Connecting Patients with Providers

A Pan-Canadian Study on Remote Patient Monitoring

Canada Health Infoway

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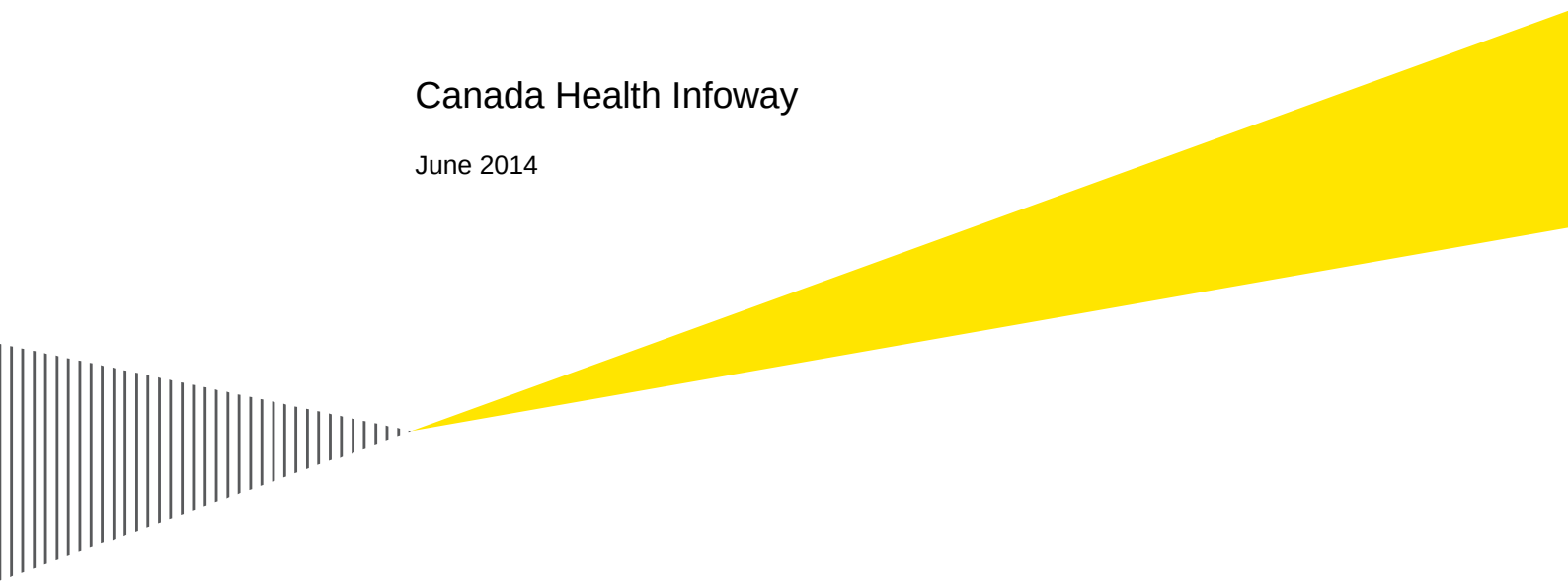

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Acknowledgments

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Executive Summary

In October 2013, Canada Health Infoway (Infoway) commissioned Ernst & Young LLP (EY) to conduct a pan-Canadian study of Remote Patient Monitoring (RPM) to inform the potential for RPM implementation across Canada.

This study is comprised of four parts:

1. **Current State**; a discussion of available literature, current deployment in Canada, as well as lessons learned from previous implementations of RPM in Canada and internationally;
2. **Case Study Review**; an assessment of four RPM programs in Canada including a review of health system benefits of implementing these programs;
3. **Emerging Solutions**; a review of emerging, innovative RPM programs in Canada; and
4. **Critical Success Factors**; a synthesis of the key factors emerging from the selected case studies and emerging solutions necessary to design and implement RPM programs, and to support further growth and uptake across Canada.

Methodology

In collaboration with Infoway's Expert Advisory Panel (Appendix A) the following steps were undertaken to understand the RPM evidence base, the state of existing programs, lessons learned from international implementations and critical success factors to inform future program planning, development and implementation across Canada.

1. Detailed program information, including utilization data, funding applications, pilot results, satisfaction surveys and evaluation findings;
2. A literature review of RPM activity in Canada and internationally, complemented by a pan-Canadian scan of Telehealth and RPM activity in Canada completed by Infoway;
3. Key interviews with over 20 key informants including policymakers, clinicians, scientists and vendors with extensive RPM and Telehealth experience;
4. A synthesis and review of available Canadian evidence from RPM program and pilot evaluations; and
5. Detailed provider and consumer surveys distributed to featured programs to gather detailed cost and benefit information.

Current State

Evidence suggests that RPM activity is growing in Canada. A recent national survey found that one per cent of Canadians used medical devices that captured and transmitted data electronically (e.g., via Internet or SMS) to their healthcare providers for chronic disease or post-surgical discharge monitoring.[1] The 2013 Canadian Telehealth Report showed that Home Telehealth endpoints across the country have grown since 2010.[2] Our study identified approximately 5,000 patients enrolled in 19 RPM programs across seven provinces and territories, supporting continued growth of 15-20% annually. These programs provide care for patients along different stages of the care continuum using technologies with varying degrees of complexity. As such, the growth in RPM activity has been met with both technological innovation and the targeting of patients across different stages of illness.

Many of the large-scale, established programs are designed for patients with chronic conditions, such as Congestive Heart Failure (CHF), Chronic Obstructive Pulmonary Disorder (COPD) and Diabetes. Such patients are the 'traditional' candidates for RPM as appropriate ongoing management in the community, such as in the home, can reduce the need for acute care and improve wellness. Many of these programs involve the use of complex medical devices and installed technologies that automate a patient's connection with their provider.

The smaller-scale programs reviewed are utilizing less complex and costly technologies designed to either mimic formalized monitoring programs or facilitate patient self-monitoring. While these programs have focused on providing patients with the information to self-manage their condition, rather than consistent monitoring by a healthcare provider, they intend to ensure that patients do not progress to a stage of illness requiring more intensive care and/or monitoring. Such programs have the potential to avoid the utilization of costly healthcare resources downstream.

