Provincial Health Services Authority

2023 PHSA REMOTE PATIENT MONITORING WHITE PAPER

Executive Summary

The COVID-19 pandemic led to accelerated uptake and adoption of virtual health technologies across Canadian provinces and territories, transforming models of care and service delivery, while increasing the convenience and accessibility of health care services for patients. There is a dire need to continue to explore new virtual models of care delivery to ensure sustainment of the health care system.

Remote patient monitoring (RPM) is a virtual health solution that has the potential to move care management into non-traditional health care settings, particularly patients' homes, where patients' health and daily habits can be reviewed, and real-time feedback provided, to alter the course of their illness. RPM also helps improve patient engagement and self-management behaviours while increasing efficiency and productivity of the health care system. Available literature indicates that RPM has numerous benefits, including improved patient reported outcomes and quality of life, decreased patient mortality, hospital readmissions, emergency department visits, and length of stay, as well as increased patient confidence and knowledge about their disease and their ability to self-manage. Overall, RPM technologies help move away from an episodic approach to care and instead toward a focus on prevention, early detection, and timely treatment, ultimately benefiting patients, providers, and the health system.

The purpose(s) of this document includes, but is not limited to, the following:

1. Supporting a strategy for RPM within PHSA programs and services
2. Evaluating the current state of RPM provincially
3. Summarizing the available literature and national and global use of RPM
4. Presenting best practices for successful RPM implementation
5. Highlighting lessons learned to inform the future growth and sustainability of RPM initiatives
6. Identifying gaps and areas for further exploration, knowledge gathering, and/or improvement
7. Sharing patient and family stories and first hand experiences of using RPM
8. Discussing best practices in diversity, equity, and inclusion within the RPM landscape
9. Exploring key technical requirements for RPM program development

Ultimately, this document will serve as an informative guide for health care leaders and decision-makers to plan for new models of care delivery within specific programs or services using RPM.

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1. Introduction

The Canadian health care system is under enormous strain as a result of a variety of factors, including workforce burnout, staffing shortages, increasing health care needs from a rapidly aging population, limited access to primary care placing increased demands on emergency health and other services, and vast disparities for equity-deserving populations such as those living in rural and remote areas (Deloitte, 2022). Virtual health solutions have the potential to address some of these strains by increasing the convenience and accessibility of health care services for patients.

Remote patient monitoring (RPM) is a virtual health solution that can help improve patient engagement and self-management and increase efficiency and productivity of the health care system.

> RPM is the delivery of health care to patients outside of conventional care settings (e.g., a patient's home), which is made possible by connecting the patient and their care team through technology. RPM involves the electronic transmission of patient data (e.g., symptoms, vital signs, outcomes) from a remote home location to the care team, as well as the supporting services and processes required to conduct data review, interpretation and potential alteration of the patient's course of care. (Gheorghiu & Ratchford, 2014)

RPM is a technology-enabled clinical delivery model that provides high-quality health care to people in various geographical locations. Rather than the patient being required to come to the clinical setting, RPM enables the health care system to go to the patient.

Since 2011, RPM technologies have been adopted across the province of British Columbia (B.C.) according to regional priorities, interest, and resources. At the Provincial Health Services Authority (PHSA), there has been an uptake of RPM in programs such as BC Emergency Health Services (BCEHS), BC Cancer, BC Children's Hospital, and BC Women's Hospital and Health Centre.

During the COVID-19 global pandemic, there was a provincially coordinated effort to expand the use of RPM technology to monitor confirmed and suspected cases of infection. Provincial collaboration through the establishment of a provincial working group and executive committee helped streamline remote monitoring efforts of COVID-19 across B.C., thereby improving patient care and RPM initiatives overall.

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Provincial Virtual Health (formerly known as the Office of Virtual Health) leads and provides strategic direction on virtual health initiatives at Provincial Health Services Authority and across the health sector in British Columbia. It brings together clinical experience, knowledge of virtual tools, expertise in patient engagement, educational methodologies, change management approaches, project management frameworks, process analysis and optimization, practice, policy and privacy laws and mandates—all to elevate and transform what it means to provide care virtually. It works closely with clinical programs and their clients, and also works with partners in the Provincial Digital Health and Information Services (PDHIS) portfolio.

A. History of Remote Patient Monitoring in B.C.

RPM, also known as Home Health Monitoring (HHM), was first used in the B.C. health care system in 2011. A Strategic Investment Fund (SIF) was provided by TELUS Health to the province as part of the Change Order for Home Health Monitoring and Related Services under the Telecommunications Service Master Agreement (TSMA) and the Strategic Relationship Agreement (SRA). Over a 10-year period from 2011 to 2021, SIF funds supported the deployment of innovative solutions to B.C. citizens across a range of areas, including health care and HHM. In addition to the RPM projects funded through the SIF funds, there has been a small number of other RPM projects across B.C., including at PHSA in the BC Women's Diabetes in Pregnancy clinic to remotely monitor blood glucose levels of patients with gestational diabetes.

Between 2011 and 2021 there have been pilot initiatives in various provincial health authorities, which have addressed small subsets of patients in particular geographical locations. A few of these pilot initiatives have turned into ongoing programs, but only patients with specific conditions residing in participating health authority regions have been able to access these services. For example, Island Health has developed a program open to certain regions on Vancouver Island for patients living with heart failure or chronic obstructive pulmonary disease.

Traditionally in B.C., RPM has focused on chronic disease education for patients for the purposes of self-management, and while a small number of initiatives were implemented during COVID-19 for other purposes, it is important to note that RPM can be used in a wide variety of ways to address different clinical objectives across the care continuum. Furthermore, prior to the global pandemic, RPM projects across the province were primarily driven by priorities specific to regional health authorities. More recently, focused work has begun to streamline and coordinate RPM efforts across the province to reduce siloes, increase quality of patient care, and improve efficiency and overall sustainability of RPM initiatives.

A provincial RPM collaborative group was created in March 2020 in response to the rapid adoption of RPM to meet care needs and ensure patient and provider safety during the COVID-19 pandemic. This collaborative group continues today and is co-chaired by PHSA's Provincial Virtual Health and the BC Ministry of Health . The Provincial RPM Collaborative Group ensures alignment and support for all regional health authorities and health organizations (e.g., Doctors of BC, BC Ministry of Health) in B.C. This group sets clinical and technical requirements for RPM in the province, highlights issues with the current vendor, and provides feedback on solutions. Currently, PHSA's Provincial Virtual Health offers support to the BC Ministry of Health through coordination and leadership of requirements gathering, coordination of Canada Health Infoway funds received (which supports RPM initiatives), and support for MoH with vendor management.

B. Current State of Remote Patient Monitoring in PHSA

Currently, most RPM initiatives within PHSA is delivered through the TELUS Health managed service, which uses RPM software through a vendor called Tunstall Healthcare. PHSA's Provincial Virtual Health has had varying levels of involvement in the projects listed below. Some programs within PHSA had implemented their own RPM projects using other vendor solutions or through research projects. PHSA's Provincial Virtual Health has played a supportive role in many of these with regards to project, clinical, and evaluative support. The following summary highlights a general overview of the initiative design (evaluation results are not included). Programs are listed in alphabetical order.

Disclaimer: Additionally, this paper may not reflect new programs that have been developed or implemented since the creation of this document.

BC Emergency Health Services – Community Paramedicine

Community Paramedicine introduced RPM as a tool in 2017 to augment home care for primarily older adults living with heart failure, diabetes, or chronic obstructive pulmonary disease (COPD). Primary care providers across Vancouver Island can refer patients with heart failure, COPD, diabetes, or gestational hypertension to a monitoring program operated by Island Health's central monitoring team. Similarly, in rural and remote areas, primary care teams refer patients with heart failure, COPD, and diabetes for monitoring by community paramedics. Community paramedics help set up the equipment consisting of a tablet and Bluetooth-enabled devices such as pulse oximeters, blood pressure monitors, and scales in patients' homes. Patients submit their vital signs and complete a survey specific to their chronic condition daily. Monitoring is conducted on an ongoing basis through a review of patient trends and potential concerns. The service aims to help improve patient knowledge of their chronic disease and ways to better self-manage their health, as well to help support early intervention. Within both the Community Paramedicine monitoring program and Island Health program, care is escalated back to the primary care provider as required.

BC Cancer – Kelowna

BC Cancer Kelowna piloted RPM between June 2021 and June 2022 with patients receiving immunotherapy treatment, including single drug immunotherapy, combined immunotherapy, and immunotherapy combined with chemotherapy. All patients were within their first eight weeks of starting immunotherapy treatment. The objective of this pilot was to understand how the RPM model of care could be used to effectively monitor, educate, empower, and provide care for patients. Patients received surveys on their TELUS Health HHM tablet. Biometric data, such as pulse and temperature, were submitted twice weekly. Patient survey responses or biometric readings outside normal ranges prompted an alert in the platform for the monitoring nurse, who then called the patient. The nurse further verified the clinical issue or concern and provided advice directly or consulted the patient's medical oncologist.

BC Cancer – Victoria

RPM was used to manage care for dual modality head-and-neck and lung cancer patients who were receiving concurrent systemic and radiation therapy. Participants were provided with a tablet, thermometer, oximeter, weight scale, and pedometer to use during the duration of the monitoring program. Monitoring occurred for 12 to 16 weeks beginning after their first follow up appointment with the oncologist. Every weekday, participants answered a series of questions and submitted their biometric data through devices measuring their heart rate, oxygen saturation, temperature, weight, and step count. The information was securely sent to the BC Cancer clinical team to review and provide support to help patients manage symptoms.

BC Centre for Disease Control – Temporary Foreign Workers

The COVID-19 Rapid Response Surge nursing team conducted ongoing daily monitoring of temporary foreign workers until they were medically cleared by the Surge team's medical lead physician. Participants went through an initial COVID-19 case interview at enrollment, after which they were remotely monitored by the

team via telephone calls. The HHM technology solution was used for documentation, and supported care management was done through the review of the monitoring dashboard. Based on the participants' clinical status and isolation day, the nurse completed an assessment using the standard monitoring interview.

BC Women's Hospital – Diabetes in Pregnancy (DiP) Program

The BC Women's Diabetes in Pregnancy Service provides personalized care to pregnant people with type 1, type 2 diabetes, or gestational diabetes or those at risk of developing diabetes during pregnancy. The program uses a technology solution from LifeScan to facilitate the transfer of patient information, including carbohydrates, ketones, weight, and glucose (blood sugar) levels, through OneTouch glucometer readings transmitted to the clinic for review. All patient information is securely transferred through the glucometer via Bluetooth connection and the OneTouch mobile app on patients' cellular phone. The diabetes team members then review patient results and provide individualized care to help pregnant people manage their glucose levels and lower the risk of diabetes related complications.

BC Children's Hospital, Oncology – Home international normalized ratio (INR) monitoring program

The BC Children's Oncology Thrombosis program provides patients and families who require frequent bloodwork due to unstable INR values with a self-testing device, called Coagucheck, for at-home INR monitoring via finger poke. Patients' families collect the INR results and call or text the information to the thrombosis team. A clinician from the team follows up with the patient and family with next steps, including anticoagulation adjustment if required. Patients and families are supported to ensure accuracy in the INR readings through built-in quality control features within the device and patient education.

Cystic Fibrosis Care BC (CFCBC)

The adult Cystic Fibrosis (CF) clinics in Vancouver (Providence Health Care) and Victoria (Island Health) have implemented programs to monitor patients from home to reduce patient treatment burden, maintain patient lung function, and improve quality of life through monitoring, early intervention, coaching, and education. Island Health has built upon their existing COPD monitoring plan and included temperature and spirometry monitoring as a method of early exacerbation detection. Videoconferencing technology is leveraged to provide virtual physiotherapy and social work support. Through integration efforts with Cerner electronic health records (EHR) at Island Health, patient data can be viewed in their EHR. Providence Health Care has targeted a specific patient population that are starting a new drug to assess patient response to the treatment.

Cardiac Services BC

Providence Health Care has implemented a program to virtually monitor patients after cardiac surgery to ensure optimal recovery. The program includes post-surgery monitoring and medication dosage optimization to targets to help enable earlier and safer discharge and reduce post-surgical complications and hospital re-admission. The program aims to increase patient education and engagement with their care and improve patient and family satisfaction. The patient population monitored include cardiac surgery patients with a longer predicted length of hospital stay, specifically those requiring anti-coagulation therapies and those with low ejection fraction. Patients are monitored over a period of 6 to 8 weeks. The monitoring devices include a tablet, scale, blood pressure monitor, and pulse oximeter which are provided by the program. For future expansion, the program intends to add handheld INR devices for patients receiving anti-coagulation therapies and electrocardiograms (ECG) when vendor solution updates are available.

C. Scope and Limitations

During the development of this white paper, the BC Ministry of Health led an environmental scan and needs assessment for RPM in B.C. This material has been omitted from the scope of the current document to avoid duplication of work. Much of the information in this paper has been included in the Ministry's environmental scan.

2. Literature Review

A literature search was conducted reviewing articles within the past 15 years from 2007 to 2022 to examine the clinical benefits of RPM in a variety of patient populations, as well as best practices in RPM that result in positive impact on patients, health care providers, and the health system overall (see Appendix 1 for additional information on the literature search methods).

According to the literature, RPM programs can be grouped and categorized in a variety of ways including models of care and monitoring intensity (from least to most intensive). Based on examples from the literature, RPM can be classified through various organizational models including centralized service, hub and spoke, and most commonly a primary care team model (Figure 1). There is no evidence to suggest one model is superior to another; different models can be operationalized based on technology, clinical need, demand from patients, and human resource availability (Daley, 2021; Lemelin, 2020; Maines, 2020; Mantena & Keshavjee, 2021). Please see Appendix 2 for detailed summaries of RPM programs found in the literature.

Model or Service Design

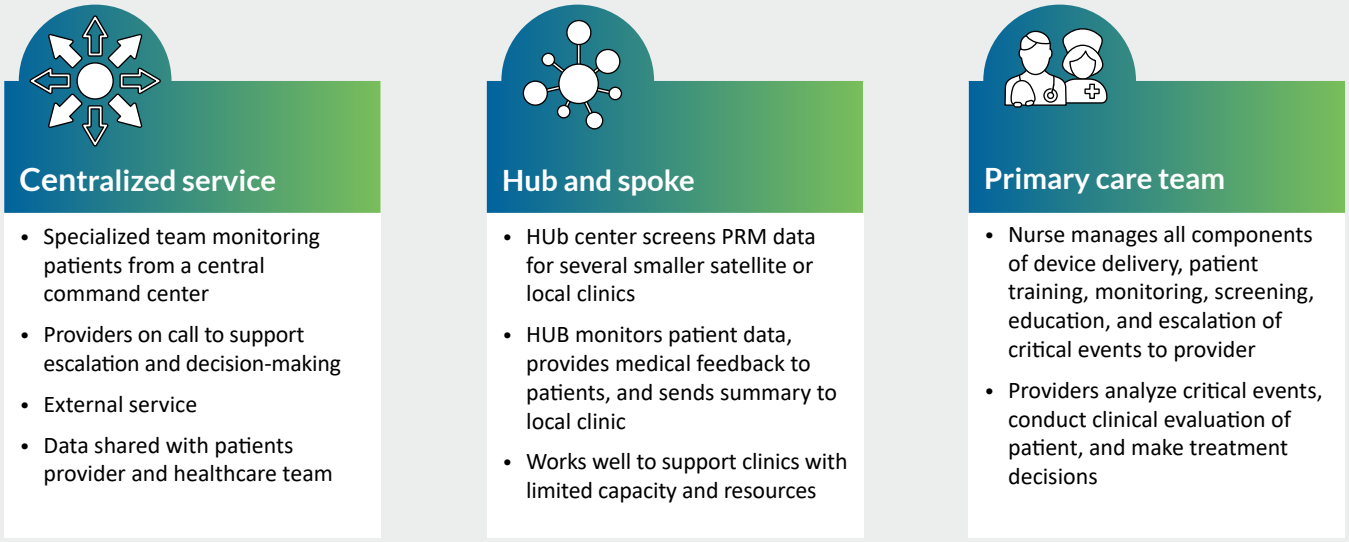


Figure 1.

