antibiotic treatment, and reduced medicine waste.			

	Rapid review of applications of e-health and remote monitoring for rural residents (25)
	
	• What types of remote-monitoring technologies can be used?
	  o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  o Older adults
	  o Frail older adults
	  o Caregivers
		This review aims to identify approaches to care delivery that have demonstrated successful use of e-health for rural residents. E-health services include telehealth and remote monitoring. This review included studies undertaken in Australia, Canada, and the U.S., and included 19 articles.
		
		This review found that e-health can increase access to services in rural areas, by reducing travel costs, and physical and practical inconveniences associated with travelling. E-health was also found to enable more rapid identification and management to changes in a patient's condition. The studies included also indicate a high level of concordance between the diagnoses and decisions from e-health and face-to-face services.
		
		This review found that telehomecare allowed patients to detect changes in their condition, which allowed them to maintain or improve their functional statuses and quality of life. Additionally, this reduced the pressure on existing health resources. The use of vital-signs monitoring technology allows older people to remain independent at home after discharge.
			Last searched June 2013	Not applicable	2/19

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada

	• In what health-system sectors can remote-monitoring technologies be used?
	  o Home and community care
	• For what purpose or goal(s) can it be used?
	  o Help people manage their care needs at home for as long as possible
	  o Enable patient- and caregiver-friendly care in long-term care and allow residents to avoid hospital admission
	  o Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts
	• How can the use of remote-monitoring technologies be supported?
	  o Training and education (including for enhanced overall digital literacy)
	  o Other infrastructure supports
		The authors of this review recommend that e-health in rural areas should be introduced alongside sound changes in management principles, which include a communication strategy to engage clinicians and patients, community consultation, and training. An important consideration of e-health is that disadvantaged communities have a higher prevalence of chronic illness, however, these communities often have less access to the internet.
		
		The authors concluded that e-health has the potential to address clinical needs, meet social and cultural needs, and contribute to overcoming workforce shortages in rural and remote areas. Further research should focus on the development of e-health literacy skills and engagement strategies for groups such as rural communities and older people.
		
		The quality of the evidence of the included studies tends to be low due to limitations in the study design, or a lack of a full description of the study design.			

Protocols	Devices for remote continuous monitoring of people with Parkinson's disease (31)
	
	• What types of remote-monitoring technologies can be used?
	  o Non-invasive and automatic (e.g., wearable devices)
	  o Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants)
	• Who can use remote-monitoring technologies?
	  o Caregivers
		This study plans to assess the use and cost-effectiveness of remote-monitoring technology (RMT) to monitor and record the motor symptoms of people living with Parkinson's disease, by the United Kingdom's National Health Service.
		
		The authors plan to assess five non-invasive monitors that can be used outside of clinical settings to aid in clinical care. Devices include smartwatches, a waist-worn inertia recorder, and smartphone and tablet applications.
		
		The authors propose to measure a range of outcomes including: impacts on clinical decision-making; morbidity (e.g., frequency and length of hospital admissions, falls); mortality; and patient and carer experience.
			Anticipated 25 January 2023	Not applicable	Not applicable

Type of review	Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	○ People with one or more conditions ▪ Other • For what purpose or goal(s) can it be used? ○ Post-discharge monitoring to avoid hospital readmission or intervene earlier to mitigate health impacts ○ Enhance safety (e.g., falls prevention)				
	Implementation and use of mHealth home telemonitoring in adults with acute COVID-19 infection: A scoping review protocol (47) • What types of remote-monitoring technologies can be used? ○ Non-invasive and patient-engaged (e.g., websites, smartphones, personal digital assistants) • Who can use remote-monitoring technologies? ○ People with one or more conditions ▪ Other	The scoping review that this protocol describes will evaluate the determinants of successful implementation of and use of mHealth telemonitoring for acute outpatient COVID-19. mHealth refers to digital technologies that uses smartphones, mobile apps, and specialized digital sensors to provide real-time assessments of a patient's health status.	Published 27 September 2021	Not applicable	Not applicable

Appendix 2: Titles and their hyperlinks of middle- to low-relevant systematic reviews and other types of reviews about remote-monitoring technologies and associated technologies that enable people to stay in their homes or existing level of care

Type of evidence document	Title of evidence document	Year of last search/ publication date
Guidelines (n=3)	The COVID-19 pandemic and eating disorders in children, adolescents, and emerging adults: virtual care recommendations from the Canadian consensus panel during COVID-19 and beyond	Published 16 April 2021
	Behaviour change: digital and mobile health interventions	Published 7 October 2020
	Guidance for remote reporting of digital pathology slides during periods of exceptional service pressure	Published 23 March 2020
Systematic reviews (n=19)	COVID-19 remote consultation services and population in health inequity-concentrating territories: A scoping review	Published August 2021
	Telemedicine and multiple sclerosis: A comprehensive literature review	Published September 2020
	Combining the benefits of tele-rehabilitation and virtual reality-based balance training: A systematic review on feasibility and effectiveness	Published January 2019
	The use of telemedicine for delivering healthcare in Japan: Systematic review of literature published in Japanese and English languages	Published December 2017
	Use of telehealth for healthcare of Indigenous peoples with chronic conditions: A systematic review	Published September 2017
	mHealth-based interventions for the assessment and treatment of psychotic disorders: A systematic review	Published 14 August 2017
	Telemedicine for patients with rheumatic diseases: Systematic review and proposal for research agenda	Published August 2017
	Systematic literature review on effectiveness of self-management support interventions in patients with chronic conditions and low socio-economic status	Published April 2017
	Cancer survivors' experience with telehealth: A systematic review and thematic synthesis	Published 9 January 2017
	The use of phone technology in outpatient populations: A systematic review	Published 30 April 2016
	A systematic review of telehealth tools and interventions to support family caregivers	Published January 2015
	A systematic review of mobile health technology use in developing countries	Published 2015
	Which components of heart failure programs are effective? A systematic review and meta-analysis of the outcomes of structured telephone support or telemonitoring as the primary component of chronic heart failure management in 8,323 patients	Published September 2011
	Heart failure patients monitored with telemedicine: Patient satisfaction, a review of the literature	Published August 2011
	Asynchronous and synchronous teleconsultation for diabetes care: A systematic literature review	Published May 2010

Type of evidence document	Title of evidence document	Year of last search/ publication date
	Home telemonitoring for Type 2 diabetes: An evidence-based analysis	Published 1 October 2009
	The contribution of teleconsultation and videoconferencing to diabetes care: A systematic literature review	Published 14 December 2007
	Clinical outcomes resulting from telemedicine interventions: A systematic review	Published 21 November 2001
Rapid reviews (n=3)	Smart Peak Flow for monitoring asthma	Published 11 January 2022
	Patient status engine for wireless monitoring of vital signs	Published 10 August 2021
	Lifelight First for monitoring vital signs	Published 8 April 2020

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