Many programs initiated as pilot projects have been formally adopted by regional planning bodies or health service providers, such as the Ontario Telehomecare Expansion Project developed by the Ontario Telemedicine Network (OTN). The success of pilot implementations has also translated into the integration of programs as the standard of care for certain sub-sets of patients, such as the University of Ottawa Heart Institute's (UOHI) Regional Home Monitoring Program.

[1] Annual Tracking Survey conducted by Harris/Decima and commissioned by Canada Health Infoway, 2014
[2] Canadian Health Informatics Association. 2013. *2013 Canadian Telehealth Report*. Retrieved from: http://coachorg.com/en/resourcecentre/resources/TeleHealth-Public-FINAL-web-062713-secured.pdf.

International examples of RPM offer lessons learned for Canadian implementations. National programs such as the Whole System Demonstrator Project in the UK and the Veteran Health Administration's Care Coordination/Home Telehealth program, found considerable reductions in hospitalizations, emergency department (ED) visits and bed day occupancy, largely through the integration of evidence-based care pathways[3,4]. Such programs have consistently achieved benefits through ongoing collaboration with providers and by engaging clinicians and patients throughout the recruitment, design and implementation of the programs.

As interest in RPM in Canada grows, a number of promising examples of RPM programs have emerged. While chronic disease patients remain the primary candidates for these programs, a growing number of programs are focusing on lower acuity patients. This is coupled with a shift towards less complex technology, enabling patients to self-manage their condition through the use of readily available tools.

Defining RPM

For the purpose of this study, RPM was defined as the delivery of healthcare to patients outside of conventional settings enabled by a technological application or device. RPM hinges on the electronic transmission of patient data to a provider as a series of integrated services and processes, ranging from health coaching to the alteration of a patient's course of care.

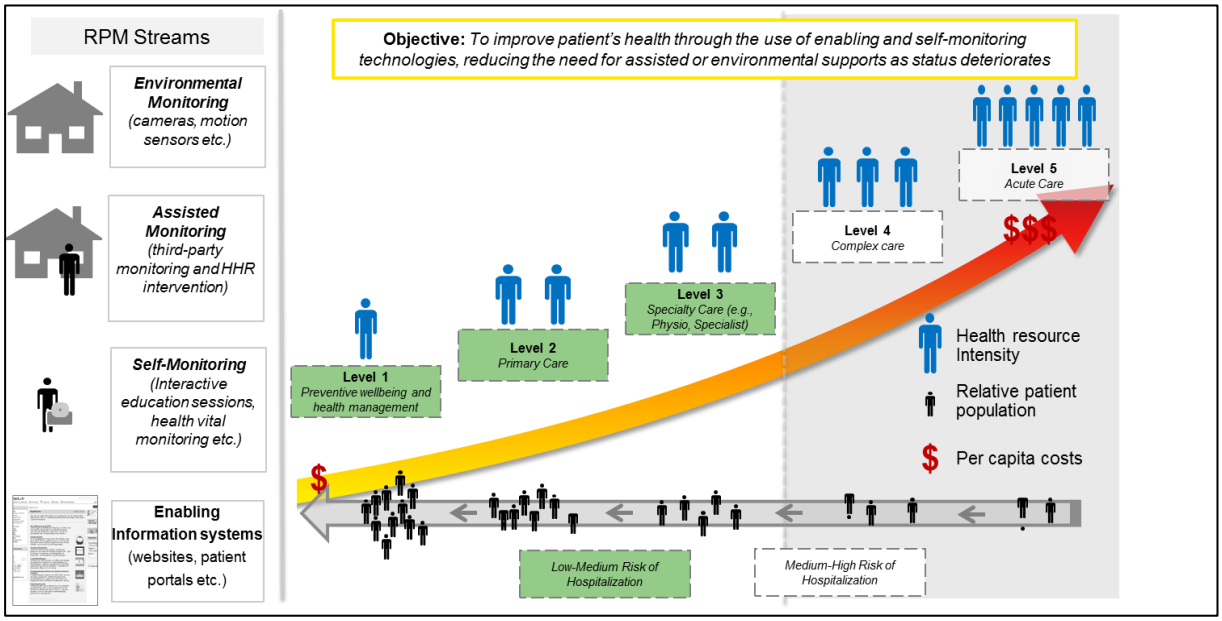
The relationship between technological complexity and acuity can be conceptualized as a spectrum of programs consisting of four streams.

1. **Enabling Information**: The provision of information relating to a patient's condition through websites, patient portals and mobile applications. Enabling information may exist as a component of RPM programs, but is limited to the provision of information about a patient's condition, such as their care plan and medication regime.
2. **Self-Monitoring**: Programs in which patients report their health information through an enabling technology at regular intervals to a care provider. Interventions are triggered when thresholds aligned to a patient's health status are surpassed.
3. **Assisted Monitoring:** Programs involving patient monitoring or coaching at prescribed intervals, through the direct use of community care professionals, when complex patients are discharged into the community.
4. **Environmental Monitoring**: Programs designed for highly complex patients (e.g., those with a functional disability and/or multiple, complex comorbidities) involving the use of installed devices that monitor their ability to live independently. Self-monitoring is not typically a component of these programs.

[3] Darkins, A. 2008. The systematic implementation of health informatics, home telehealth and disease management to support the care of veteran patients with chronic conditions. *Telemedicine and e-Health*, 2008.
[4] Steventon, A., Bardsley, M., Billings, J., Dixon, J., Doll, H., Hirani, S., ... & Newman, S. (2012). Effect of telehealth on use of secondary care and mortality: findings from the Whole System Demonstrator cluster randomised trial. *BMJ*, 344.