A. Clinical Benefits of Remote Patient Monitoring

There are many benefits of RPM that have been highlighted across its various applications globally. In general, an increase in access to patient data through RPM supports the care team to better deliver patient care services and enhances the understanding of a patient's clinical condition. In parallel, patient engagement in an RPM program helps patients to have a better understanding of their personal health concern and ways to self-manage their condition, as well as when and how to seek assistance. Below is a summary of the clinical benefits of RPM across the literature sources reviewed.

i. Improved Control of Health Condition

RPM helps to provide a clearer picture of a patient's health over time and supports the care team to be able to respond to variabilities in the patient's condition outside of conventional care settings. Studies have demonstrated patients are able to reach target hypertension and diabetes control rates and to sustain these targets when an RPM model of care is used (Fisher, 2019; Songsermpong, 2021). RPM facilitates the ongoing review of biometric data, such as patient blood pressure and blood glucose, thereby enabling the health care team to identify and respond to instabilities with adjustments in medication regimens, appropriate patient education, and additional supports (such as outreach programs or community-based interventions) (Songsermpong, 2021).

At Brigham Women's Hospital in Boston, Massachusetts (2017), patients were enrolled in a hypertension management program run by a team of patient navigators with the support of medical doctors and licenced health care professionals and the use of clinical algorithms. Patients reached their target control blood pressures within 7 weeks and demonstrated significant sustained reductions in blood pressures at an average of 7 months after discharge from the RPM program (Fisher, 2019). Another study evaluating RPM for uncontrolled hypertension found that blood pressure differences were sustained for up to 24 months post discharge, and there were fewer cardiovascular events in the intervention groups when compared to the control groups (Margolis, 2020).

The Virginia Health Care System (2012) in Iowa City, Iowa, implemented an RPM program for patients with poorly controlled diabetes, which involved conducting daily glucose, weight, and blood pressure readings that were transferred through a secure server and then reviewed by a registered nurse case manager (Klobucar, 2012). Results from this study demonstrated that the intervention group sustained their hemoglobin (Hb) A1C levels 12 months post discharge, in comparison to the control group who demonstrated a short period of improvement (i.e., decrease in HbA1C levels) initially then followed by steady upward trends in their readings 3 months into the program.

Improvements in rates of control over health conditions can be attributed to a combination of biometric data transmission, communication between patient and care team, reminders, medication guidance, lifestyle and dietary coaching, and improved patient engagement (Fisher, 2019; Klobucar, 2012; Margolis, 2020; Montero, 2021; Park, 2021).

ii. Improved Patient Satisfaction and Quality of Life

Patient survey results from various applications of RPM have shown that RPM as a model of care significantly improves patient reported outcomes such as satisfaction and quality of life (Gheorghiu & Ratchford, 2015). A key factor in the benefits of RPM include positive impact on the patient-clinician relationship. RPM helps to reduce the episodic nature of care and improve the relationships that form between the care team and patients (Coye, 2009; Gheorghiu & Ratchford, 2015). Throughout the patient's duration of care, the RPM clinician helps with monitoring and assessment, care coordination, and educational support, as well as supporting treatment and prescription changes in collaboration with provider groups (Gheorghiu & Ratchford, 2015).

Care provided to patients in their home environment can help with reduction of anxiety and stress levels (Kesavadev, 2021; Songsermpong, 2021). Remote monitoring programs help to provide a sense of safety and

confidence for patients through assurance that their care team will monitor incoming data and initiate contact with the patient if any concerns arise (Hicks, 2009; Mantena & Keshavjee, 2021; Songsermpong, 2021; Tobah, 2019). In a study comparing prenatal patients receiving traditional methods of care versus RPM, the RPM group indicated lower levels of prenatal stress at mid-pregnancy and near full term (Tobah, 2019).

At the University of Pennsylvania, an RPM program called COVIDWatch was implemented to screen patients symptomatic for COVID-19 (Mantena & Keshavjee, 2021). Patients completed text message-based questionnaires to report their symptoms. Individuals who exhibited signs of worsening symptoms were automatically referred to an emergency department or an on-call team of virtual providers for follow-up (Mantena & Keshavjee, 2021). Ongoing monitoring of patient symptoms and a direct pathway to access clinical care have been reported to provide patients with an overall sense of security and help increase patient satisfaction levels (Lemelin, 2020; Mantena & Keshavjee, 2021).

iii. Early Intervention and Reduction of Surgical Complication Rates

Patients undergoing surgery are at risk of a myriad of complications, which can range from minor concerns that resolve with some intervention, to more serious life-threatening complications that require multiple interventions, including multi-organ failure, long-term disabilities, or even death (Tevis, 2013). RPM can be used after patient discharge from hospital to monitor patients for post-operative complications.

Post-operative RPM programs combine gathering of patient vital signs, including blood pressure, heart rate, and pulse oximetry results, along with high resolution video conferencing technology to monitor surgical wounds and incisions (Palombo, 2009). Video assessment also enables the care team to monitor and assess a patient's psychosocial status on an ongoing basis, thereby enhancing the delivery of RPM services (Palombo, 2009). Through RPM, clinical programs are able to rapidly readmit patients to hospital based on clinical assessments, ensuring that patients receive the right level of care when they need it. Beyond monitoring patients post-operatively, RPM programs also ensure that standards of safety are in place. For example, if a patient requires immediate surgical intervention, systems are put in place to help support this, such as emergency health service collaboration for transport and pathways for expediting patient care (Palombo, 2009).

Early discharge after a surgical procedure can heighten patient stress and anxiety; however, knowing that the care team is reviewing and monitoring health data and having the ability and option to have video consultation with a surgeon or care team member help to ease patient concerns (Palombo, 2009). A family-centred approach whereby a patient's family or relatives are included in the onboarding and care plan has also shown to provide patients a sense of comfort (Palombo, 2009).

One study looked at 30-day surgical outcomes of ostomy patients who received care under a remote monitoring and telehealth program called SmartCare (Fearn, 2020). The program used technology to support data collection by tracking patient ostomy output, potential leakages, and skin irritation through sensors embedded in their ostomy pouch. Patient coaches provided peer health coaching and assisted patients with any educational, psychological, and technological needs and helped escalate concerns as required (Fearn, 2020). When data sets were compared across the intervention group, results demonstrated that the remote care monitoring group had lower rates of hospital readmission, fewer emergency department visits, and fewer hospital visits due to dehydration which is known to be the primary reason for readmission to hospital after ileostomy surgery (Fearn, 2020).

iv. Improved Access and Continuity of Care

Geographical distance is a major barrier to health care service accessibility. Rural and remote communities, particularly those that are far from urban health care settings, face greater difficulty in accessing primary and specialty care and greater barriers in recruiting and retaining health care staff (Hicks, 2009). The use of RPM technology can help improve access to care for those who live in rural, remote, or harder to reach areas. Through RPM, patients who otherwise are required to commute or drive long distances to access their care provider can have their health monitoring conducted within the comfort of their own homes.

RPM programs collect patient health information such as vital signs and clinical symptoms, which often lead to detection of high-risk concerns and enable early intervention (Wright, 2018). RPM technology helps to facilitate communication between patients and their care teams and support the development of a shared partnership in care management; through this process the patient is able to learn how to manage other contributing factors that affect their health and wellbeing, such as diet, exercise, and lifestyle (Wright, 2018). The RPM model of care is well suited to support patients who have more complex health care and social needs, as they often benefit from ongoing case management, communication, and check-ins with their monitoring clinicians (Agarwal, 2021).

RPM programs can also help to increase accessibility and continuity of care for patients who do not have pre-existing or close connections to primary care. The Women's College Hospital in Toronto launched an RPM program where a multi-disciplinary family medicine team consisting of a family physician, medical resident, mental health or social worker, nurse practitioner, and pharmacist followed patients 7 days a week during the acute phase of their recovery from COVID-19 (Agarwal, 2021). In the program, patients had access to specialists for virtual consults on an as-needed basis, as well as a 24-hour on-call service (Agarwal, 2021). This type of team-based approach enables greater access to needs-based care for patients. Multi-disciplinary teams tend to not only focus on the immediate medical concern but also consider other domains of health including the patient's psychosocial wellbeing (Agarwal, 2021). By increasing access to mental health care and social supports, providers can facilitate improved patient outcomes.

v. Increased Patient Empowerment and Self-Efficacy

RPM programs can help create a shared partnership between patients and care teams and enable patients to become active participants in their personal care plans. Upon enrolling in an RPM program, participating patients often receive education on the purpose of monitoring and the technology they will use to support biometric monitoring. Monitoring devices can include items such as blood pressure cuffs, pulse oximeters, and heart rate monitors, as well as other tools such as weight scales, spirometers, and pedometers. Patients also receive education on signs and symptoms to monitor and learn about their own individual alert thresholds and parameters (Hicks, 2009; Lemelin, 2020; Maines, 2020; Roesler, 2015; Walker, 2019). Through this process, patients can become more aware of their condition(s) and gain skills in self-management.

RPM technology is an excellent tool to promote behaviour change interventions for patients, as the system design supports the ability to remind patients to complete various tasks, assessments, and activities. Through pre-programmed algorithms, patient task reminders, and messages of encouragement, RPM technology helps support patient self-motivation and promote greater self-management (Lemelin, 2020; Walker, 2019). Algorithms can be programmed to generate automated feedback to patients (e.g., lifestyle modifications, medication adjustments) based on their individual biometric data, survey response thresholds, and care plan goals (e.g., blood pressure rates and other vital sign targets) (Lemelin, 2020; Walker, 2019; Wright, 2018). This means that patients can work with their care team to monitor their vital signs, adjust lifestyle and other factors as needed, and manage their own health.

Many RPM programs have patient education built into the software, offering access to repositories of teaching materials and knowledge translation content. Patients can access these resources by navigating through a library of health content and choosing materials that suit their needs or by responding to survey questions about their health and/or transmitting their biometric data (e.g., blood pressure readings), which in turn triggers the delivery of individually curated education materials (e.g., on nutrition, exercise, self-management) (Lemelin, 2020). Thus, RPM offers patients individualized and tailored support so they can gain self-management skills and take a more proactive and preventative approach to their own health management. RPM programs have demonstrated success in supporting patients to make healthier choices related to self-care, exercise, diet, and nutrition (Lemelin, 2020).

The RPM care delivery model facilitates an ongoing relationship between the clinical team and patient, where clinicians are able to provide coaching through the technology in a somewhat repetitive but interactive basis, helping patients to identify when trends and values are outside the normal range and to self-manage symptoms as they occur (Roesler, 2015; Rosner, 2017; Willems, 2008; Wright, 2018). Clinicians

can employ various techniques, such as motivational interviewing, to motivate patient behaviour change (Coye, 2009). Over time, patients can become more active participants in their own care management, increase self-motivation, and increase their independence with regard to health self-management (Wright, 2018). Patients may also feel greater empowerment and satisfaction with RPM technology when they have the ability to discuss monitoring data with their clinicians and understand more about their condition (Nundy, 2014). Ultimately, patients' desire to know more about their health condition – its seriousness, consequences, and how to improve and manage it on a day-to-day basis – and RPM programs, can effectively help to build patient health knowledge and health literacy levels (Liu, 2020; Nundy, 2014; Walker, 2019).

vi. Reduction of Acute, Emergency, and Outpatient Visits

When designed appropriately (with consideration of patient, provider, and environmental/contextual factors), RPM can decrease acute care service utilization (Taylor, 2021). RPM technology allows care teams to track patient health data and clinical symptoms outside of conventional health care settings, providing them with a clearer picture of patients' health status over time. Clinicians can take a proactive approach to patient care as opposed to being reactive. In standard models of care, health concerns are most often recognized at a point when patients' health has deteriorated, and/or their symptoms have become severe, to the point of requiring an escalation to emergency or acute care. By contrast, with RPM, a patient's health status is continuously monitored by dedicated care teams, and any emerging health concerns are identified early and immediately trigger the care team to intervene accordingly, thereby preventing hospitalization and severe illness (Kesavadev, 2021; Songsermpong, 2021).

RPM programs enable care teams to safely monitor patients while supporting early discharge, allowing patients at lower risk for complications to return to their home environment where they may feel more comfortable and at ease, while still being monitored safely by the care team (Gheorghiu & Ratchford, 2015; Palombo, 2009). Early discharge programs can be customized by the service area based on patient population needs and goals of monitoring. Patients who meet certain eligibility criteria defined by the clinical program or service area are set up with biometric devices in their home for the collection of vital signs and symptoms (Margolis, 2020; Palombo, 2008; van den Heuvel, 2021).

The combined use of structured interviews with patients and biometric devices after patients have been released from hospital has revealed the effectiveness of RPM in reducing hospital readmissions (Gheorghiu & Ratchford., 2015; Mantena & Keshavjee, 2021; Steinberg, 2021). In one example, RPM was used to provide an early, protected discharge for eligible patients who underwent carotid endarterectomy (Palombo, 2009). Patients were provided equipment to monitor blood pressure and heart rate and to conduct video visits for surgical wound assessment. The RPM approach proved effective in supporting immediate treatment of hypertension, and the combination of RPM with video technology helped to reduce feelings of insecurity among patients and family as well as post-operative stress (Palombo, 2009).

In the context of primary and specialty care, RPM can be used within a hybrid model to reduce the number of in-person patient visits while maintaining delivery of high-quality care and levels of patient satisfaction (Lemelin, 2020; Rosner, 2017; Tobah, 2019; van den Heuvel, 2021). At the University of Montreal Health Centre (2020), people with gestational diabetes were assigned to an RPM program in which they received access to a patient-specific portal. Within the portal, patients manually entered their blood glucose readings and answered questions related to their health and wellbeing on a weekly basis. The monitoring nurse clinician reviewed patient data daily, analyzed biometric results, responded to alerts, and escalated concerns to the physician, prompting necessary changes to the patient's care plan (Lemelin, 2020). In this use case, the medical team met on a biweekly basis to conduct reviews of patient data and charts, and although this model increased the nursing clinician time spent on monitoring, results identified a significant 56% decrease in overall medical visits, without compromising pregnancy outcomes, quality of care, safety, and patient satisfaction levels (Lemelin, 2020). Thus, integrating RPM into patient visit schedules can be an effective method to reduce the number of scheduled visits while still maintaining high-quality and satisfaction of care.

Envisioning new models of care that incorporate RPM should be considered by organizations and systems that face challenges around health care consumption and provider resourcing concerns (Lemelin, 2020).

B. Best Practices in Remote Patient Monitoring

Presented below are a compilation of best practices that have been highlighted in the literature related to planning and operationalizing an RPM program, factors to consider when designing an RPM program, and key considerations during RPM implementation.

Please note that literature reviewed does not rank or specify an order or hierarchy of importance of best practices. Therefore, the layout of the material presented below does not indicate an order of importance.

i. Operational and Project Considerations

Program Oversight

- **Include a physician medical director and a nurse administrative leader to manage clinic operations.** This approach is in alignment with a primary nursing model and is the most feasible in practice (Daley, 2021; Willems, 2008).

Staffing

- **Optimize resources and efforts through implementation of a dedicated team with clearly defined roles and responsibilities.** Having a specialized team to monitor remote monitoring transmissions helps to streamline clinician workflows. RPM relies on reorganization of standard methods, which includes newly defined roles for both clinical and non-clinical staff.
- **Consider the use of new staff positions, such as patient navigators, to support patients for their health-related needs for the duration of the program.** Patient navigators are health care professionals who guide patients through the health care system, connecting them to appropriate professionals and helping them to gain access to available resources. This staff position helps to build trusting relationships with patients, promotes greater usage, and understanding of health applications (Daley, 2021; Kesavadev, 2021; Liu, 2020).

Partnerships

- **Consider effective partnerships with internal and external groups to support program efficiency and quality.** For example, this may include partnerships with community health volunteers for medication and equipment delivery and pharmacies for medication education. Some programs may consider creating quick activation pathways into emergency or surgical services as part of care escalation pathways (Margolis, 2020; Songsermpong, 2021).

Change Management

- **Engage appropriate partners and collaborators early and consider change management principles to ensure program success.** To address any potential or actual resistance to RPM use by end-users of the technology, consider engagement across various groups including health care administrators, clinicians, providers, and patients and family members. Groups should be informed of the value proposition to gain buy-in. Addressing the needs of various groups creates a sense of collective ownership and contributes towards success of the program (Ferrua, 2020; Fisher, 2019; Gheorghiu, 2015).