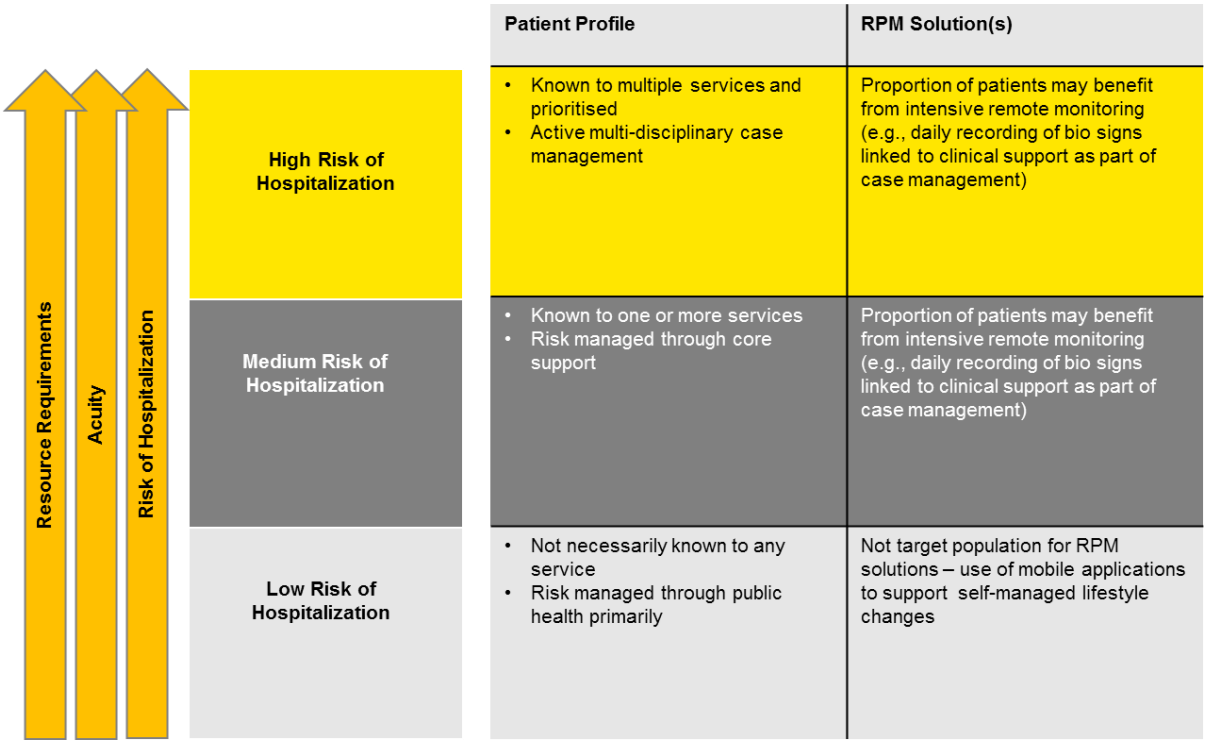
The following framework was constructed to categorize RPM programs in Canada reviewed in this study and to illustrate the relationship between technological complexity and patient acuity. The framework also demonstrates the associated impact on the utilization of health system resources as programs attract highly complex, acute patients.

Figure 1. RPM Study Framework



Ensuring alignment between patient acuity and technological complexity is critical to maximize patient and system level benefits of any RPM program. Using a risk stratification framework enables managers to structure their programs around groups of patients that are at varying levels of risk of being admitted to a hospital (levels 1-5 above). The framework below was applied to the programs reviewed in this study to identify the patient groups that would be associated with the greatest benefit from being included in an RPM program.

Figure 2. Risk Stratification Framework[5]



Evidence of Benefits

Using Infoway's Benefits Evaluation Framework, a series of benefit hypotheses were constructed to evaluate programs based on quality, access and productivity benefits realized. The hypotheses were constructed in collaboration with Infoway and members of the Expert Advisory Panel based on a literature review and supported by key informant interviews with academics, program administrators, subject matter experts and industry representatives.

Overall, the literature review relied on meta-analyses, systematic reviews of peer reviewed RPM programs, program evaluations, evidence from large-scale Randomized Controlled Trials, such as the UK's Whole System Demonstrator project and a separate literature review conducted by Infoway. Although definitions, patient populations, outcome measures and evaluation quality vary widely in the literature, the cumulative benefits story of RPM programs for chronic disease patients is encouraging.

[5] The risk stratification framework was informed by the Kaiser Permanente Triangle for Managing Health Conditions: Hudson, B. (2005). Sea change or quick fix? Policy on long-term conditions in England. *Health Soc Care Community, 13*(4), 378-385.

The following table provides a summary of the benefits against each of the hypotheses identified. Hypotheses that were validated with a moderate-to-high evidence base are displayed in bold, green text. The strength of the evidence was assessed with members of Infoway's Advisory Panel based on the availability of published evidence and discussion with key informants.

Table 1. Evidence of Benefits Summary

	Benefits	Strength of evidence
Quality	▸ ↑ **Patient satisfaction** ▸ ↑ **Patient compliance** ▸ ↑ **Quality of life** ▸ Promote integrated care	O O O •
Access	▸ ↓ **Caregiver burden** ▸ ↑ Access to specialists ▸ ↑ Dissemination of health data	O • •
Productivity	▸ ↓ **ED visits/hospitalizations** ▸ ↓ **Per client health $** ▸ ↓ Per client care time	● O •

*● = High availability of evidence (>/= 10 published studies), O = Moderate availability of evidence supporting hypotheses, • = Low availability of evidence supporting hypotheses (</=2 published studies).

As illustrated in the table above, the strongest evidence supports reductions in emergency room visits, hospital admissions and bed days, patient satisfaction, and quality of life given appropriate patient selection into a program.[6,7,8,9]

[6] Logan AG, Irvine MJ, McIsaac WJ, Tisler A, Rossos PG, Easty A, Feig DS, Cafazzo J.A. Effect of Home Blood Pressure Telemonitoring With Self-Care Support on Uncontrolled Systolic Hypertension in Diabetics. Hypertension. 2012 Jul;60(1):51-7.
[7] Seto, E., Leonard, K. J., Cafazzo, J.A., Masino, C., Barnsley, J., & Ross, H. J. (2012). Mobile Phone-Based Telemonitoring for Heart Failure Management: A Randomized Controlled Trial. Journal of Medical Internet Research. 2012 (Feb 16); 14(1):e31
[8] Home Telemonitoring for Chronic Disease Management: An Economic Assessment, HEC Montreal, August 2012
[9] Darkins A, Ryan P, Kobb R, Foster L, Edmonson E, Wakefield B, Lancaster AE. Care Coordination/Home Telehealth: the systematic implementation of health informatics, home telehealth, and disease management to support the care of veteran patients with chronic conditions. Telemed J E Health. Dec 2008.

It is important to note that many of the existing evaluations have focused on smaller scale projects which have featured variability in the use of technologies, patient populations, chronic diseases and locations.[10] Nearly all the reviews and studies examined here, which collectively involve thousands of patients, span multiple years, cover multiple countries and include various RPM technologies and delivery models, consistently argue that additional research is needed to optimize the benefits of RPM, identify the right technology mix, and uncover the key drivers of sustainable RPM initiatives.

Case Study Review

An in-depth review of four established RPM programs in Canada demonstrated strong evidence for quality, access and system benefits, including decreased ED utilization and fewer hospitalizations.

Table 2. Case Studies

	Ontario Telehomecare Expansion Program - OTN	University of Ottawa Heart Institute (UOHI) Regional Home Monitoring Program	BreatheWELL at Home Program	Jardins Roussillon (JRHC) Telehomecare Program
Year established	2007	2006	2012	2010
Province	Ontario	Ontario	British Columbia	Quebec
Condition(s)	COPD, CHF	Cardiac (including CHF)	COPD	CHF, COPD, Diabetes
Annual patients	1,400	300	300	180

Although there is considerable variation in the design and structure of these programs, they each target chronic disease patients with a medium-to-high risk of being hospitalized. Such patients remain the focus of RPM programs as they have demonstrated the ability to effectively manage a patient's clinical condition before deteriorating to a more resource-intensive course of care.

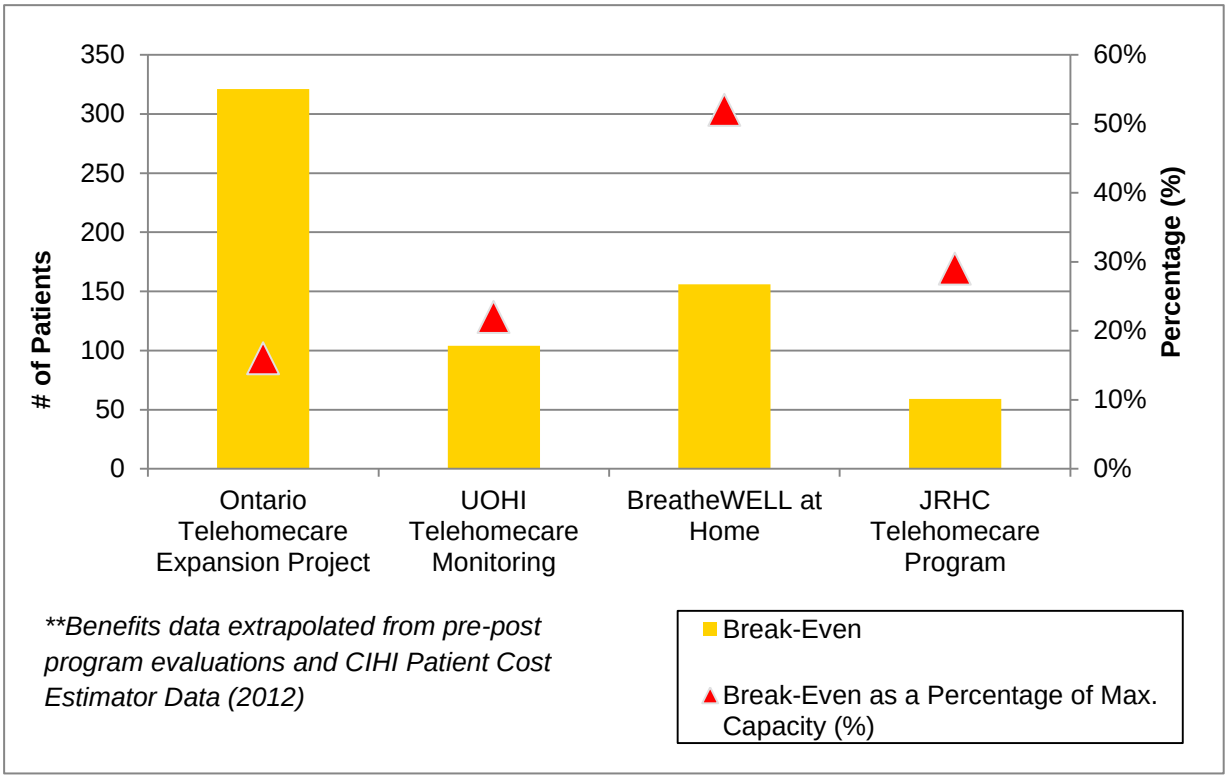
[10] Mobile Computing in Health Care Delivery – White Paper. Canada Health Infoway Inc., 2013.

The case studies looked at the value of these benefits to the health system and compared them to the costs to establish and operate the respective programs. While these programs consistently realized system-level benefits, inconsistencies in how these benefits are measured present barriers in forecasting the benefits of growing these programs across Canada. The diverse methods by which benefits are analyzed and monitored create difficulties in assessing the minimum number of patients a program should support to remain viable and the design factors that will realize access, quality and productivity benefits.

As the Canadian RPM market continues to expand and new programs emerge, understanding and assessing the ability of an RPM program to recruit and retain a critical mass of patients will be critical to facilitating larger-scale implementations.

The following figure illustrates the number of patients required for larger-scale RPM programs to 'break-even.' The patient "break-even" or "point of sustainability" calculation and the percentage of current maximum capacity takes into account the patient threshold required for the program benefits to outweigh the costs.

Figure 3. ROI Analysis



Despite the obvious variability in the number of patients an RPM program requires to achieve a break-even position, the findings provide a signpost for smaller, emerging programs that are considering how to structure and design their program to maximize benefits for their patients. While start-up costs for programs may be high, this analysis provides evidence to suggest that long-term sustainability is a realistic goal for a variety of RPM programs.

Emerging Solutions

In addition to the established programs described above, four additional RPM programs were identified as examples of emerging solutions based on their potential to realize sustainable and scalable benefits for patients:

1. mDAWN (British Columbia),
2. Wel-Tel (British Columbia),
3. Virtual Cardiac Rehabilitation Program (vCRP) (British Columbia),
4. MyHome Health Program (Alberta).

Many of the RPM programs reviewed demonstrated the potential to realize significant benefits for a variety of patient populations using both simple and complex technologies to connect patients and providers. Many of these programs are within the pilot phase and involve smaller sub-sets of patients and in some cases, limited evidence of measurable benefits.