Device Delivery

- **Consider all aspects of biometric device delivery to patients across geographical areas.** There can be difficulty in finding services that operate during optimal hours and dates. Ensure device drop-off and retrieval processes are confirmed as timely shipping is key to prevent any delays in patient participation (Vindrola-Padros, 2021).

ii. Program Design

Problem or Pain Point

- **Clearly define the problem that the program is trying to solve with RPM.** When setting up an RPM program there should be a clear understanding if there are any gaps or inefficiencies in care that RPM can help support. Know the value proposition and be concrete about how the RPM can help patients, their families, and the health care system overall (Pinnock & McKinstry, 2016).

Patient Population

- **Identify the patient population whose needs will be met by the RPM.** Map out the eligibility criteria for patients, including inclusion and exclusion factors. Understanding potential risks and unsuitability is key to developing these criteria (Gheorghiu, 2015; Palombo, 2009).

Monitoring Plans

- **Identify the clinical questions to be asked and addressed, the biometric data to be collected, and the methodology for collecting the data.** Some things to consider are: manual vs. automatic transmission of biometric data, frequency and cadence, management of alerts and escalation pathways, and consideration of patient education materials.

Clinical Algorithms and Decision Trees

- **Ensure that clinical algorithms and decision trees for remote care go through multi-disciplinary review and approvals.** Invite input from a variety of perspectives, including clinicians, providers, specialists, and health program administrators. Use of human-centred design is a key principle in design and is facilitated by an iterative process of review and feedback (Agarwal, 2021; Ferrua, 2020; Vogtmann, 2013).

Clinical Engagement Strategy

- **Engage the appropriate clinical partners and collaborators early in the process (e.g., during the planning stages of an RPM program).** Plan how patients will be recruited into the program and who will be involved in their care journey. Identify individuals outside each patient's immediate care team who should be involved. Establishing a clear clinical engagement strategy from the very beginning will help with adoption and sustainment of RPM initiatives (Gheorghiu & Ratchford, 2015).

Patient Engagement Strategy

- **Ensure patient engagement opportunities throughout all design phases, including the RPM technology and program workflows.** Patient and family engagement should occur in design phases. This is especially important as a way to make up for reduced in-person interactions as a result of RPM. Data sharing with patients needs to occur in a way that aligns with patients' preferences and capacities; therefore, it is crucial to have patients and family members actively involved in all program design phases, including equipment testing and workflow redesign. Ensure clear communication with patients regarding the purpose of RPM and plan for frequent interactions via the RPM technology, as this helps to strengthen trust and relationships with patients (Daley, 2021; Vindrola-Padros, 2021).

Patient-Centred Care

- **Limit the frequency of excess data collection from patients to minimize burden of conducting manual tasks and activities.** Auto-transmission of data should be used where applicable as it helps improve patient adherence.
- **Establish shared decision-making amongst the care team and the patient.** Provide patients options that are minimally disruptive to their daily lives and select monitoring modalities that closely align with the benefits that motivate the patient to adopt RPM (Daley, 2021; Oikonomidi, 2021; Palombo, 2009; Thee, 2021).

Data Driven Decision-Making

- **Consider how the RPM data will be used to support clinical decision-making.** RPM significantly increases the availability of patient assessment data. At an organizational level, program administrators should examine how this data can be used to make decisions around strategy, program optimization, and future program development.

Evaluation

- **Establish a robust evaluation plan and ensure ongoing measurement of impact, process, and outcomes.** Consider incorporating evaluation into multiple touchpoints—for example, after each video connection and at the time of discharge (Ferrua, 2020; Palombo, 2009).

iii. Program Implementation

Patient Supports

- **Provide patients with technology free of charge to help improve adherence rates.** Ensure that the solution is simple and user-friendly to overcome any technology or health literacy gaps.
- **Support initial tech visits to train patients on how to use the RPM technology.** This will help increase patient uptake and engagement. It is also an opportunity to alleviate or eliminate potential patient concerns about RPM.
- **Involve family and caregivers in program onboarding and training to help reduce patient and family anxiety and stress.** Use teach-back methods (i.e., asking patients to repeat what was explained to them in their own words) to confirm patient understanding (Ong, 2016; Palombo, 2009; Ramadas, 2015; Williams, 2021; Zanotto, 2019).

Patient Accessibility

- **Consider patient access to network connectivity.** Patients who live in rural or remote areas and those who do not have a fixed address may have difficulty participating in RPM due to a lack of steady and reliable Internet connection, among other factors.
- **Respect language and cultural diversity.** Offer interpretation and translation services to ensure that monitoring interviews, biometric directions, education, and lesson plans are in the patient's preferred language.
- **Address health literacy.** Patients with low health and technology literacy may need additional support when using RPM technology. Develop plans to address how patients can be supported to be successful in their use of RPM (Ramadas, 2015; Vindrola-Padros, 2021).

Staff Training and Education

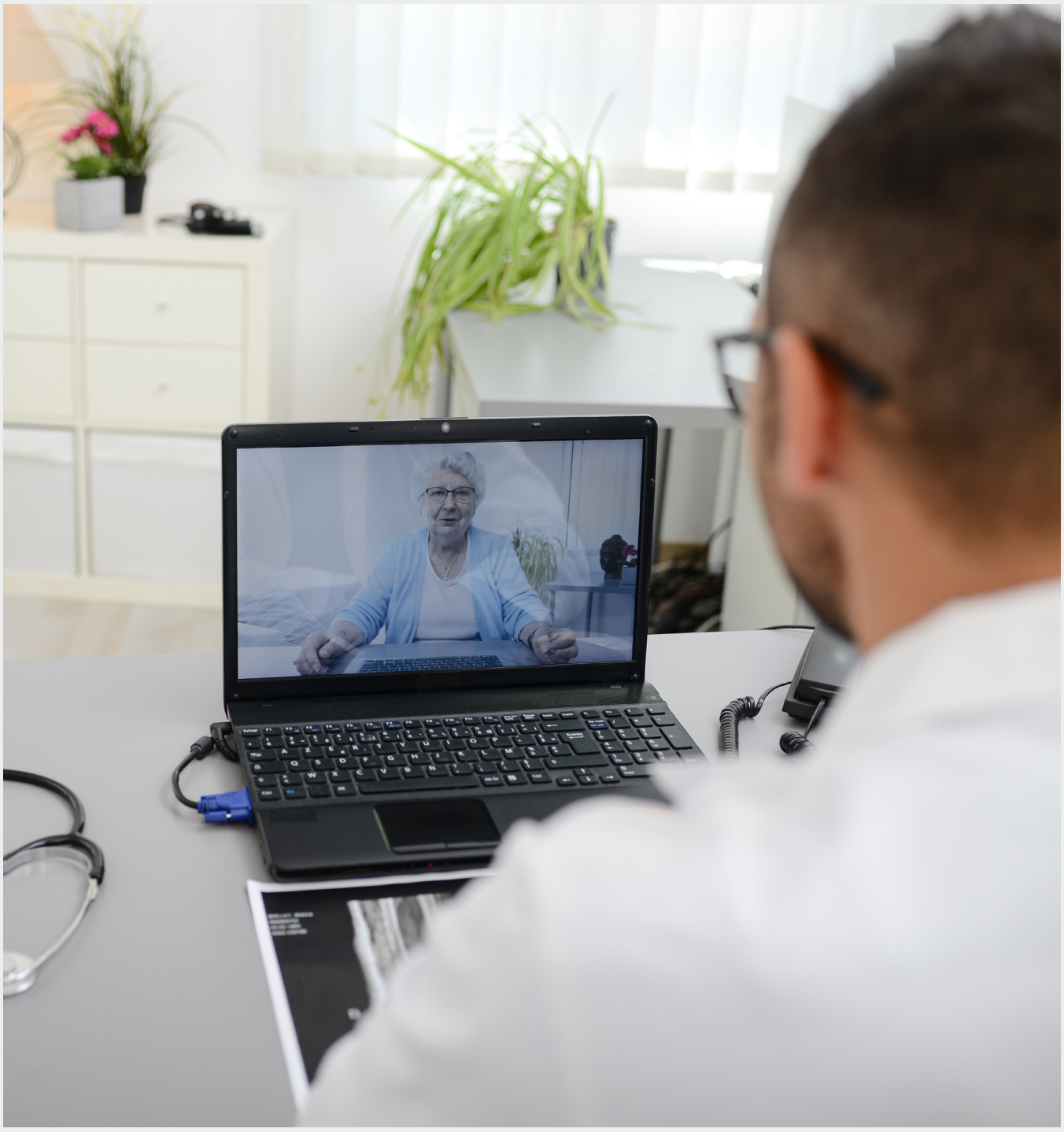
- **Ensure that staff are provided with appropriate training around the use of technology, as well as a code of conduct for RPM models of care.** Develop a comprehensive onboarding and training plan to support staff in all aspects of RPM program delivery. Training should also consider aspects of remote monitoring data utilization for care delivery (Kesavadev, 2021; Riley, 2015).

Alert Management

- **Standardize the alert management and triaging process.** Consistent alert management protocols should be developed and communicated to all RPM team members to ensure that all patient assessment findings are assessed effectively and in a timely manner. (Park, 2021).
- **Clarify the escalation process.** Clear communication pathways and well-defined roles and responsibilities are required to ensure critical patient alerts are addressed appropriately. Escalation pathways need to be program- or population-specific and may also be customized per individual patient alert thresholds (Park, 2021).

Electronic Health Records (EHR) Integration

- **Integrate patient data.** Real-time auto-transmission of patient information and biometric data into the EHR systems avoids duplication of inputting patient data, helps to reduce the burden on clinician workflows, and improves the patient's longitudinal health record (Agarwal, 2021; Fisher, 2019).

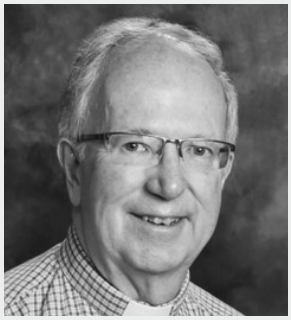


3. Patient Stories

Before the COVID-19 pandemic, a few hundred patients in B.C. were being monitored remotely each year. Now, more than 24I,000 patients are enrolled in RPM programs province-wide, empowering patients to take an active role in their health journey.

The following are stories from three of these patients who have adopted or used RPM for their care from PHSA and other provincial programs.

RPM Journey: Jim Lyster



Following hospitalization for heart related issues, I became registered in the RPM program available through Island Health (i.e., Home Health Monitoring, or HHM). Through RPM, I've developed a pattern of paying daily attention to my symptoms and making more appropriate decisions in managing my activity levels and adjusting medications based on symptoms observed.

This program has given me and my family great comfort in knowing that my vital signs (such as blood-pressure, oxygen levels, weight, and a review of other risk factors) are being monitored. For my spouse, RPM has been a true form of respite. I'm not the only member of our family with health issues, and knowing a clinician is reviewing my results daily gives additional peace of mind and one less item to manage.

Remote monitoring doesn't require a family practitioner visit, either in person or by phone/virtually—data is automatically entered into my electronic health record through a tablet. My clinician can send my data to my primary care provider or specialist after any unusual activity in my vital signs and in advance of a scheduled appointment. If I have questions about my current situation, RPM allows me to reach out to the clinician without needing to contact and wait for an appointment with my primary care provider. Point-in-time education/support by the clinician (i.e., when anomalies in the data are noted) is a powerful tool provided by RPM—information can be provided at the time that it's most relevant.

Living with regular low blood pressure (BP) due to my medication regime, I sometimes miss the significance of changes or trends in readings, which will be noted by the RPM clinician. In one instance, having the clinician call me due to a particularly low BP reading caused me to wonder about my situation in a support group. Another participant noted their BP was lower after exercising. This led me to reassess the timing of checking BP and exercise and adjust my routine to include a preliminary BP check. This change has allowed for more accurate information being placed in my health record.

RPM is important in assisting patients in becoming independently able to manage and improve their symptoms over a wide range of health concerns, including heart failure, COPD, palliative care, kidney function, and undoubtedly many more (including COVID-19). It's important to note that RPM is not just the technology; there's a person/clinician behind the technology who is interacting with it and with me (or any patient).

At its best, RPM provides me with the ability to develop a relationship with a clinician who is familiar with me and my subtle nuances and idiosyncrasies and to know when to reach out. It appears that with recent changes with HHM, I have less of a long-term relationship with a clinician who knows me. I see this as potentially detrimental to my care and my own ability to manage life with a chronic health condition. For me, the ongoing relationship with the RPM clinician is a key value. It would also be good to develop ways that individuals are able to use personal devices (Bring Your Own Device) to provide relevant data to RPM.

BC Cancer—Kelowna RPM Program: Jennifer Turner

When I was asked if I would be interested to become involved with the Home Health Monitoring program at BC Cancer–Kelowna, I had no hesitancy. I felt that anything to help patients when we are going through a difficult health problem was well worth the time. The ease of using something like this from home should certainly encourage others to be involved.

I was in constant touch with the office and spoke to my coordinator quite often. When I did experience some issues, they were able to contact my oncologist immediately and deal with it. Having that extra "go to" person along with my oncologist helped tremendously.

My best interests always seemed at the forefront, and I did not find the actual inputting of the information on the Tablet to be confusing or difficult. It is a well-planned and programmed study.

I hope my participation in this Home Health Monitoring program will help it to become the standard for the future, as I am sure it is a tool for creating valuable information not only for PHSA but also for patients.

BC Cancer—Victoria RPM Program: Matthew Varley

Diagnosed with an aggressive form of cancer in December 2020, Matthew began using RPM in January 2021 and his health data was sent to a monitoring nurse and his care team 5 days a week. His take on it? Matthew felt empowered.

"A lot of people feel helpless when they're diagnosed with an illness. Instead of everyone doing things for me, the remote monitoring was my way of participating too," said Matthew.

"I was helping myself and helping the doctor by providing data and information that he used to help me."

The diagnosis came about by chance. Matthew went in for a hearing check-up and told his general practitioner he felt like he "didn't have enough room" in his chest. A subsequent chest X-ray showed a 4-inch-long tumour on his lung, and the biopsy showed it was a very aggressive cancer. The specialists wanted to treat it immediately. "It was truly a shock to get a cancer diagnosis," said Matthew.

At age 59, Matthew is in strong physical shape thanks to an active lifestyle and a physically demanding career. Being in good health meant Matthew could withstand aggressive medical treatment. He worked hard to maintain a positive attitude and received a lot of encouragement from his family and community.

"I'm not very tech savvy, but I didn't find this intimidating at all. The tablet made it easy and I became comfortable with the process because I knew what I was being asked."

Nursing staff at BC Cancer reviewed his readings to understand how his treatments were going and to see if exercise was beneficial or hindering. By mid-June, doctors told Matthew he'd made remarkable progress with his treatment.

4. Diversity, Equity, and Inclusion

Diversity, equity, and inclusion (DEI) have been identified in recent literature as key factors in the success of digital and virtual health initiatives (Crawford & Serhal, 2020). While there is limited literature on DEI in relation to RPM initiatives specifically, the principles, research, and evidence related to DEI in virtual health overall are highly recommended for consideration and application in RPM program development.

A. Digital Health Equity

The Digital Health Equity Framework (DHEF) outlines key principles for equitable and sustainable implementation of any virtual health initiative, inclusive of RPM (Crawford & Serhal, 2020). This model furthers previous health equity models and adds the digital determinants of health that are linked to additional factors shaped by socio-economic and cultural contexts (Dover & Belon, 2019).

As outlined in the DHEF, the digital determinants of health include:

- Access to digital resources;
- Use of digital resources for health seeking or health avoidance;
- Digital health literacy;
- Beliefs about the potential for digital health to be helpful or harmful;
- Values and cultural norms/preferences for use of digital resources; and
- Integration of digital resources into community and health infrastructure (Crawford & Serhal, 2020, p. 2).

Based on the digital determinants of health, Digital Health Equity is defined by the presence of the following principles:

- Equal access to digital health care and equal outcomes for digital health care, irrespective of age, gender, ethnicity, income, and geography;
- Health care providers with competencies/training to provide equitable digital health care and necessary adaptation;
- Measurement and quality improvement to improve access and outcomes; and
- Involvement of people from equity-deserving populations in leadership, health professions, co-design, and data stewardship (Crawford & Serhal, 2020).