Each program utilizes an innovative approach to manage a patient's condition, often relying on technology patients have readily available, such as smartphones and/or internet connectivity. While the benefits of these programs are still early and not fully realized, the emergence of such programs represents a shift towards RPM programs with lower technological complexity and cost structure, with a broadened scope towards patients who can self-manage their condition.

Critical Success Factors

As demonstrated by the case studies, literature review, expert interviews and emerging solutions, to gain the greatest value from implementing an RPM program at-scale there must be sufficient recognition of four factors within program design:

1. **Engagement and collaboration.** As clinicians are at the forefront of understanding the clinical complexity of patients, they should assist in designing an RPM program, along with the patient and/or caregiver, including the selection of appropriate technology that aligns with a patient's acuity and health care requirements. Clinicians are uniquely positioned to describe and deliver a compelling value proposition to potential patients, facilitating greater recruitment and retention.
2. **Patient recruitment and retention.** This is to ensure that providers identify patients that can benefit from the RPM program based on the complexity of the patient's condition, potential benefit from using the supporting technology and the actual technology involved. Appropriate recruitment and retention of patients relies on a consistent level of communication with patients regarding both the benefits of the program and the potential to track progress towards improving their health status throughout the duration of the program. The analysis also found that achieving a critical mass of patients is necessary to maximize benefits, recover program costs and return savings to the health system for reinvestment. This minimum number of patients was found to be highly variable and dependent on the scope and design of the program.
3. **Benefits measurement.** As RPM programs remain a relatively new care delivery enabler in Canada, determining likely benefits and consistently measuring those benefits will allow patients, clinicians and policymakers to understand the patient and system-level value RPM programs provide.
4. **Integrated care and care-coordination.** RPM should be integrated into a clinician's workflow through an assisted or environmental monitoring program, or coordinated across the care continuum through a self-management program in order to achieve the best patient benefit.

Conclusion

RPM is an emerging enabler of care delivery in Canada. The results from this study have demonstrated the growth in formalized RPM programs, evidenced by the large-scale programs featured as case studies. As the evidence base for RPM programs continues to grow, this study has highlighted a number of key points that should be considered by policymakers, technology vendors, patients and providers to facilitate widespread uptake and adoption:

- RPM programs in Canada are progressing from pilots to established solutions,
- Much of the activity in large and small-scale programs remains focused on chronic disease patients presenting a medium-to-high risk of admission to a hospital,
- Larger scale programs have demonstrated considerable economic, system-level benefits through decreased utilization of health system resources,
- Smaller scale programs are emerging that leverage enabling information and self-monitoring technologies targeted to patients with a low and medium risk of being admitted to a hospital,
- Preliminary cost analysis provides evidence to support the feasibility of RPM programs in both smaller and larger jurisdictions,
- Extrapolating benefits from established programs is limited by variations in program design, patient cohorts and outcomes measurement, and
- RPM remains an emerging enabler for health system transformation with the potential to improve outcomes and the patient experience through self-management and home-based care.

The role of information technology is a critical enabler to improving health services delivery. As decision-makers consider options for delivering high quality care at the right cost, there is a need for innovative solutions that potentially reconfigure traditional service delivery models. RPM is a critical enabler for this transformation with the potential to incentivize self-management, support the delivery of care in home settings and significantly improve the patient experience. The continued growth and sustainability of RPM programs in Canada will be dependent on consistent engagement and collaboration, recruiting and retaining the right patients, and striking an appropriate balance between integrated and coordinated care while consistently measuring and demonstrating benefits.

Introduction

The Canadian healthcare system is undergoing extensive and sustained transformation[11]. In this context, there is an imperative to enable patients to take an active role in managing their health, while continuing to find cost-efficiency and quality in healthcare service delivery.

This renewed focus on quality and cost driven the growth and adoption of information technology in healthcare. The 'bending of the cost curve' mentality embedded into health system priorities has created an appropriate foundation for providers to reconsider traditional models of care delivery. These factors have catalyzed the growth of solutions that enable patients to self-manage their conditions, while striving to control costs to the system.

Over the past few years, technology has emerged as a key enabler to connecting patients with providers. While uptake is progressing across the healthcare sector, an increasing number of technology interventions aligned with assisted care and self-management models are becoming available. These technologies enable providers to connect with their patients in new ways that effectively extend the provision of care regardless of time, space or geography. With new products and growing choice for these solutions, patients, clinicians and policymakers often want to understand the ability of these applications to translate into quantifiable and scalable benefits across different jurisdictions and patient populations. Further, as with any technological innovation, the realization of sustainable benefits is often a function of a program's maturity, which may create a barrier to long-term investment and adoption.

This study focuses on one avenue of healthcare that relies on information technology to bridge the gap between patient and provider: remote patient monitoring (RPM). RPM is an emerging enabler of healthcare delivery in Canada with many promising and innovative solutions that facilitate the delivery of care to patients across various stages of the care continuum. The evolving evidence base coupled with a renewed focus on health system innovation has created a renewed interest for a pan-Canadian benefits evaluation study on RPM.

Building on the 2011 Pan-Canadian Telehealth Study[12], Canada Health Infoway (Infoway) commissioned this study to:

- Assess the current state of RPM solutions,
- Examine the quality, access and productivity benefits realized to date, and
- Determine the critical success factors needed to support further investment and implementation at scale of RPM solutions across the Canadian healthcare system.

The benefits articulated in this study are intended to demonstrate the value and opportunity within RPM in Canada to inform policy planning, program development/expansion, clinician engagement and patient awareness.

[11] Health Council of Canada. 2013. Progress timeline: highlights of health care reform. http://healthcouncilcanada.ca/rpt_det.php?id=833
[12] Canada Health Infoway. 2011. Telehealth Benefits and Adoption – Connecting People and Providers across Canada.

Background

Infoway is an independent not-for-profit corporation funded by the Canadian government through Health Canada. Since its creation by Canada's First Ministers in 2001, Infoway has been granted $2.1 billion to strategically invest in needed electronic health systems across Canada. To achieve its mandate, Infoway collaborates with provinces and territories, healthcare providers, patient groups and vendors to facilitate the uptake and implementation of electronic solutions that improve access, quality and productivity across the Canadian healthcare system.

In 2013, Infoway engaged EY to conduct a Pan-Canadian study on the benefits of Remote Patient Monitoring.

Defining Remote Patient Monitoring (RPM)

As defined in this study, RPM is the delivery of healthcare to patients outside of conventional settings, such as in the home, enabled by a technological application, device or monitoring by a care professional. RPM hinges on the electronic transmission of patient data to a provider as part of a series of integrated services and processes ranging from health coaching and assistance to the alteration of a patient's course of care. RPM supports the delivery of care to patients regardless of geographical constraints and enables clinicians to monitor patients for extended periods of time, potentially reducing the need for more complex interventions.

This study conceptualizes RPM as a key support to a spectrum of programs based on the complexity of the technology used and the acuity of patients it targets. The spectrum consists of four streams designed for patients of increasing acuity and requirement for intervention:

1. **Enabling Information** –the provision of information relating to a patient's condition through websites, patient portals and mobile applications. Enabling information may exist as a component of RPM programs, but is limited to the provision of information about a patient's condition, such as their care plan and medication regime.

2. **Self-Monitoring** – programs in which patients report their health information through an enabling technology continuously or at regular intervals to a care provider. Interventions are triggered when critical thresholds aligned to the patient's health are surpassed.

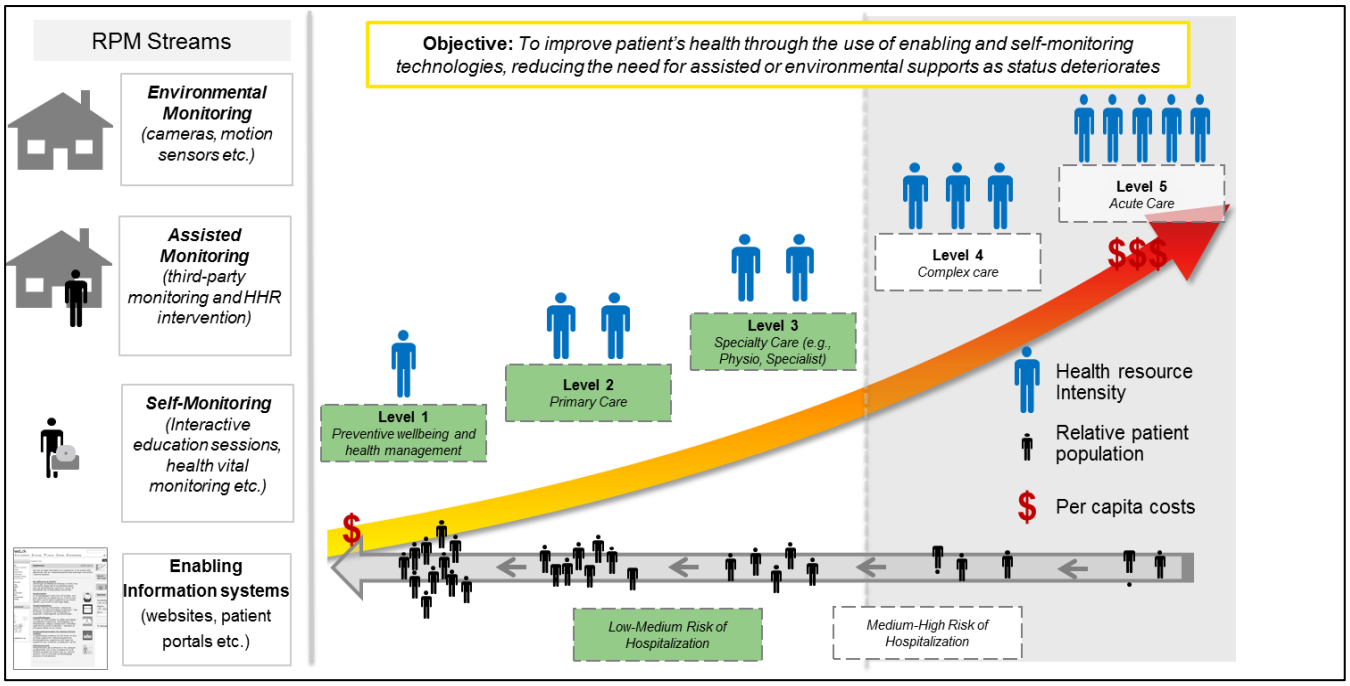
3. **Assisted Monitoring** – programs involving patient monitoring or coaching at prescribed intervals, through the direct use of community care professionals, when complex patients are discharged home.

4. **Environmental Monitoring** – programs designed for highly complex patients (e.g., those with a functional disability and/or multiple, complex comorbidities) involving the use of installed devices that monitor their ability to live independently. Self-monitoring is not typically a component of these programs.

Each of the above streams is associated with five acuity-based levels of care. As patients progress to a higher level of care, so does their relative resource intensity of care utilization and costs. For example, on the lower end of the spectrum, Level 1 patients will leverage enabling information systems that avoid progression towards a higher level of care. Level 5 patients require a level of acute care that is aligned to their condition, such as through assisted or environmental monitoring.

Figure 4 contains the framework used to categorize the programs and innovative solutions described in this study, and illustrate the relationship between acuity, technological complexity and per capita costs of RPM programs.

Figure 4. RPM Framework[13]



[13] © Ernst & Young LLP. 2014. All rights reserved.

RPM Utilization across Canada

Formal RPM programs have historically targeted chronic disease patients who require considerable healthcare resources to facilitate the management of their condition. For example, patients with chronic conditions are more likely to be readmitted to hospital within 30 days of initial discharge and are more likely to return to an emergency department within 7 days of their last visit[14]. As a result, the rising prevalence of patients with these conditions in Canada[15] imposes pressure on the healthcare system. RPM programs have emerged as a result of the need to develop alternative care delivery models that promote patient self-management and increased care at home, effectively minimizing the need for higher-cost interventions that place a greater burden on scarce healthcare resources.

Data obtained from the Canadian Telehealth Forum and key informant interviews shows approximately 5,000 Canadians enrolled in formal programs using RPM and pilots aimed at reducing avoidable inpatient admissions and emergency room visits, with the bulk of activity occurring in Ontario, British Columbia, and Quebec (see Appendix B). Other jurisdictions are in the process of developing RPM programs targeted toward chronic disease patients. The majority of programs are designed to support Congestive Heart Failure (CHF), Chronic Obstructive Pulmonary Disorder (COPD) and Diabetes, due largely to these conditions allowing for appropriate practitioner monitoring and the avoidance of complex medical interventions downstream.