B. Artificial Intelligence and Health Equity

RPM is a tool that, when enabled by artificial intelligence (AI), can profoundly improve health care and allow care teams to deliver care with greater efficiency. RPM supports the collection of patient data over time, and applying AI technologies to this process can help support a data-driven, preventative approach to health care whereby risk of disease can be predicted earlier than when using standard methods of health care delivery (Obermeyer, 2019). Unfortunately, "algorithms may reproduce racial and gender disparities via the people building them or through the data used to rain them" (Obermeyer, 2019, p. 447). "Algorithmic bias" is defined as

> the instances when the application of an algorithm compounds existing inequities in socioeconomic status, race, ethnic background, religion, gender, disability or sexual orientation to amplify them and adversely impact inequities in health systems. (Panch, 2019, p. 1)

Algorithmic bias, therefore, can exacerbate health inequity. Panch et al. (2019) identify the following strategies to mitigate algorithmic bias:

- **Consider differential needs of different groups.** This is best achieved through multi-disciplinary data science teams and by appropriate regulation and evaluation of algorithms and the data science process itself.
- **Create control mechanisms.** Often, there will likely be a trade-off between the speed of algorithm deployment and algorithmic bias—rapid processing of data can come at the cost of perpetuating health inequities. A reasonable control mechanism to counter this trade-off is to create "human-in-the-loop" systems, where algorithmic outputs are passed to a human decision-maker with necessary caveats with the human as the ultimate decision-maker.
- **Build diverse data teams.** Data science teams should be as diverse as the populations that will be

affected by the AI algorithms. Diverse teams are more likely to be intimately familiar with the challenges faced by those who are underrepresented in data sets or unfairly targeted by algorithms. Specifically, the interests, skills, and life experiences of underrepresented minority populations are relevant factors when building teams to identify potential sources of bias.

- **Generate awareness of implicit biases.** Diversity alone will not eliminate implicit bias in data science teams. Awareness and sensitivity to implicit biases and their influence on decision-making is as important for data science teams as it is for clinicians and policy-makers.

C. Patient Engagement and Activation

Patient engagement and patient activation are closely related concepts. Although various definitions exist, patient engagement generally refers to a multi-stage process that involves cognitive, emotional, and behavioural changes leading toward self-management (Barello, 2014). Patient activation is a measure of patients' knowledge, skills, and confidence to manage their health in the context of the care they receive (Hibbard, 2013). In an RPM diabetes management program, both patient engagement and activation support were provided via nurse coaches, nutritional counselling, disease-self-management support, measurements, and assessments (Su, 2019). This study showed that higher levels of patient activation and engagement were associated with better glycemic control outcome (Su, 2019). Importantly, the authors note:

> Developing targeted interventions for different groups of patients to promote their activation and engagement levels would be important to improve the effectiveness of remote patient monitoring in diabetes management. (Su, 2019, p. 952)

The different groups of patients can be considered using the lens of the digital determinants of health discussed above, as well as intersectionality discussed below. To actively support the engagement and activation of patients who face digital barriers to health and those from underrepresented groups, the DHEF principle of ensuring that health providers have the appropriate competencies and training to support equitable digital health care would be an important component of RPM programs (Crawford & Serhal, 2020).

D. Intersectional Approach

Intersectionality promotes an understanding of human beings as shaped by the interaction of different social locations (e.g., 'race'/ethnicity, Indigeneity, gender, class, sexuality, geography, age, disability/ability, migration status, religion). These interactions occur within a context of connected systems and structures of power (e.g., laws, policies, state governments and other political and economic unions, religious institutions, media). Through such processes, interdependent forms of privilege and oppression shaped by colonialism, imperialism, racism, homophobia, ableism and patriarchy are created. PUT SIMPLY: According to an intersectionality perspective, inequities are never the result of single, distinct factors. Rather, they are the outcome of intersections of different social locations, power relations and experiences. (Hankivsky, 2014, p. 5)

Applying an intersectional approach when planning RPM initiatives will promote the consideration of all population groups' needs, especially underrepresented groups. The following are some important intersectional factors described in the literature to consider when developing RPM initiatives.

- **Internet connectivity:** Remote and rural populations are often identified as the population that would highly benefit from virtual health/RPM as it would reduce travel time and bring health care closer to the community. Kelly et al. (2020) outline challenges of stable Internet connectivity in some areas and identify alternate solutions to video conferencing, such as phone appointments, as well as significant investment into infrastructure to increase connection in remote and rural areas in particular.
- **Limited English Profiency (LEP):** Rodriguez et al. (2021) measured the use of virtual health by patients with LEP. Individuals with LEP had lower rates of virtual health use compared with proficient English speakers (4.8% versus 12.3%). Results identify language barriers as an important challenge in virtual health use. Patients with LEP experience disparities in care access, satisfaction, utilization, and quality (Rodriguez, 2021). Craig et al. (2021) identified the following principles to address language barriers:

- Establish digital health equity as a strategic priority
- Invest in innovative multilingual digital health technology
- Allocate resources for multilingual digital health support
- Integrate equity into data analytics
- Incorporate multilingual patient experiences into user-centered design decisions

- **Older adult populations:** Walker et al. (2019) identified the perceptions of older populations related to RPM, which included concerns about additional burden, reluctance to learn something new, and lack of trust in the technology. These concerns may be addressed with personalized training and support, as well as designing the RPM technology to "have minimal user burden, be user-friendly, and have mechanisms installed to provide reassurance of safety" (Walker, 2019, p. 84).

Although the literature on other intersectional factors related specifically to RPM is limited, it is certainly applicable to consider learnings associated with virtual health use. These include:

- **Gender-affirming care:** Addressing the individual needs and experiences of Two-Spirit, trans, and gender diverse people within a RPM program should not only focus on eliminating societal stigma and discrimination but actively addressing prevalent concerns related to privacy. In a study by Sequeira et al. (2022), concerns regarding privacy and safety—in particular, hesitation regarding camera use—were prevalent among gender-diverse youth using telemedicine for gender-affirming care (Sequeira, 2022).
- **Indigenous cultural safety and humility:** Fraser et al. (2017) highlight the importance of continued partnership and meaningful engagement with Indigenous Peoples and communities to better understand their use of virtual health. Additionally, in respect to supporting Indigenous Peoples with chronic conditions, and regardless of how care is being delivered, "the modality needs to be culturally competent and the care received must be culturally safe" (Fraser, 2017, p.1).

The Accessible BC Act requires that public sector organizations, including health authorities, "establish an accessibility committee, an accessibility plan and build a tool to receive feedback on their accessibility" (Government of British Columbia, 2022). This requirement presents an opportunity to improve accessibility of RPM program design and to expand the scope of the committee to include diversity, equity, inclusion, as well as accessibility.

Considerations for Equitable Practices in Remote Patient Monitoring

Based on these findings from the literature, it is highly recommended that RPM programs build their teams with members from diverse backgrounds and experiences and provide training on digital equity and ways to address implicit bias in order to address health equities while designing the future of RPM in B.C.

5. Evaluation Resources

Evaluation of RPM initiatives in B.C. enables programs to identify applicable evaluation outcomes and indicators to support the optimization of health for individuals, populations, and systems alike. Similar to other virtual care and home health monitoring initiatives in other Canadian jurisdictions, B.C.'s evaluation is primarily based on the Canada Health Infoway Benefits Evaluation Framework (2012) and the Institute for Healthcare Improvement (IHI) Triple Aim Framework. In addition to these leading frameworks, below are additional evaluation resources that can contribute to comprehensive RPM program evaluation planning.

BC Ministry of Health - Common Evaluation Framework

The Home Health Monitoring (HHM) Common Evaluation Framework was developed to evaluate all HHM initiatives across B.C. receiving funding support from the BC Ministry of Health Strategic Initiatives Fund (2018). The Common Evaluation Framework is an evidence-based model grounded on Ontario's Investment Management Asset Assessment Guide (October 2018) which focuses on value added for patients, providers, and the health system as a whole across the following dimensions:

- Impact on outcomes related to patient-centered care and patient health;
- Factors related to the sustainability of the above outcomes, balancing investments required and uptake of the initiative;
- Impact on the health system, including resource utilization and efficacy; and
- User experience.

For additional information, please refer to the Common Evaluation Framework.

BC Patient Safety & Quality Council - BC Health Quality Matrix

The BC Health Quality Matrix (2020) is a framework that supports the development of evaluation metrics that considers a wholistic approach to health and wellness (physical, mental, emotional, spiritual) while emphasizing relational care and cultural humility (BC Patient Safety & Quality Council, 2020). Specifically, the Matrix enables measurement of quality across seven Dimensions of Quality—five dimensions (Respect, Safety, Accessibility, Appropriateness, Effectiveness) focusing on individual experience and two dimensions (Equity and Efficiency) examining system performance—across five Areas of Care that represent various stages in an individual or a community's journey toward health and wellness (BC Patient Safety & Quality Council, 2020).

For additional information, please refer to the BC Health Quality Matrix Companion Guide that provides more information on applying the definition of quality in a specific setting.

Benefits Evaluation Toolkit - Canada Health Infoway - Benefits Evaluation Toolkit

Originally developed in 2006 and updated in 2012, Canada Health Infoway's Benefits Evaluation Framework allows evaluation of information and communication technology health solutions via assessment of quality at system, information, and service levels with respect to patient safety and outcomes, access and participation, and efficiency and cost (Canada Health Infoway, 2012). The Canada Health Infoway Benefits Evaluation Indicators Technical Report (2006) contains guidance on evaluative planning, as well as indicators and corresponding methods and data sources.

For additional information on the Benefits Evaluation Framework, as well as templates and examples of benefits evaluation plans, guidance and templates for surveys, and other resources, please refer to the Canada Health Infoway's Benefits Evaluation Framework and Tools webpage.

6. Cost-Effectiveness and Return on Investment

Upfront Investments vs. Direct and Indirect Cost-Savings

When implementing RPM initiatives, there is often a larger upfront capital investment required, which includes the cost of equipment, software, installation, training, and various other miscellaneous costs (De Guzman, 2022; Mantena, 2021). While technology is one of the largest costs associated with RPM, staffing is another area where a significant investment is required, both for clinical providers to deliver RPM services and for IT personnel to provide support for employees and patients (Mantena, 2021). Despite the initial investment costs, the literature shows both direct and indirect cost-savings resulting from RPM initiatives in the longer term (Beard, 2020; Coye, 2009; Kesavadev, 2021; Lemelin, 2020; Margolis, 2020; Matovic, 2012; Palombo, 2009; Riley, 2015; van den Heuvel, 2021). These cost reductions materialize through:

- Shortened length of hospital stays;
- Reductions in outpatient and medical visits;
- Improvements in staffing resource optimization; and
- Reductions in hospital and emergency department admission and readmission rates (Coye, 2009; Gheorghiu & Ratchford., 2015; Kesavadev, 2021; Lemelin, 2020; Maines, 2020; Mantena & Keshavjee, 2021; Willems, 2008).

Organizational Considerations

At an organizational level, there are many additional considerations with regard to RPM implementation which can influence the cost-effectiveness of RPM initiatives. For example, integration of RPM into program workflows, as well as the integration of RPM technology into existing systems, can drive up initial resource, software, and training costs (De Guzman, 2022). However, personalized implementation plans and greater integration with existing systems, EHRs, and clinical program workflows are key components to overall effectiveness of RPM programs (De Guzman, 2022; Liu, 2020; van den Heuvel, 2021; Vogtmann, 2013). Keeping these considerations in mind, it is favourable for health organizations to invest in integration efforts.

Condition-Specific Downstream Effects of RPM

Evidence of cost-savings concerning specific clinical presentations requires a deeper look at the downstream effects of RPM initiatives. RPM can provide significant cost-savings over the long-term in certain patient population groups. For example, in patients with hypertension, RPM can facilitate the prevention of future high-cost health events such as heart attack and stroke (De Guzman, 2022). At Brigham Women's Hospital in Boston Massachusetts, patients enrolled in a hypertension management program reached their target goal blood pressures in as little as seven weeks and, when followed over half a year later, the participating patients maintained these reductions in blood pressure rates (Fisher, 2019). RPM helps patients to reduce critical risk factors, which may lead to future adverse health events, ultimately saving the health care system funds through downstream effects.

Patients with conditions that are more complex or those with comorbidities, such as COPD and heart failure, require more vital sign monitoring and more expensive equipment with additional peripherals, which can drive up the initial technology-related costs (De Guzman, 2022). Despite the initial costs, multiple studies have shown that the use of RPM in patients with chronic pulmonary or cardiac issues or diabetes results in a reduction of hospital service utilization (Coye, 2009; Gheorghiu & Ratchford, 2015; Lemelin, 2020; Riley, 2015; Park, 2021).

Considerations for Planning and Development

Knowing that RPM requires an initial upfront investment, which may take longer to recuperate, it is recommended that health organizations look for ways to reduce the initial capital costs of RPM to help yield greater cost-savings in the long-term (De Guzman, 2022). As indicated above, cost-effectiveness of RPM depends on many factors including initial capital investments, workflow and integration efforts, and the specific clinical circumstances in

which RPM is used. Many RPM initiatives demonstrate direct and indirect cost-savings from reduced health service utilization, but it is important to also consider broader societal costs such as those resulting from reduction in travel time to medical appointments and the associated productivity gains for patients and their families (Beard, 2020; De Guzman, 2022; Gheorghiu & Ratchford, 2015). A more digitally enabled health care system allows patients to avoid physical displacement and travel to access care, which in turn helps to reduce carbon emissions (i.e., fossil fuel) and contribute to the move towards net zero health care (Rasheed, 2021).

7. Provincial Top-Rated Vendors

In July 2021, PHSA participated in a National Request For Pre-Qualification (RFPQ) with Canada Health Infoway (see Appendix 4 and Appendix 5 for PHSA RFPQ questionnaire to vendors regarding clinical and business requirements and technical requirements, respectively). This process resulted in a list of the following six qualified vendors, including existing PHSA vendor, TELUS Health:

- Vivify Health (www.vivifyhealth.com)
- TELUS Health Solutions (www.telus.com/en/health)
- Seamless Mobile Health Inc. (https://seamless.md/)
- TeleVU Innovation Ltd. (https://televu.ca/)
- GE Healthcare (www.gehealthcare.ca)
- Cloud DX Inc. (www.clouddx.com)

It is important to mention that, as an existing PHSA RPM vendor, TELUS Health had a distinct advantage in their response to the RFPQ.

In June 2022, Canada Health Infoway conducted an RFPQ vendor refresh to provide vendors who were previously unable to participate in the 2021 RFPQ an opportunity to submit their proposals. PHSA participated in RFPQ vendor refresh, which resulted in the addition of the following four pre-qualified vendors to this list:

- Calian Ltd. (Dapasoft) (www.calian.com)
- LeoMed Technologies (https://www.leomed.co)
- Medtronic Canada ULC (www.medtronic.com/ca-en/index.html)
- Ricoh Canada (www.ricoh.ca/en-CA)

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Appendix 1. Methodology and Key Definitions

Search Terms and Methodology

The Provincial Virtual Health team developed a comprehensive literature search strategy. A peer review of electronic databases was completed in December of 2022, inclusive of articles within a 15-year period from 2007 to 2022 to examine the clinical benefits of RPM on a variety of patient populations. Two reviewers independently screened titles, abstracts, and full-text articles and selected studies meeting the inclusion criteria from the following electronic databases: Academic Search Premier, CINAHL, Medline OVID, EBSCO, ScienceDirect, PubMed, Directory of Open Access Journals, JSTOR and Google Scholar.

Research Question:

Population	Intervention/Exposure	Comparison	Outcome
Different patient populations	RPM service or program	No RPM and across different types of program delivery	Impact on patients, providers, health outcomes

Question: When administering (I) to a variety of patient populations (P), how are different programs delivered (C), and what are the outcomes on patients, health care providers, and the health system/organization?

Search terms from Medline:

1. 'Remote patient monitoring and devices'
2. 'Virtual monitoring'
3. 'Programs evaluation'
4. 'Models and Organization'
5. 'Delivery of Health Care'
6. 'Electrocardiography, Ambulatory'
7. 'Neurophysiological monitoring' or 'telemetry' or 'remote sensing technology'
8. 'Blood glucose self-monitoring' or 'drug self-monitoring' or 'fetal monitoring' or exp monitoring, or ambulatory
9. 'Wearable electronic devices' or 'fitness trackers'
10. 'Bio-sensing techniques'
11. 'Home Monitoring'

Appendix 2. Summaries of RPM Programs Found in Literature

Although the RPM literature was not available in all health care sector areas at the time of the literature search, learnings across RPM model or service design areas may be applicable to different clinical areas as appropriate.

A. Public Health

i. Adoption, Feasibility and Safety of a Family Medicine-led Remote Monitoring Program for Patients with COVID-19

Health organization and location	Year	Target population
Women's College Hospital, an ambulatory academic hospital in Toronto, Ontario	April 8 to May 11, 2020	Community dwelling patients in the Greater Toronto Area diagnosed with COVID-19, who did not have a pre-existing close connection to primary care. Patients who lived in long-term care and those who did not have access to telephone were excluded from this study. N=97

Context/Background: During the COVID-19 global pandemic, milder cases of the disease could be managed via primary care. However, in Ontario, many primary care providers reduced services as they adjusted to virtual care, and for some providers managing a novel infectious disease at a distance was a challenge. A family medicine-led inter-professional model of RPM was established to monitor patient with COVID-19 (COVIDCare@Home). Patients were provided telephone or video visits seven days a week with a multidisciplinary team consisting of a family physician, resident, registered nurse, mental health or social worker, nurse practitioner and pharmacist. Specialists were available for virtual consultation, and patients had access to a 24-hour on-call service. Monitoring, risk stratification, and protocols were based on available evidence and clinical expertise. Pulse oximeters and thermometers were couriered to patients deemed to be at high risk: older than 60 years, presence of multiple comorbidities, and current respiratory symptoms. The nurse practitioner supported case management for complex conditions, and social workers provided counselling and access to community services. Reports were shared with patients' primary physician to facilitate shared care.

Objective: To evaluate the initial adoption, feasibility, and safety of a model of care for patients with COVID-19.

Outcome: COVIDCare@Home demonstrates that a well-designed RPM service may help improve care for patients, especially those that are typically underserved. The study showed strong patient adoption and retention over the time course of COVID-19, with limited need to transfer to the emergency department and no hospitalizations or deaths. 77% of patients had a family doctor to whom care was transferred after discharge from the program; the remaining patients did not have a regular primary care provider and stayed in the program. The team-based model and primary care expertise enabled the team to support mental health and social needs of patients when it was required, which included resources to support their mental health or address the social determinants of health.

Reference: Agarwal, P., Mukerji, G., Laur, C., Chandra, S., Pimlott, N., Heisey, R., . . . Martin, D. (2021). Adoption, feasibility and safety of a family medicine-led remote monitoring program for patients with COVID-19: a descriptive study. CMAJ Open, 9(2), E324-e330. doi:10.9778/cmajo.20200174

ii. Program for Hospital Discharged COVID-19 Patients

Health organization and location	Year	Target population
Five hospitals in the Mass General Brigham health care system in Boston, Massachusetts	October 2017-2018 This isn't possible—pre-COVID	Patients >18 years of age, diagnosed with COVID-19 or presumed COVID-19 if nasopharyngeal polymerase chain reaction (PCR) was negative, but clinical suspicion was high. Patients who had high-risk comorbidities such as advance heart failure with dyspnea or any cognitive or behaviour health barriers without family or caregiver support were excluded. (N=225)

Context/Background: During the COVID-19 global pandemic, with the reduction non-essential visits, an RPM program was developed to help manage resources (e.g., support early discharge from hospitals and thereby increase inpatient beds, hospital capacity, and reducing number of in person appointments for follow up) and keep patients and staff safe by minimizing disease transmission. Patients received an app and were provided with biometric devices (e.g., pulse oximeter, thermometer). Patients reported their symptoms daily through a short five-symptom questionnaire. Abnormal readings were addressed and actioned by a team of nurse clinicians from a central call centre between 8 a.m. to 8 p.m. daily. The program was staffed by a primary care physician during daytime hours and by an on-call physician during evening hours for escalation and treatment support.

Objective: To use RPM technology to monitor patients with COVID-19 upon discharge from hospital.

Outcome: RPM was associated with a reduced risk of readmission to emergency department or hospitals. Of the patients enrolled who completed monitoring questionnaires, 66% did not have any alerts that needed nurse intervention of follow-up, demonstrating that patients may not require contact or follow-up after discharge from hospital aside from the initial enrollment calls. The study suggests that patients can be monitored passively, and this is a scalable method of monitoring in a post acute care setting. Additional research needs to be completed to determine impact on patient clinical outcomes and cost implications of RPM programs.

Reference: Gordon, W. J., Henderson, D., DeSharone, A., Fisher, H. N., Judge, J., Levine, D. M., . . . Boxer, R. (2020). Remote Patient Monitoring Program for Hospital Discharged COVID-19 Patients. Appl Clin Inform, 11(5), 792-801. doi:10.1055/s-0040-1721039

B. Cancer/Palliative Care

i. The HOPE Pilot Study: Harnessing Patient-Reported Outcomes and Biometric Data to Enhance Cancer Care

Health organization and location	Year	Target population
Dana-Farber Cancer Institute in Boston, Massachusetts	April 12 to June 23, 2017	Patients with a diagnosis of recurrent, incurable gynecologic cancer; intent to receive chemotherapy, and age above 20 years. Patients had to have access to a smartphone (iOs or Android) and a willingness to wear two accelometry devices for at least 30 days. (N=10)

Context/Background: The objective in palliative chemotherapy treatment is to support patients by reducing their symptoms and extending survival. Yet, the standard forms of symptom monitoring are not yet fully developed, and much data related to treatment toxicities go missed. Integrating patient-reported outcomes to monitoring presents an opportunity to help improve symptoms, communications, and clinical outcomes. An RPM model of care was piloted using wearable accelerometers to track patient physical activity and a research platform to collect patient-reported outcomes. The platform actively gathers patient data on quality of life, cancer related symptoms, and physical function. There is branching logic and algorithms within the platform which support survey questions that are tailored to patient-reported symptoms. The RPM platform further helps to stratify patients by risk, deliver customized symptom management, and support communication between clinicians and patients on high-risk symptoms. Patient data were reviewed daily by the research team, who further contacted patients by telephone to investigate any changes in behaviour patterns. The research team advised patients to call their clinical team if concerns arose and directly notified the primary clinician and the program nurse.

Objective: To assess the feasibility, acceptability, and perceived effectiveness of an RPM initiative called HOPE (helping our patients excel) to collect patient-reported outcomes and activity as measures of patient health.

Outcome: Among the patients recruited for the RPM initiative, 100% consented to participate and 70% adhered to the use of the wearable accelerometers and symptom monitoring surveys. Nine out of 10 patients said they would recommend RPM to friends who were undergoing chemotherapy treatment (one expressed regrets due to non-adherence). The RPM initiative helped improve symptom management and the detection of high-risk clinical events. Both patients and clinicians noted that the RPM initiative improved physical activity, communication, and patient symptom management. This successful pilot supports the rationale for larger randomized control trials to assess the efficacy of RPM on patient symptoms, quality of life, clinical outcomes, and health care use.

Reference: Wright, A. A., Raman, N., Staples, P., Schonholz, S., Cronin, A., Carlson, K., . . . Onnela, J. P. (2018). The HOPE Pilot Study: Harnessing Patient-Reported Outcomes and Biometric Data to Enhance Cancer Care. JCO Clin Cancer Inform, 2, 1-12. doi:10.1200/cci.17.00149

ii. Feasibility and Usability Aspects of Continuous Remote Monitoring of Health Status in Palliative Cancer Patients Using Wearables

Health organization and location	Year	Target population
University Hospital in Zurich, Switzerland	February 2017 to May 2018, 12-week duration	Patients treated with palliative intent, being discharged from inpatient setting. Patients were estimated to have a life expectancy of <8 weeks and <12 months as judged as judged by the physician. Patients with cognitive impairment were excluded from the study. (N=30)

Context/Background: Cancer patients in palliative care are a population that experience several health symptoms and deterioration of health status which leads to emergency visits for symptom management for pain, shortness of breath, and fatigue. In many cases, these visits are deemed avoidable through early detection and intervention. Continuously monitoring patients in outpatient health care settings is not always feasible due to human resourcing challenges. Palliative patients in this study were provided a sensor-equipped arm bracelet, an Android smartphone with a prepaid SIM card, and an activity monitoring app to track and predict decline in health status. The activity monitoring mobile app was designed before the study, and interviews with cancer patients were conducted to adapt the app to the user needs, including making the interface simple and easy to handle. The sensors collected daily heart rate and step count.

Objective: To evaluate the feasibility and patients' acceptance of remote monitoring using wearables in palliative cancer patients.

Outcome: Patients fared well with use of a smartphone and sensor, provided their condition did not worsen rapidly. Of the 30 patients enrolled in the study, 25 completed the entire study period of 12 weeks starting at discharge from inpatient care at radiation oncology or a specialized palliative ward. Of the five patients who dropped out of the survey, two were due to technical issues, and three were due to severe and rapid decline in health. 93% of patients reported no major issues with handling the devices throughout the study period. There was an overall 71% positive rating from patients with some direct comments from patients around challenges with smartphone battery life, wearable devices, and questions around data security. Three patients stated that they wanted to see the data that was collected by the wearable and that feedback should be given to patients if there is a worrisome trend in vital signs—this highlights a need for a patient-facing dashboard and transparency around the data as well as clear communication with patients when data is abnormal. Patients were more consistent with their monitoring during the daytime, whereas monitoring during night hours was not achieved due to a variety of factors such as having to charge the device, patients finding it too uncomfortable to wear as it was hot and led to sweating, sizing issues of the bracelet. This study shows that it is possible to use RPM in palliative cancer patients, but there needs to be more research on patient health outcomes and impact on hospital re-admissions.

Reference: Pavic, M., Klaas, V., Theile, G., Kraft, J., Tröster, G., & Guckenberger, M. (2020). Feasibility and Usability Aspects of Continuous Remote Monitoring of Health Status in Palliative Cancer Patients Using Wearables. Oncology, 98(6), 386-395. doi:10.1159/000501433

C. Chronic Care

i. Development of an Entirely Remote, Non-physician Led Hypertension Management Program

Health organization and location	Year	Target population
Brigham and Women's Hospital (BWH) in Boston, Massachusetts	2017	Patients from one primary care practice and principal cardiology clinic at BWH with a baseline clinic BP greater than or equal to 140/90. (N= 130)

Context/Background: Hypertension leads to increased risk for cardiovascular disease and places a large burden on health care systems. Standard methods of care delivery, where patient's blood pressure (BP) is managed via in-person office visits have been shown to be both ineffective and inefficient. A navigator-led hypertension RPM program was developed to leverage algorithmic care pathways, at-home blood pressure monitoring, and ongoing patient coaching to support immediate medication titration and patient education. In the early stages, patient care was managed by pharmacists and nurse practitioners; as the program was established, patient navigators were trained to follow expert-developed clinical algorithms and pathways to support patients.

Patients were enrolled in a program for six months, where they monitored their BP at home using monitors that transmit data in real time to the hospital EHR. Weekly BP averages were calculated and used to support medication adjustments via telephone consultation with patient navigators following the clinical algorithm. Patients waited one week for stabilization and then repeated BP measurements at home for one week, resulting in medication titrations every two weeks as needed. Pharmacists reviewed and signed all new prescriptions.

Objective: To determine if a home-based BP control program run by non-physicians can provide efficient, effective, and rapid control of hypertension in patients.

Outcome: Among 116 patients who completed the program, 91% reached their target blood pressure in an average of 7 ± 7 weeks without large increase in pill burden. In these patients, systolic BP fell from baseline clinic pressure 155 ± 18 to 124 ± 8 mm Hg average home BP. Diastolic BP fell from 92 ± 13 to 74 ± 8 mm Hg. Within one year post pilot, follow-up blood pressures were obtained from 99 patients over an average of seven months. The reductions were sustained despite the fact that patients had no regular contact with clinic staff and did not receive reminders to measure blood pressure or guidance on medication and lifestyle. Contributing factors to success of this project included coordinated teamwork across all tiers of the health care system, clinical champions dedicated to hypertension control and provider education, and widespread educational efforts especially amongst providers who were concerned about loss of autonomy.

Reference: Fisher, N. D. L., Fera, L. E., Dunning, J. R., Desai, S., Matta, L., Liquori, V., . . . Scirica, B. M. (2019). Development of an entirely remote, non-physician led hypertension management program. Clin Cardiol, 42(2), 285-291. doi:10.1002/clc.23141

ii. Expanding Telemonitoring in a Virtual World: A Case Study of the Expansion of a Heart Failure Telemonitoring Program during the COVID-19 Pandemic

Health organization and location	Year	Target population
Toronto General Hospital in Ontario, Canada	March 9, 2020	Heart Failure Patients enrolled at the discretion of their cardiologist. Qualitative Case Study probing the experiences of patients n=16), clinicians (n=9), and operational staff (n=4) from the Medly tele-monitoring program at the heart function clinic in Toronto, Canada. (N=29)

Context/Background: Concerns regarding patient safety during the COVID-19 pandemic spurred the Peter Munk Cardiac Centre (PMCC) Heart Function Clinic at Toronto General Hospital to transition its services to a virtual care model. Clinicians enrolled patients to the Medly program, a mobile-based monitoring program that remotely supports patients with heart failure. Enrollment was based on cardiologist clinical judgment, and patients used a smartphone provided by the program or brought their own device with the Medly app to input data such as weight, blood pressure, and self-reported symptoms. Care management through the platform was done through rules-based dashboards and clinical alerts through email and the application, all of which were overseen by the clinical care team. In March 2020 the program served 565 patients then expanded to include 117 additional patients between March to June.

Objective: To understand the experiences related to the expanded role of an RPM program under the changing conditions of a pandemic.

Outcome: During the expansion of this project, RPM was able to increase patient access to care However, under the pandemic conditions, the challenges of unintegrated and siloed systems such as the electronic health record and laboratory systems were highlighted as contributing to a burden on clinician workload. To support adaptability and scaling of RPM, recommendations included: revisiting the scope and eligibility for RPM in consultation with clinicians, staff, and patients; expanding informational modalities and ensuring patient uptake; supporting efficient modes of communication across platforms and between clinicians; and including other health indicators to personalize patient information collection.

Reference: Wali, S., Guessi Margarido, M., Shah, A., Ware, P., McDonald, M., O'Sullivan, M., . . . Seto, E. (2021). Expanding Telemonitoring in a Virtual World: A Case Study of the Expansion of a Heart Failure Telemonitoring Program During the COVID-19 Pandemic. J Med Internet Res, 23(1), e26165. doi:10.2196/26165

D. Cardiac Care

i. Cardiac Care: Evaluation of a Mobile Application for Heart Failure Remote monitoring

Health organization and location	Year	Target population
Hospital Universitario San Ignacio in Bogota, Colombia	Six-month pilot	Patients of the HF and Heart Transplant Program with an ability to use mobile devices and regular connection to the internet. N=20

Context/Background: For patients with heart failure, treatment adherence and continuous monitoring support improvements in symptoms, minimize risk of hospitalization, and contribute to overall quality of life. A multi-disciplinary team of researchers from nursing, medicine, and engineering developed a mobile app for patients, which is connected to a web-based app for clinicians to be able to monitor patients in real time. The app provides patients with education and tips on self-care and offers a way to track biometric data such as weights, blood pressure, heart rate and to record their symptoms daily. Data beyond thresholds generate alerts for nurses with possible actions to take such as modifying drug treatment, avoiding progression of symptoms, and potential hospitalization. The app system is integrated into the hospital EHR.

Objective: To develop and evaluate an RPM application for heart failure, through a web-based interface for clinicians, and a mobile app for patients.

Outcome: During the six-month study period, 164 alerts were generated from patient self-reported data which were related to patient weight gain, low blood pressure values, or symptoms reported in assessment questionnaires. 91% of patients enrolled in RPM did not present with hospital re-admission due to decompensation. 100% of patients found the app useful and easy to use, and 90% were in total agreement that they would continue to use the app, with the remaining 10% in agreement. The two nurses who used the clinician app during the study agreed that the app helped them perform their jobs and was easy to use. The positive acceptance of the app by nurses and patients suggests that RPM can be implemented as a follow-up strategy in heart HF patients.

Reference: Achury Saldaña, D. M., Gonzalez, R. A., Garcia, A., Mariño, A., Aponte, L., & Bohorquez, W. R. (2021). Evaluation of a Mobile Application for Heart Failure Telemonitoring. Comput Inform Nurs, 39(11), 764-771. Doi:10.1097/cin.0000000000000756

ii. Implementation of Remote Follow-Up of Cardiac Implantable Electronic Devices in Clinical Practice

Health organization and location	Year	Target population
Santa Maria del Carmine Hospital in Trentino, Italy	2016 to December 2018	Patients who already had a CIED and all patients undergoing implantation. N=2024

Context/Background: Many expert guidelines recommend remote follow-up as part of standard practice for patients with cardiac implantable electronic devices (CIEDs) such as pacemakers, implantable cardioverter defibrillators, and implantable loop recorders. Following a primary nursing model, each patient was assigned to an experienced nurse and a physician in charge with pre-established tasks and responsibilities. The nurse contacted the patient with educational interventions, managed data, screened data, identified critical issues, reviewed alarms and alerts, discussed cases with physicians, and generated reports. Patient data in this system was accessible by patients, hospitals, and family general practitioners, enabling data sharing with the patient's circle of care. The physician in charge was responsible for analyzing any critical transmissions submitted by the nurse, conducting further clinical evaluation of the patient, and making any treatment decisions as needed.