Evidence of further RPM activity has been found at various levels within the health system: over 20% of hospitals surveyed in Canada reported providing patients with remote telemonitoring services in the last 12 months[16]. Furthermore, a 2014 survey conducted by Harris Decima found that 10% of Canadian adults used medical devices that captured and transmitted data to their healthcare team for monitoring[17]. When narrowing the sample to individuals actively monitored for chronic disease or post-surgical discharge, as well as those who used devices that captured and transmitted data electronically (e.g., via Internet or SMS) to their healthcare providers, that number was reduced to 1%. These statistics are indicative of an opportunity for growth given the increase in the number of patients requiring support for managing chronic diseases in Canada[18], often the primary candidates for RPM. A growing number of programs are also being designed for post-acute monitoring to support patients in maintaining compliance with medication regimens and post-discharge rehabilitation. Such programs typically involve less complex technology solutions such as smartphones and tablets that interface with information systems.

A review of Canadian RPM programs indicates growth of 15-20% annually, representing a steady increase of activity across different jurisdictions. This review supports the findings of

[14] Canadian Institute for Health Information. 2012. *All-Cause Readmission to Acute Care and Return to the Emergency Department*. 1-64. Accessed on 19 November 2013. https://secure.cihi.ca/free_products/Readmission_to_acutecare_en.pdf
[15] 7 Canadian Institute for Health Information. 2012. *All-Cause Readmission to Acute Care and Return to the Emergency Department*. 1-64. Accessed on 19 November 2013. https://secure.cihi.ca/free_products/Readmission_to_acutecare_en.pdf
[16] Ambulatory Care Baseline Survey conducted by Harris/Decima and commissioned by Canada Health Infoway, 2013.
[17] Annual Tracking Survey conducted by Harris/Decima and commissioned by Canada Health Infoway, March 2014.
[18] Canadian Institute for Health Information. 2013. *Health Indicators 2013: Definitions, Data Sources and Rationale, May 2013*. http://www.cihi.ca/CIHI-ext-portal/pdf/internet/IND_DEFIN_2013_EN

the 2013 Canadian Telehealth Report[19] suggesting that the number of jurisdictions adopting RPM programs has increased. While RPM pilot programs are common in provinces and territories, many jurisdictions have moved towards larger programs in which RPM is the standard of care, evidencing a recognition at the provincial level that patient and system-level quality, access and productivity benefits can be consistently realized through these initiatives. A listing of the programs reviewed as part of this study is found in the Appendix B.

RPM in the International Context

No two examples of RPM implementation are the same. However, the challenges Canada faces in relation to an aging population, growth in chronic diseases and the need for fiscal conservatism by government are common to other economies. The need to evaluate and invest in information technologies to respond to these challenges has created a sizeable evidence base from international implementations. Reviewing the components of such programs assists in the identification of issues and challenges which are broadly applicable to other jurisdictions considering similar implementations.

A review of eight solutions from international health systems suggests that clinical leadership and engagement, patient recruitment and retention, benefits measurement and scalability are critical to any successful implementation and sustainability, regardless of the acuity of patients targeted or the technological complexity of the intervention featured. A detailed description and summary of each solution and critical success factors[20] is outlined in Appendix C.

There are two well-known examples of national RPM programs, which demonstrate both measurable benefits and a series of implementation considerations for smaller-scale programs: the UK's Whole System Demonstrator Project (WSD) and the Care Coordination/ Home Telehealth (CCHT) Program developed by the Veterans Health Administration (VHA) in the United States. The WSD involved the development of a series of large-scale randomized controlled trials designed to measure the effect telehealth technologies for patients managing COPD, CHF or Diabetes. The national CCHT Program coordinates the care of veterans with chronic conditions using home telehealth and electronic health records to avoid unnecessary hospitalization. Both programs are discussed below.

[19] Canadian Health Informatics Association. 2013. *2013 Canadian Telehealth Report*. Retrieved from: http://coachorg.com/en/resourcecentre/resources/TeleHealth-Public-FINAL-web-062713-secured.pdf.
[20] The term 'RPM' is inconsistently applied in international implementations. Solutions aligning to the definition of RPM identified in this report were considered in this review.

While an example of international success, the WSD Program produced mixed results. Patient outcomes, hospitals admissions, emergency room visits, length of hospital stays and mortality improved compared to a control group of patients[21]. However, the program could not provide consistent evidence of cost effectiveness compared to usual care, and found no improvements in the utilization of primary care resources, quality of life or psychological wellbeing. WSD program managers identified an over emphasis of patients at high risk of hospitalization requiring significant supports and environmental monitoring as a potential reason for the mixed results. This underscores the need to strengthen patient recruitment practices to align with the program objectives and appropriate technology.

The CCHT Program was established in 2003 to provide home-based monitoring services to veteran patients with chronic diseases, in addition to those with psychological disorders such as depression. The Program revolves around care coordinators to manage a group of patients, select an appropriate home health technology, provide training to the patient's immediate caregiver and/or patient and supports active case management by periodically reviewing telehealth monitoring data[22]. Patients are enabled to self-manage their condition through the use of the technology solution that is calibrated to trigger an appropriate response when clinical thresholds are surpassed. The Program has prided itself on its ability to target patients with a considerable risk of hospitalization, its tailored approach extending to the technology solution selected and its ability to empower patients to self-manage their condition as critical success factors. The Program has achieved considerable reductions in hospital admissions and bed day occupancy, while maintaining a lower per-patient cost structure when compared with the range of VHA's other non-institutional care offerings[23].