Objective: To implement a remote follow-up program for patients with cardiac implantable electronic devices and evaluate the impact on clinic organization, as well as health care resources utilization.

Outcome: The study demonstrated that an RPM follow-up service can be implemented and efficiently managed by nursing staff with minimal physician support, in line with recommendations. Although more nurses were needed, their scope and role were enhanced, and physician time was gained back into the system. Patients were also followed up with greater continuity and reported improved satisfaction. The vast majority of patients agreed to be monitored using RPM model of care and reported positive experiences of using the system after one year of follow-up as well as preference for the new follow-up approach. RPM reduced in-person meetings and provided the nurse with a pivotal role in patient management. Only 3% of all transmissions resulted in unplanned hospital visits for assessment and treatment, and only 21% of transmissions were submitted by the nurse to the physician for further clinical evaluation. Between 2016-2017, all CIED patients on active follow-up were included in the new service. Since 2018 the service has been fully operationalized for all patients post-implantation hospital discharge.

Reference: Maines, M., Tomasi, G., Moggio, P., Peruzza, F., Catanzariti, D., Angheben, C., . . . Del Greco, M. (2020). Implementation of remote follow-up of cardiac implantable electronic devices in clinical practice: organizational implications and resource consumption. J Cardiovasc Med (Hagerstown), 21(9), 648-653. Doi:10.2459/jcm.0000000000001011

iii. Workload and usefulness of daily, centralized home monitoring for patients treated with CIEDs: results of the MoniC (Model Project Monitor Centre) prospective multicentre study

Health organization and location	Year	Target population
Monitor centre located in Berlin, Germany serving nine satellite clinics in Germany and Austria	2012 (patients monitored over 1 year)	Patients who had an indication for an ICD or dual chamber pacemaker, reachable by phone, and willing to attend all follow ups. If patients had a life expectancy of <12 months or were under age of 18m pregnant, or breast-feeding, or living in an area with poor network connectivity they were excluded from the study. N = 128

Context/Background: Remotely monitoring patients who are treated with pacemakers and implantable cardioverter defibrillators (ICDs) helps enable earlier detection and treatment of significant clinical events, including cardiac arrhythmias, or technical issues with the devices themselves, which may not be discovered immediately with standard methods of care. In a centralized home monitoring model, the daily automatic home monitoring data from patients with pacemakers and ICDs from nine satellite clinics were screened and filtered by a central monitor centre. The centre operated Monday to Friday 8 a.m. to 4 p.m. and was staffed by two nurses and two physicians. RPM data collected were categorized as red, yellow, green to help guide timing and urgency of clinical follow-up required.

Objective: To test the workflow of a centralized model of RPM for pacemakers and ICDs.

Outcome: A centralized remote monitoring program was found to be feasible, safe, and clinically useful. The monitoring centre received 1,649 notification reports per 100 patients/year, and after applying pre-defined algorithms for escalation, only 131 messages and 148 event notifications were sent to the local satellite clinics. At a local level, these messages either received further action or follow-up, hospitalization, cardiologist appointments, device reprogramming, or medication changes. The local satellite clinics classified 73.7% of messages forwarded by the centralized service as being clinically valuable. An optimized RPM model of care that is based on automated alerts and uses decision trees can target clinically relevant events and reduce organizational consumption of resources without compromise to patient care. Extended data screening should be limited to, for example three-month intervals, to achieve a better workload-benefit balance.

Reference: Vogtmann, T., Stiller, S., Marek, A., Kespohl, S., Gomer, M., Kühlkamp, V., . . . Baumann, G. (2013). Workload and usefulness of daily, centralized home monitoring for patients treated with CIEDs: results of the MoniC (Model Project Monitor Centre) prospective multicentre study. Europace, 15(2), 219-226. Doi:10.1093/europace/eus252

iv. Interactive Home Telemedicine for Early & Protected Discharge 1 day after Carotid Endarterectomy

Health organization and location	Year	Target population
Vascular and Endovascular Surgery, San Martino Hospital, in Genoa Italy	October 2005- June 2006	Patients operated on for carotid endarterectomy (CEA) fulfilling inclusion criteria for discharge after surgery. Inclusion criteria were: an ability to use a mobile phone, home to hospital distance less than 30km, residence in a town with network connectivity. Clinically patients must have no neurological, cardiac post operative complications, absence of fever, cervical hematoma, no abnormality in lab tests, and no hypertension or hypotension. N=147

Context/Background: Atherosclerosis can lead to a build up of plaque in the carotid artery which leads to narrowing and carotid artery disease and increases the risk for stroke. Carotid endarterectomy (CEA) is a surgical procedure to remove plaque build-up in the common carotid and internal carotid arteries to improve blood flow. An RPM program was developed to support early and protected discharge for patients one day after surgery with the goal to decrease length of hospitalization and health system costs, and to maintain high safety standards for patients undergoing CEA. Patients were provided an electronic blood pressure monitor and technology to support video connection with the care team. Monitoring consisted of blood pressure, heart rate, surgical wound assessment, and psychological state of the patient. The patients were monitored every four hours for two days post-discharge. Patients could call their surgeon if necessary, with emergency health services enabled for emergency intervention and transport.

Objective: To demonstrate the feasibility and safety of a program for early and protected discharge one day after CEA using an RPM system.

Outcome: CEA can be safely achieved as a 1-day surgery using RPM in cases with an uncomplicated postoperative course. Patients who were discharged home early with the RPM system had higher levels of insecurity and anxiety about potential risk of complications than the control group. However, upon initial video connection, at-home insecurity decreased in the RPM study group, whereas it persisted in the control group until postoperative day eight. Patients who were discharged early with RPM had increased satisfaction scores upon returning home. There were no surgical wound complications in the study group. The length of video connections were 604.79 ± 42.87 seconds, and about seven video calls per patient. The overall cost of video connections during the 48-hour period after discharge was 25.39 ± 0.25 Euros per patient, while the cost of a one-day hospital stay in Italy is 470.00 Euros, thereby demonstrating significant cost-savings.

Reference: Palombo, D., Mugnai, D., Mambrini, S., Robaldo, A., Rousas, N., Mazzei, R., . . . Spinella, G. (2009). Role of interactive home telemedicine for early and protected discharge 1 day after carotid endarterectomy. Ann Vasc Surg, 23(1), 76-80. doi:10.1016/j.avsg.2008.06.013

v. Cardiovascular Events with Costs with Home Blood Pressure Telemonitoring and Pharmacist Management for Uncontrolled Hypertension

Health organization and location	Year	Target population
16 Primary Clinics at HealthPartners Medical Group	2009	Patients with uncontrolled BP (≥140/90 mmHg or ≥130/80 mmHg if diabetes mellitus or kidney disease was present). N= 450

Context/Background: Uncontrolled high blood pressure (BP) is the greatest risk factor for all cause and cardiovascular mortality in the United States population, and yet BP remains largely uncontrolled. Self-monitoring of BP by patients without any support can result in modest BP reductions. However, when enhanced with counseling and educational care management, self-monitoring often results in significant reductions and improved control. An addition of biometric monitoring is expected to improve BP management far beyond standard care. Standard care for patients with uncontrolled hypertension was compared with at-home BP monitoring with pharmacist care management. After 12 months of intervention, systolic and diastolic BP was lower in the intervention group with differences persisting for up to 24 months after.

Objective: To evaluate the health and economic outcomes of patients who participated in the RPM trial five years post-intervention.

Outcome: Two analyses were conducted: one was a cost comparison of cardiovascular events observed in patients during a five-year follow-up period, and the second was a microsimulation analysis using a microsimulation model to determine whether observed cardiovascular events were similar to model-predicted results. During the five-year follow-up, there was a net cost-saving of $1,438 per patient with the intervention compared to standard care. Return on investment (ROI) was 119% when using a secondary composite measure and including cardiac revascularization costs associated with the events. The microsimulation analysis used virtual counterparts of patients in each study group using characteristics at baseline. This model simulated the incidence of cardiovascular events such as heart attacks, stroke, heart failure, and cardiovascular death in both groups. The results on future cardiac events were not deemed statistically significant, but this may have been due to the impact on cardiovascular risk factors that were not considered in this study. This study showed that at-home blood pressure monitoring and pharmacist care management leads to reductions in BP and may reduce costs by avoiding cardiovascular events over five years. Future RPM studies should plan for long-term follow-up and detect differences in clinical cardiovascular events, as well as measuring other changes in risk factors such as smoking and lipid profiles that could be influenced by counseling and education.

Reference: Margolis, K. L., Dehmer, S. P., Sperl-Hillen, J., O'Connor, P. J., Asche, S. E., Bergdall, A. R., . . . Maciosek, M. V. (2020). Cardiovascular Events and Costs With Home Blood Pressure Telemonitoring and Pharmacist Management for Uncontrolled Hypertension. Hypertension, 76(4), 1097-1103. Doi:10.1161/hypertensionaha.120.15492

E. Mental Health and Substance Use

i. The Use and Effectiveness of Mobile Apps for Depression: Results from a Fully Remote Clinical Trial

Health organization and location	Year	Target population
National Institute of Mental Health - all 50 US states	August 2014	626 English-speaking adults (≥18 years old) with mild to moderate depression. N= 626

Context/Background: Major depressive disorder affects approximately 7% of the United States population each year, and approximately 16% will experience major depression at least once in their lifetime. Mobile technology for mental health has the potential to overcome access barriers to mental health care, but there is little information on whether patients use the interventions as intended and the impact these technologies have on mental health outcomes. In this study participants were assigned to one of three intervention apps that either 1) used gamification via problem solving therapy to create action plans specific to patients' self-identified goals and help modulate cognitive control or 2) delivered daily health tips such as self-care and physical activity. The app included internally programmed reminders, via email or SMS per their indicated preference, to notify participants that an assessment is ready for completion.

Objective: To compare use patterns and clinical outcomes of patients across the United States who use one of three different mobile apps for assessment and treatment of depression.

Outcome: Six hundred twenty-six (626) individuals were randomized to iPST (n=211), Project: EVO (n=209), or Health Tips (n=206). Out of the 626 participants, 77% (n=482) had a PHQ-9 score greater than 10 (moderately depressed). Of the 420 participants using the two active apps, 57.9% (n=243) did not download the intervention app that was allocated to them, but they did not differ demographically from those who did use the app. Participants with a baseline PHQ-9 score of more than 10 showed differential treatment effects, with the cognitive training and problem-solving apps having a stronger positive impact on mood than the information control app (P=.04). Mobile apps for depression appear to have their greatest impact on people with more moderate levels of depression. An app that is designed to engage cognitive correlates of depression had the strongest effect on depressed mood in this sample. This study suggests that smartphone apps reach many people and are useful for more moderate levels of depression.

Reference: Arean, P. A., Hallgren, K. A., Jordan, J. T., Gazzaley, A., Atkins, D. C., Heagerty, P. J., & Anguera, J. A. (2016). The Use and Effectiveness of Mobile Apps for Depression: Results From a Fully Remote Clinical Trial. J Med Internet Res, 18(12), e330. Doi:10.2196/jmir.6482

ii. Evaluation of a remote monitoring system in people with mental illness and medical comorbidity

Health organization and location	Year	Target population
70 Community Mental Health Centers (CMHC), USA	2012	Patients diagnosed with severe mental illness and either diabetes, hypertension, cardiac disease, COPD, or chronic pain. N= 37 received remote monitoring immediately N= 33 received remote monitoring after a 6 month wait.

Context/Background: High medical comorbidity, poor health behaviours, side effects from medication, and lack of adequate health care contribute to a 25- to 30-year life expectancy in patients diagnosed with serious mental illness. Virtual health interventions such as RPM enable daily monitoring of health status and risks to help improve outcomes for patients living with severe mental illness. However, these programs are rarely used or evaluated. In this study patients were randomly assigned to receive remote monitoring immediately or after a six-month wait.

Objective: Primary objective: To determine the feasibility and acceptability of an in-home remote monitoring system programmed with daily dialogues specific to the participants medical and psychiatric condition in outpatients diagnosed with serious mental illness, and either diabetes, hypertension, cardiac disease, COPD, or chronic pain.

Secondary objective: To evaluate the potential effectiveness of remote monitoring with respect to management of psychiatric and medical illness symptoms.

Outcome: The mean adherence across all patients for six months was 71%, and over half of the patients completed 89% of their sessions. Patients who received the device immediately had greater improvements in their symptoms compared to patients who on a six-month waitlist. Use of the RPM device helped support significant reductions in diastolic blood pressure and significant increase in depression self-management. For patients who had concurrent diabetes, RPM resulted in lower fasting glucose and reduction in urgent care visits. 66% of diabetic participants had glucose >140 at baseline. At six months, 50% had achieved a >20% reduction. Patients reported high satisfaction rates at 81% at the six-month mark and shared that they would be very willing to continue use. Remote monitoring led to improved management of psychiatric symptoms and patient health outcomes, especially in patients with severe mental illness and diabetes. In treatment of severe mental illness, challenges such as patient and clinician communication, symptom management, and adherence can be supported through the use of remote monitoring technology. The tool can enhance patient's ability to live independently and has potential to reduce emergency visits, as well improve patient health outcomes and quality of life.

Reference: Pratt, S. I. (2012). Evaluation of a remote monitoring system in people with mental illness and medical co-morbidity. Int J Integr Care, 12(Suppl1).

iii. A comparative study of engagement in mobile and wearable health monitoring for bipolar disorder

Health organization and location	Year	Target population
University of Michigan, Ann Arbor, U.S.	November 2017-2018	Patients with a diagnosis of Bipolar Disorder were recruited from the Heinz C. Prechter Longitudinal Study of Bipolar Disorder (PrBP), an open cohort study at the University of Michigan. N= 50

Context/Background: Bipolar disorder is a mental illness that is characterized by pathological mood swings that range from mania to depression. The course of illness is unpredictable and can cause disruption to patient's personal, social, and vocational life. To help reduce risks of disruption in care, it is recommended for patients to monitor their mood and symptoms to facilitate identification of needs and treatment decisions. Patients involved in the study used a mobile app and wearable device to collect information about their physical activity, sleep, and heart rate. Every morning and evening, patients used the mobile app to report on three symptoms focused on mania (i.e., increased energy, rapid speech, irritability), and three for depression (i.e., depressed mood, fidgeting, fatigue). Patients were also able to view their own biometric data trends in a graphical format via a patient-facing dashboard in the mobile app. Patients were surveyed at the end of the study to gain insights on engagement.

Objective: To evaluate engagement strategies for patients with bipolar disorder to monitor patient symptoms longitudinally.

Outcome: Patients self-monitored their symptoms using an activity tracker and synchronized mobile app over a period of six weeks. Half of the patients were assigned to a group that were able to review their own activity information week by week, and the other half did not review this data. Adherence levels were similar between groups. Patients reported that they would prefer to review the data with a clinician on a monthly basis. They also reported that sleep was the most important symptom to monitor, forgetfulness was the largest barrier to self-monitoring, and raising their self-awareness as the best motivator for self-monitoring. It is recommended when designing similar programs to use a combined strategy of wearables and mobile app monitoring which has reminders, targets that help raise patient self-awareness, and sleep tracking. It is also recommended that clinicians review symptoms on a monthly basis with patients and provide further coaching and education.

Reference: Van Til, K., McInnis, M. G., & Cochran, A. (2020). A comparative study of engagement in mobile and wearable health monitoring for bipolar disorder. Bipolar Disord, 22(2), 182-190. Doi:10.1111/bdi.12849

iv. Commonly available activity tracker apps and wearables as a mental health outcome indicator: A prospective observational cohort study among young adults with psychological distress

Health organization and location	Year	Target population
Australia	2016	Young adults experiencing depression, anxiety and stress. Participants were recruited from a mental health website ReachOut.com; an online mental health support platform for youth between ages of 13-25. N= 120

Context/Background: Digital-based continuous monitoring has the potential to support individuals suffering from common mental health disorders in the community. Early identification of warning signs through passive data collection, or patient day-to-day interactions can help facilitate real time monitoring and supportive care for individuals with psychological distress. This study was a prospective observational cohort design over a period of eight months.

Objective: To elicit a descriptive overview of young adults with common mental health disorders using physical activity trackers and wearable device data.

Outcome: Participants with moderate psychological distress were willing to share their personal information around symptoms and wear daily activity trackers. They found the devices easy to use, and satisfactory and reported that they would continue to use them. Some issues around Bluetooth connection, network connectivity, and app performance negatively impacted patient experience and lowered satisfaction levels.

It appears viable to use continuous monitoring with mobile applications and wearables to track and collect behavioural indicators of mental functioning and support assessment and augmentation of clinical care for patients with common mental health disorders. This strategy can also support patient health self-management. Given the observational nature of the study, the findings have no direct causal links. As well, a convenience sample was used from the community rather than a clinically diagnosed sample. Further evidence through randomized controlled trials is needed to explore impact on patient clinical outcomes. Study findings can provide a basic proof of concept justification for the ability to use continuous digital monitoring for young adults experiencing moderate levels of psychological distress.

Reference: Knight, A., & Bidargaddi, N. (2018). Commonly available activity tracker apps and wearables as a mental health outcome indicator: A prospective observational cohort study among young adults with psychological distress. J Affect Disord, 236, 31-36. doi:10.1016/j.jad.2018.04.099

F. Maternity Care

i. Randomized Comparison of a Reduced Visit Prenatal Care Model Enhanced with Remote Monitoring

Health organization and location	Year	Target population
IMayo Clinic - Outpatient Obstetrics Division, Rochester, Minnesota	March 2014 – January 2015	Pregnant women, aged 18-36 years old, <13 weeks gestation, whose pregnancy were documented as low risk by an obstetrician. N=300

Context/Background: In the United States, the COVID-19 pandemic spurred decision makers to reassess a variety of programs and shift away from in-person visits and toward virtual models of care. This prompted a review of existing prenatal care models. On average, prenatal care consists of 12 to 14 in-person visits per pregnancy which can be costly and resource intensive to health organizations, without any true evidence to support the established structure. The OB Nest was developed as an alternative bundle of care, based on reduced frequency of on-site appointments and supplemented with virtual health visits with a primary nurse, biometric devices such as blood pressure and fetal heart rate monitors, and access to an exclusive online community of prenatal individuals.

Objective: To develop and evaluate the acceptance and efficacy of a new innovative model of care, OB Nest, a reduced frequency pre-natal care model supplemented with remote monitoring of patients at home, and remote nursing support.

Outcome: When compared to the standard method of care delivery, the OB Nest model resulted in higher levels of patient satisfaction, decreased prenatal stress, and a reduced number of visits while maintaining excellent maternal and neonatal outcomes. Provider costs were decreased significantly as a result of decreased time required, from the average of 215.0 (+/− 71.6) to 160.8 (+/− 45.0) minutes. However, nursing costs increased due to an increase in nursing time from 99.6 (+/− 29.7) minutes to 237 (+/− 25.1) minutes. This nursing time included care coordination, management of labs and tests, assessment of symptoms and medical history, and prescription management. The program saw reductions in overhead costs which helped offset some costs.

Reference: Tobah, Y. S. B., LeBlanc, A., Branda, M. E., Inselman, J. W., Morris, M. A., Ridgeway, J. L., ... & Famuyide, A. (2019). Randomized comparison of a reduced-visit prenatal care model enhanced with remote monitoring. American journal of obstetrics and gynecology, 221(6), 638-e1.

ii. SAFE@HOME – New Care Pathway Including a Digital Health Platform for Women at Increased Risk of Preeclampsia

Health organization and location	Year	Target population
Two perinatal centres in urban areas in the Netherlands: one university hospital (2500 deliveries annually, both secondary and tertiary care), and one general teaching hospital; (3000 deliveries annually)	October 2017- 2018	Pregnant women at risk of preeclampsia with a singleton pregnancy and one (or more) of the following risk factors for preeclampsia: chronic hypertenstion, pre-eclampsia in a prior pregnancy, maternal cardiac disease, or maternal kidney disease. N=97

Context/Background: Hypertension in pregnancy is a key factor contributing to maternal and neonatal morbidity and mortality. To determine hypertensive disease and allow for early identification in pregnant people, it is necessary to frequently monitor blood pressure, fetal growth, blood, and urine. An RPM platform was developed to monitor patient blood pressure measurements and self-reporting of preeclampsia symptoms. This newly designed model of care aims to improve patient interaction and independence with monitoring and delivery of safe antenatal care.

Patients were asked to submit a blood pressure reading on weekdays before 10 a.m. with daily reminders being sent to patients three hours before their reading was due. If blood pressure was elevated, then the app prompted patients to complete a series of questions on preeclampsia and general pregnancy symptoms. Alerts and values exceeding the threshold were reviewed by the monitoring team as per program established protocols. If required, the monitoring team escalated care to the obstetrician and contacted the patient for follow-up.

Objective: To evaluate the use of a digital health RPM platform for collection of blood pressure and symptoms combined with a minimal antenatal visit schedule.

Outcome: The use of RPM model of care for monitoring blood pressure and preeclampsia symptoms enabled fewer antenatal visits, ultrasound assessments, and antenatal hypertension related admissions. For patients, there was also decreased travel time, decreased loss of productivity costs, and higher levels of satisfaction. No difference was found in maternal or perinatal outcomes between the study group and the comparison retrospective group. The study results show that RPM is feasible in a high-risk pregnant population; however, larger studies are needed to evaluate patient safety outcomes, medical effectiveness, and cost-effectiveness of RPM in this population.

Reference: van den Heuvel, J. F. M., van Lieshout, C., Franx, A., Frederix, G., & Bekker, M. N. (2021). SAFE@HOME: Cost analysis of a new care pathway including a digital health platform for women at increased risk of preeclampsia. Pregnancy Hypertens, 24, 118-123. doi:10.1016/j.preghy.2021.03.004

iii. Demonstrated Cost Effectiveness of a Remote Homecare Program for Gestational Diabetes Mellitus Management

Health organization and location	Year	Target population
Centre hospitalier de l'Universite de Montreal (CHUM) in Montreal, Canada	February 2016-2017	Women over 19 years of age newly diagnosed with GDM and a singleton pregnancy. N=161

Context/Background: Gestational diabetes mellitus (GDM) has been steadily increasing in prevalence in recent years, placing pregnant people with GDM at an increased risk for obstetrical and neonatal complications. Pregnant people who are adequately treated have significant reduction in risk for major complications. Therefore, multidisciplinary follow-up from a variety of team members including nursing, physicians, and nutritionists is imperative. Due to the growing number of GDM diagnoses, the demand on hospital resources for education and management have risen. However, limited clinic capacity and overbooked schedules have resulted in delays in services, placing a burden on pregnant people in terms of costs from missed work, childcare, and transportation. The remote homecare system (THCa) is a remote model of care delivery which includes the electronic transmission of patient data for follow-up, education, and therapeutic adjustments, intended to re-organize care to be more efficient and improve access for GDM management.

Objective: To evaluate the impact of an RPM model of care for pregnant people with GDM on clinical cost-effectiveness, pregnancy outcomes, and overall patient satisfaction with the service.

Outcome: The use of RPM model of care for monitoring GDM led to a decrease in medical visits by 56%. A comparison of pregnant people enrolled in THCa and those not unenrolled showed no difference in diabetes control or maternal/fetal complications. There was a 10-fold increase in nursing interventions in the THCa group and patient satisfaction was high. Overall, there was a 16% cost-savings with the THCa group compared to the control group.

Reference: Lemelin, A., Paré, G., Bernard, S., & Godbout, A. (2020). Demonstrated Cost-Effectiveness of a Telehomecare Program for Gestational Diabetes Mellitus Management. Diabetes Technol Ther, 22(3), 195-202. doi:10.1089/dia.2019.0259

G. Specialty Care

i. A multi-centre, randomized, controlled trial on coaching and remote monitoring in patients with cystic fibrosis: Connect CF

Health organization and location	Year	Target population
Four different medical settings in Germany: two major cities (Charité – Universitätsmedizin Berlin and Cystic Fibrosis Centre Munich-West), a conurbation (University Medicine Essen), and one rural area (University Medicine Rostock and three associated doctor's practices in Berlin)	2021, 18-month duration	Patients greater than 12 years of age with CF, who have had one pulmonary exacerbation in the year before enrollment and forced expiratory volume (FEV1) <90% of the predicted value. If on cystic fibrosis transmembrane conductance regulator modulator therapy, patients must have been stable on the treatment for 3 preceding months. Patients were excluded from the study if they had an acute depressive or psychotic episode, substantial immobility, no prescribed inhalation therapy, no smartphone, or unable to complete lung function testing or if it was contraindicated for any reason such as pneumothorax or lung surgery. N=402

Context/Background: Cystic fibrosis (CF) is an inherited multi-organ disorder that causes damage mainly to the lungs but also to organs of the digestive system such as the pancreas and liver. Extensiveness of lung disease is the most important prognostic factor for survival in patients with CF, and lack of adherence is the main reason for treatment failure. Early detection of deteriorating lung function and optimizing treatment adherence are crucial. Digital health technology opens up the possibility of monitoring patients remotely, intervene early in case of lung function decline, improve patient access, and help patients improve self-management and reduce travel to specialized centres. In this RPM program, patients receive electronic devices that allow them to conduct at-home spirometry, and data is transmitted between patients and physicians. The program also includes a self-management app, video conferencing, and professional telephone coaching.

Objective: To evaluate the efficacy of remote monitoring of adherence, lung function, and health condition along with behaviour change interventions using digital technology.

Outcome: Clinical trial remains in progress. Study offers the ability to evaluate the effect of adherence interventions using RPM devices and their impact on lung health and treatment adherence in CF patients.

Reference: Thee, S., Stahl, M., Fischer, R., Sutharsan, S., Ballmann, M., Müller, A., . . . Mall, M. A. (2021). A multi-centre, randomized, controlled trial on coaching and telemonitoring in patients with cystic fibrosis: onnect CF. BMC Pulmonary Medicine, 21(1), 131. Doi:10.1186/s12890-021-01500-y

H. Surgical Care

i. Improved 30-Day Surgical Outcomes in Ostomates Using a Remote Monitoring and Care Management Program

Health organization and location	Year	Target population
19 health care institutions in the states of New York, New Jersey, Ohio, California, Massachusetts, and Indiana	October 2018 – January 2020	Patients who underwent surgery for the formation of an ostomy. N = 166

Context/Background: Patients who undergo major intestinal surgery resulting in an ostomy often have impaired quality of life due to post-surgical complications, including dehydration and peri-stomal skin conditions, which result in frequent hospital admissions.

The SmartCare remote monitoring platform is made up of a wireless ostomy appliance equipped with sensors that supports monitoring and tracking of potential leakages and skin irritation. This connects to a patient-facing mobile app through their smartphone. Biometric data is transmitted to a cloud-based server which is accessible to the patient coach and health care team. Patient coaches are trained in the provision of educational, psychological, and technical support to patients who have had an ostomy placed. The system enables patients and their health care team to monitor output and review alerts based on previously established parameters. Clinical concerns can be escalated to the health care team using virtual health which is available within the software solution.

Objective: To evaluate outcomes of new patients enrolled in the SmartCare RPM program.

Outcome: SmartCare patients experienced lower rates of hospital admission and ED visits within 30 days of surgery. Patients in the RPM program had 16.8% reduction in use of hospital-based acute care, with 9.6% fewer re-admission rates and 11.6% fewer emergency department visits in comparison to the data set used for the study. Some limitations of these results are that there were some differences in age, underlying condition, and stoma type. However, the study noted that when these differences were controlled for, there were still benefits demonstrated in the RPM group. Patients who required an escalation to acute care had more interactions with the SmartCare patient coach or nurse than those who did not have any alerts, indicating improvements in resource efficiency. The care team was able to intervene for patients who needed support to prevent further acute events, as well as managing any identified concerns.

Reference: Fearn, R. I., Gorgun, E., Sapci, I., Mehta, S. N., Dinh, B., Yowell, Q. V., & Eisenstein, S. (2020). Improved 30-Day Surgical Outcomes in Ostomates Using a Remote Monitoring and Care Management Program: An Observational Study. Diseases of the Colon & Rectum, 63(12), e581-e586. Doi:10.1097/dcr.0000000000001838

I. Organ Transplant

i. Mobile App to Improve Access to Lung Transplant and Reduce Waitlist Mortality

Health organization and location	Year	Target population
Ohio, Cleveland Clinic's Respiratory Institute	2021	Four CF patients, two who have undergone lung transplant in Cleveland Clinic

Context/Background: In the United States, patients requiring lung transplant are prioritized based on their lung allocation score (LAS), which takes into account both the risk of mortality while waiting for transplant and the chance of survival following transplant. While lung transplant is a therapy option for people with severe cystic fibrosis (CF) lung damage, the LAS does not contain all indications of CF disease severity. A group of pulmonologists at Cleveland Clinic discovered that patients with the following conditions had a greater probability of waitlist death than what LAS predicted: massive hemoptysis, hospitalization, and relative decline in forced expiratory volume in one second (FEV1). Additionally, they discovered that adding these risk variables to the LAS improved the ability to assess illness severity. A mobile app was designed to identify these risk factors in patients with CF who are on the lung transplant wait list to help improve access to lung transplant and reduce waitlist mortality. A 20-question patient survey was conducted in four patients on the wait list who used the app and reported on their symptoms, physical functioning, appetite and hemoptsys.

Objective: To evaluate the impact of the new risk assessment using a mobile app and assess patient feedback on its usage.

Outcome: Due to the usage of the technology, patients are in touch with the transplant team more frequently and have more opportunity to update their LAS. One patient's survey response suggested occasional hemoptysis, which the LAS did not detect. These findings prompted the study team to ask the LAS for a waiver given the well-established link between hemoptysis and death in CF patients. If the clinical team believes that the LAS does not adequately reflect a person's risk of death without a transplant, an exemption may be asked for. To more accurately reflect that risk, a new score is given. Ultimately, the exception request was granted and the transplant for this patient was expedited. Positive patient feedback has been received, particularly in regard to their comfort with home monitoring and increased level of involvement in their treatment.

Reference: Cleveland Clinic. (2022). New Clinical Tool May Better Detect Disease Severity in Patients with Cystic Fibrosis. Respiratory Exchange winter 2022, p 8-9. https://my.clevelandclinic.org/-/scassets/files/org/respiratory/respiratory-exchange-2022-issue-1.pdf?la=en

Appendix 3. National RPM Summary Overview

To help expand knowledge of RPM from a provincial to national level, provinces that participated in the Canada Health Infoway multi jurisdiction Remote Patient Monitoring Pre-Qualification (RPMQ) were contacted, in hopes of learning about the current state of RPM in the respective provinces. The provinces of Newfoundland and Saskatchewan participated in the inquiry, meeting with the authors of this whitepaper to answer targeted current state questions. A questionnaire template was provided to provincial RPM representatives to provide information for inclusion into the white paper.

Saskatchewan	Newfoundland
Q: What are the origins and current state of Remote Patient Monitoring in your province?	
eHealth Saskatchewan contracted TELUS Health in March 2020 to use their Home Health Monitoring (RPM) platform. Initial use case was for COVID-19 case monitoring, due to low COVID-19 cases in first wave, focus shifted to exploring alternative use cases in chronic disease management. COVID case monitoring was implemented in January 2021 in response to surge (6100 positive COVID cases enrolled for daily monitoring) & ran until July 2021 using staff resources from the SHA labour pool. In Saskatchewan today, we have six streams utilizing the platform with the potential to expand to additional pathways that have shown interest and potential use cases. • Lung Transplant • Community Paramedicine • COPD • Pediatric Nephrology • COVID Hospital Discharge • Prostate Oncology	RFP 2014 – to address high rates of chronic disease and acute admissions; First patient enrolled November 2015; started with Chronic Obstructive Pulmonary Disease (COPD) and Congestive Heart Failure (CHF) – expanded [provincially to Type II Diabetes in 2016 – related to increased need in Labrador Grenfell Health region. Since then, have expanded with various rates of success to COPD and Diabetes in Labrador Grenfell Health region; COPD and CHF in Western Health region; Discussions for Heart Failure (HF) in Central Health region. Expanded and integrated internally to Eastern Health: CHF clinic; INSPIRED COPD program; Diabetes Program, Canadian National Institute for the Blind (CNIB) Confident Living Program, COVID monitoring for higher risk patients. Most recently in past 12 months, significant work completed to date with Provincial Mental Health and Addictions program to integrate technology into practice to support access. Four key areas – Dialectical behaviour therapy (DBT) ; Opioid Dependence Treatment (ODT) ; Forensic Assertive Community Treatment (FACT) teams and Home alcohol withdrawal management. Also, development of home hypertension monitoring program for primary care with Collaborative team Clinics.
Q: What are the programs or design of service(s)?	
Initial start was a spoke model for each organization/health partner in Saskatchewan. SHA was the key partner that demonstrated the need of the platform and initiated the request. Clinical programs from within SHA were either targeted or showed interest and demonstrated use cases for the solution. Meetings, presentations, product demos and workflow reviews assisting in providing valuable data flow and sharing of information to determine monitoring plan and set up. Currently within SHA, most of the streams operate under specific clinical program and by physical location rather than provincially by disease state with centralized model.	See above. Using dual approach of core programming with dedicated team and staff and supporting other programs with use of integrated technology and program development.
Q: Who is your target population(s)?	
The main target population for Remote Patient Monitoring would be in the area of chronic disease management. The benefits for this population has been proven in many provinces and shown to not only improve health outcomes but allow patients to better manage their conditions at home.	Chronic disease – Chronic Obstructive Pulmonary Disease (COPD), Diabetes Mellitus (DM) Hi), palliative care, home dementia care. Future state – can support early discharge in more generalist approach; “hospital at home”.

Q: What device(s) is(are) involved?	
The model that Saskatchewan has chosen to follow when offering this service to their users is a Bring Your Own Device model. This allows for a much more feasible and cost-effective model. Patients can use devices that they are familiar with and can troubleshoot much easier. The barriers of deployment and training of the devices add another level of complexity and challenges in enrollment process. It is important to have the ability to pair patient devices with the application and is a requirement from the vendor chosen.	iPad mini, BP monitor, pulse oximeter, weigh scale – have options for integrated stethoscope, thermometer, glucometer.
Technical Solution(s)?	
We are currently using the TELUS Health me Health Monitoring Self Managed model in Saskatchewan. TELUS Health continues to support and guide through regular meetings, updates and upgrades.	Currently GE/Care Innovations – contract renewed to end of March 2023 – will be looking at other options in collaborations with RFPQ developed with Canada Health Infoway.
Sustainment and Expansion Plan	
Areas of focus on our RPM Provincial roadmap are system integration (EHR) and device integration (Bring Your Own Device and wearables) along with evaluating and improving clinician and patient experiences. Future design state is to look at a centralized model for all RPM as this has proven to allow for a much more sustainable service. As we bring on other partners as organizations, this model is also something that will be discussed and advised moving forward.	IN progress – great need and opportunities identified. Newfoundland is in a transition state with goal of on provincial health authority and awaiting final recommendations from health accord.

Appendix 4. PHSA Request for Pre-Qualification: Clinical and Business Requirements

Enrolling and Assessing New Patients

- Please describe how a patient is able to access the solution(s). Describe the login process and ability for patients to reset password.
- Describe how patients get entered or registered into the system. Is there an ability for patients or their family/caregiver to self-register?
- Does the proposed solution provide the ability for the patient, and or the clinicians to complete health history forms?
- Describe how the proposed solution(s) enables the customization/configuration of mandatory fields in various forms at the clinic level (i.e., patient registration, health history).

Assigning and Configuring Care Plans

- Describe how the solution supports assigning biometrics to patients to complete, as well as customization of thresholds, frequency, day/time of readings at the clinician/patient level.
- Describe how the proposed solution(s) assists with the process of configuring a variety of different assessment questions/questionnaires at the health authority, program and clinic level.
- Describe how the proposed solution(s) allows customization of assessment questions/questionnaires at varying frequencies, days, and times.
- Describe the solution(s) ability to have multi-level branching and adapt questions to the patients current status (including biometric data).
- Describe how the proposed solution(s) assists with the process of in the moment/ad hoc customization of assessment questions/questionnaires at the clinician/patient level.
- Describe how alerting logic can be customized and changed for both biometric data and assessment questionnaires.
- What kind of machine learning technology is embedded in your system and describe it in terms of patient care?

Integration

- Does the solution enable virtual health visits (audio and video) on provided/patients' own device? Describe if and how existing virtual health visit solutions can be used and integrated (e.g., Zoom, Teladoc, MS Teams)
- Does your solution support integration with the specified EHRs and other technologies through healthcare industry standards (such as HL7, CDA, FHIR, XML)? If so, please describe your experiences.
  - Cerner (Please specify versions and patient portals)
  - Meditech (Please specify versions and patient portals)
  - Other? Please provide a list of EHRs the system can current integrate with
- Please describe the inbound and outbound integration capabilities of your solution (preferably with Cerner and Meditech).

Managing Tasks and Workload

- Do you have a process for emergency delivery of devices?
- Describe how the proposed solution(s) enables health providers to acknowledge patients' responses and alerts to biometric and assessment/questionnaire data.
- Describe if the solution(s) are able to acknowledge multiple alerts at one time including missed assessment alerts.
- Describe how the solution(s) support escalation of unacknowledged alerts.
- Describe how the solution(s) allow clinicians to invalidate incorrect data points (both for biometric and assessment/questionnaires).
- Does the proposed solution support the assigning of clinicians to one or more treatment teams, so that multiple clinicians can monitor one or more patients?
- Is there a way to designate a primary clinician for each patient? If so, how?
- Describe how the solution allows for the transfer of patient care to other clinicians or promotes team-based care.
- Does the proposed solution have a dashboard that shows all the patients that are under a provider's care in a way that automatically triages them? Can this dashboard be customized at the clinician level?
- Describe if the proposed solution(s) has the ability to conduct communication, information sharing, or assign tasks to people in the care team (outside of the monitoring clinician).
- Describe the different user permission levels that exist with the proposed solution(s).
- Describe the role-based access control in general and for clinical care.
- Describe how the proposed solution enables health providers to acknowledge patient responses and alerts.

Notifications and Communications

- Describe how patients can subscribe to a list to receive an alert or messages via communication mode(s).
- Describe how the proposed solution(s) supports communicating with patients through a variety of channels including text, email, phone.
- Does the solution(s) support the collection of data from biometric devices?
- Describe the process of how data is collected from biometric devices (provided or patients own) and sent to the care team.
- Describe how the solution alerts, captures and stores biometric data when devices are offline/not connected/paired to the solution. How does patient interact with system when it is offline? How is this sent once it's back online?
- Describe how the solution supports ad hoc two-way communication between clinician(s) and patient(s) when needed.
- Describe if patients are able to take and send images or videos to the monitoring clinician.
- Describe how the solution supports educating patients to better understand their condition and how images, videos, documents and links can be embedded.
- Describe how the solution uses algorithms to allow educational content to be shown to patients as they require it.
- Describe how the solution supports automatic responses to common questions/messages received from patients. Consider the following, can you turn off Natural Language Processing (NLP) during ad hoc patient clinician communication.
- Does the solution support the configuration and sending of messages to multiple patients at the same time?

- Describe if the solution(s) has the ability for alerting logic (some way to alert the clinician to data that is out of range).
- Describe how the proposed solution alerts care team when biometric and questionnaire data is out of range. Consider both when logged into the solution and when not logged in (e.g., push notification, text email alerts).
- Describe if and how other members outside the care team if their patients data goes out of range.
- Describe how the proposed solution(s) alerts the family/caregiver if a patient's data (biometric or questionnaire data) is out of range.
- Describe how clinicians can be notified of alerts, both when they are logged into the solution and when they are not logged in.
- Describe how the solution alerts and informs the clinicians the patient has missed completing their assessment within the scheduled time limit.
- Describe how the solution(s) alert and inform the clinicians the patient has gone offline.
- Describe how the solution supports communication between clinicians including the sharing of images and videos.
- Does the proposed solution support reminders to the patient? Can patients respond to the reminders to confirm or acknowledge they are received?
- Can ad hoc reminders be added for the patient, and if so, how?
- Can the patient configure the reminders themselves? Can patients add family members to receive reminders?
- Can the solution connect to other systems in order to generate reminders (appointment reminders, medication reminders, etc.)?
- Describe how the solution enables patient or group connection. Is there capability for patients to support one another (peer support)?

Patient Experience and Accessibility

- Describe how accessibility needs are supported (i.e., patients who are hard of hearing/deaf, blind, have limited/no movement in their arms/hands/fingers, low digital/tech literacy, different languages, etc.). Consider voice over, modifiable text size.
- Does the login process support facial or fingerprint recognition in lieu of a password?
- Describe how the patient interacts with the software, (i.e., welcomes patient by name, easy access, limited clicks, friendly user experience, gamification).

Patient Monitoring

- Describe how the proposed solution(s) supports providing communication devices (computer, tablet, phone) to patients that require one.
- Describe how the proposed solution(s) supports enabling a Bring Your Own Device model in regard to communication devices required (computer, phone, tablet).
- Describe how the solution supports multiple patients using one device, for example kiosk functionality.
- Describe how the solution supports biometric readings on a continuous basis (both provided & patient's own).
  - Blood pressure
  - Blood glucose
  - Scale
  - Oximeter
  - Heart rate monitor

    - Implanted cardiac device (pacemaker/ICD)
    - Activity monitor/pedometer
- Wearables
- Describe how the solution(s) supports "providing" patients with a variety of connected biometric devices to allow monitoring of the following:
    - Heart rate
    - Respiratory rate
    - Blood pressure
    - Oxygen saturation
    - Temperature
    - Blood glucose
    - Weight
    - Height
    - Activity (minutes)
    - Spirometry
    - Prothrombin Time (PT) / International Normalized Ratio (INR) / Coagulation
    - Cardiac tracing
    - Respiratory rate
    - Heart/lung sounds (digital stethoscope)
    - Sleep
    - Fetal heart rate
    - Galvanic skin response
    - Electroencephalogram (EEG)
    - Steps
    - Global Positioning System (GPS) / Accelerometry
    - Fall detection
    - Carboxyhemoglobin
    - Bed movement
    - Toilet use (sensor)
    - Fluid intake monitoring
    - Fridge opening and closing (via sensor)
    - Door opening and closing (via sensor)
    - Medication compliance
    - Describe how the proposed solution enables the connection and collection of data from "patient's own" biometric device including but not limited to:
        - Ventilator
        - Feeding pump
        - Insulin pump
        - Thermometer
        - Fall monitor

- Does the solution have an option for an app or web browser login to see questions/messages?
- Does the solution offer a patient-facing dashboard?
- Describe how the proposed solution(s) allows for patients to use various logs (e.g., food intake, fluid intake, output).
- Describe how the monitoring clinician or other clinicians on the team can access patient data and complete monitoring on a variety of devices, i.e. computer, tablet, smart phone.
- Describe how the proposed solution(s) presents assessment/questionnaire data as a trend, including the patient's alert threshold. Please identify if this data is configurable.
- Does the proposed solution(s) provide a Patient Summary for the clinician with key clinical and program information that can be shared with other clinicians? Is it configurable?
- Does the proposed solution support multilingual capabilities? Please provide list of languages the solution is available in.
- Does the proposed solution(s) enable data to be accessible to the clinician upon transmission by the patient (no delay in sending information from patient to clinician)?
- Describe how software updates data in real time without the need to refresh the page, i.e. data automatically refreshes when the clinician is logged in to the solution.
- Describe how the monitoring clinician or other clinicians on the team can access patient's data on a variety of devices (computer, web browser, app for phone and tablet).
- Does the solution(s) provide a patient dashboard to see a trend of their vitals and responses? Can patients provide permissions for proxies to view their dashboard?
- Describe the proposed solution(s) reporting capability at the patient, group and clinic level .
- Describe how the proposed solution(s) presents biometric data as a trend, including the patient's alert threshold. Please identify if this data is configurable.

Reporting

- Does the solution support with distributing clinical reports? If so, please describe.

System Functionality

- Describe all the capabilities of the client organization's system administrators to configure and modify the system. For example, but not limited to: addition/modification of menus, forms, items, filters, white-labelling, access management, etc.

Appendix 5. PHSA Request for Pre-Qualification: Technical Requirements

In December of 2021, the PHSA Provincial Virtual Health team completed preliminary work in hopes of launching a future RFP. The team collaborated with IMITS and Privacy and Security representatives to help consolidate and prioritize a set of technical requirements. The following are an output of the Key PHSA Technical Requirements identified by the PHSA Team.

Technical - General

- An enterprise solution, which supports multiple health authorities.
- System administrators must have the ability to configure and modify the system. For example, but not limited to: addition/modification of menus, forms, items, filters, white labeling, access management etc.
- Ability to modify scripts/clinical documentation/forms.
- Ability to extract data into another data warehouse.
- Ability to support monitoring performance, storage and/or detecting issues to ensure the system is optimized and functioning as expected.
- Ability to support additional environments (example: development, test, training, sandbox) in addition to the production environment.
- Ability to support data remediation.
- Support for “offline mode” in case a real-time connection to the network is not available.
- Solution is compatible with current and latest mobile operating system versions (Android, Microsoft, and Apple).
- Solution must support a large number of concurrent users.
- Support for distributing clinical reports.
- Solution must provide post processing; compressing images/videos to meet EHR system requirements.
- Support for the latest operating systems and security patches.
- Must support integration with specified EHRs and other technologies through healthcare industry standards (such as HL7, CDA, FHIR, XML).

Technical - Integration

- Support the ability to integrate patient’s specific data and data from clinical assessments and questionnaires to and from the solution and the specified EHR.
- Ability to make adjustments and customizations to HL7 integration interfaces.
- Support with receiving/importing clinical reports to the solution from EHRs.
- Support for customized patient identifiers.
- Provide the ability to integrate with various patient portals including but not limited to:
    - Cerner patient portal
    - Meditech patient portal
    - Profile
    - Others
- Ability for a single shared instance of your solution to support integration to two or more EHRs.

Technical - Devices

- Ability to integrate with a variety of medical devices from other vendors (i.e., blood pressure cuffs, thermometers.
- Solution includes a mobile interface (i.e., for patients using their own devices).
- Ability to send images and video to the monitoring clinician to support assessments.
- Ability to pair with various Smart Devices including but not limited to the following:
    - Apple Watch/Apple Health Kit
    - Fitbit
    - Samsung
    - Others
- Ability to integrate with glucometer applications.
- Ability to interface with biometric data via Bluetooth, Wi-Fi, Mobile Data, etc.
- Support for a large number of concurrent users/devices.
- Lifecycle management and support for a variety of devices.
- Availability of Infection Prevention and Control (IPAC) protocols as a part of a fully managed solution.

Technical - Privacy and Security

- Support for audit reports/trails, involving PI/PHI (access, modification, or disclosure of PI/PHI).
- Support storage of all PI and PHI Data in Canada.
- Solution must be in compliance with BC's Freedom of Information Protection of Privacy Act and or any additional privacy legislation or standards
- Ability to provide a privacy notice (e.g., in a Privacy Policy for the proposed Solution/Device) that describes the PI/PHI collected, purposes for the collection, and how it will be used and disclosed.
- Ability to record consent when providing or assisting the provision of care to a patient
- Ability to have administrative, technological, and physical safeguards in place, to prevent theft, loss and unauthorized access, copying, modification, use disclosure or disposal of data.
- Up-to-date Privacy Impact Assessment (PIA) and/or support and cooperate with the client's PIA process.
- Ability to retrieve patient's records if requested in accordance with Part 2 of BC's Freedom of Information Protection of Privacy Act (FIPPA).
- Role-based access control (regular vs privileged vs super user etc.)
- Support the use of multi-factor authentication.
- Support password strength and complexity settings
- Support Active Directory (AD) and/or Lightweight Directory Access Protocol (LDAP) authentication.
- Infrastructure security controls and testing (i.e., vulnerability scanning, penetration testing, secure network architecture)
- Security and encryption support for mobile devices.

Technical - Support

- Support recording/logging, tracking, updating, monitoring, escalating and closing of all change requests, issues, bugs and incidents.
- Embedded help (i.e., how to videos, troubleshooting guides).
- Application support for mobile devices vendor, clinician, and Bring Your Own Device.
- Meet and maintain agreed upon uptime (SLA).

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