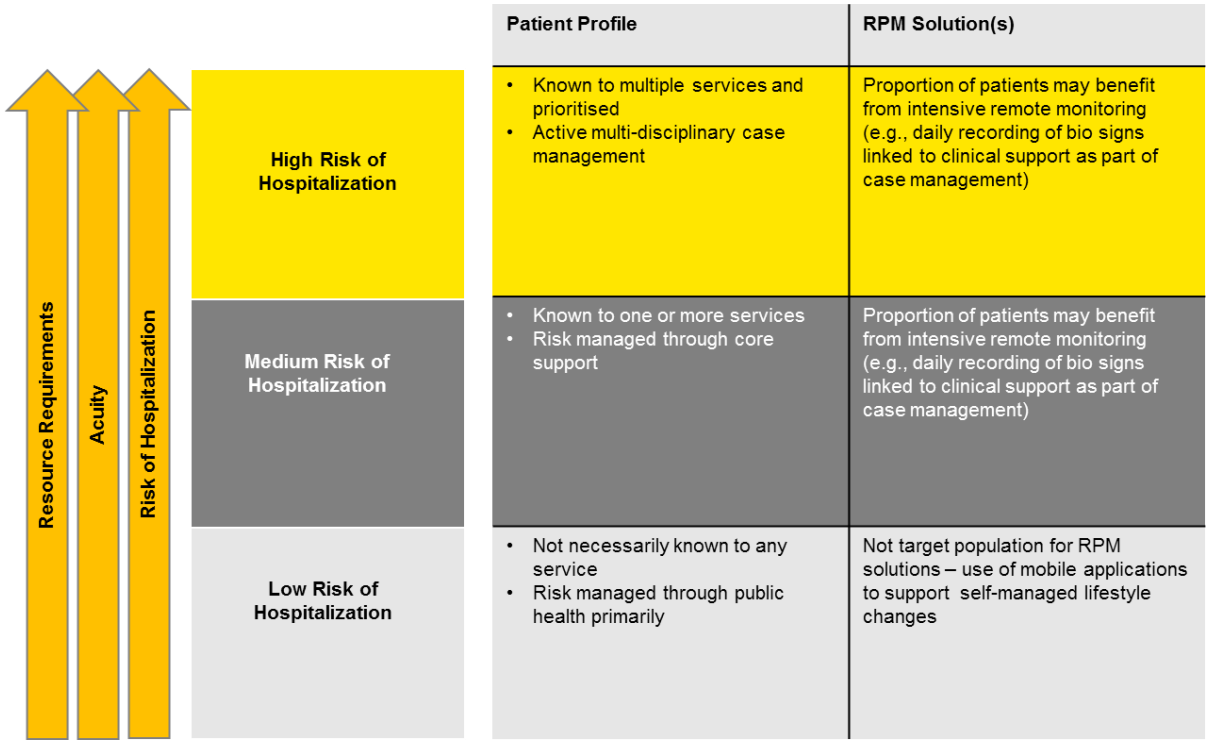
[21] Steventon, A., Bardsley, M., Billings, J., Dixon, J., Doll, H., Hirani, S., ... & Newman, S. (2012). Effect of telehealth on use of secondary care and mortality: findings from the Whole System Demonstrator cluster randomised trial. *BMJ*, 344.
[22] U.S. Department of Veteran's Affairs. 2012. VA Telehealth Services. Retrieved from: http://www.telehealth.va.gov/.
[23] Darkins, A. 2008. The systematic implementation of health informatics, home telehealth and disease management to support the care of veteran patients with chronic conditions. *Telemedicine and e-Health*, 2008.

RPM Target Population

The identification of patients appropriate for RPM solutions as part of their care plan is critical to ensuring improvements to health outcomes.

Chronic conditions are the main focus of this study for two reasons. First, RPM interventions for patients with chronic diseases have produced a sizeable evidence base. Second, chronic disease prevalence in Canada is expected to grow as the population ages in the coming decades, and calls for alternative care outside of hospital are on the rise.[24] Development of a framework for stratifying chronic disease patients based who may clinically benefit from an RPM program is critical to ensuring that the technological intervention is aligned with patients' chronic disease.

Figure 5. Risk Stratification Framework[25]



The Risk Stratification Framework was applied to the programs reviewed in this study to identify the patient groups that would be associated with the greatest benefit from being included in an RPM program. The Framework separates patients into three tiers based on a patient's risk of admission to hospital: high, medium and low.

[24] M. Hoover, M. Roterman. (2012) Seniors use of and unmet needs for home care, 2009. Statistics Canada, Catalogue no. 82-003-XPE • Health Reports, 23(4). Accessed on November 20, 2013: http://www.statcan.gc.ca/pub/82-003-x/2012004/article/11760-eng.pdf

[25] The risk stratification framework was informed by the Kaiser Permanente Triangle for Managing Health Conditions: Hudson, B. (2005). Sea change or quick fix? Policy on long-term conditions in England. *Health Soc Care Community, 13*(4), 378-385.

The **high risk** tier includes patients who are most likely to be admitted to a hospital due to the presence of multiple morbidities and complex chronic conditions. This tier includes a smaller number of patients that account for the majority of health system costs attributed to their condition. While these patients may be included in RPM programs, they may not be ideal candidates due to their level of illness, complexity of co-morbidities and subsequent challenges in self-managing their health. Due to the stage of their illness they are largely unable to progress to a less complex tier requiring fewer resources and monitoring. As such, there is high potential benefit for these patients when participating in programs that offer acute and involved treatment plans along with environmental monitoring solutions, but these benefits are unlikely to reduce overall utilization in healthcare resources.

The **medium risk** tier represents patients with a moderate risk of admission to a hospital. Such patients typically suffer from a chronic condition but have a lower acuity level of illness than those in the high-risk category. As the stage of their condition(s) has not deteriorated to the point to which they are unable to self-manage their condition, especially the case for patients with a moderate-to-high risk for hospitalization, they are common candidates for RPM programs. Programs designed for these patients have the potential to result in significant benefits both to patients, in terms of improvement to health outcomes, and the system, in terms of providing care for patients whose conditions are in a manageable disease state. Further, as improvement in a patient's outcomes can result in the management of their condition in a less complex environment requiring fewer resources, there is potential for the realization of additional system-level benefits.

The **low risk** tier represents lower acuity patients that are unlikely to be admitted to a hospital. Many of large-scale, formalized RPM programs avoid targeting such patients as the acuity of their condition does not justify a monitoring solution that offers consistent access to a care provider. While targeting these patients could result in the avoidance of deteriorating to a more complex disease state, the limited added gain in benefits would outweigh the cost in providing RPM. These patients would rely on RPM in the form of enabling technology solution to avoid becoming a candidate for a self, assisted or environmental monitoring program.

Methodology

The principal aim of this study was to assess and highlight the effects of existing Canadian RPM solutions. This was facilitated through an academic and grey literature review of results achieved in RPM projects in Canada and internationally (Appendix E); key informant interviews with program leaders, researchers, policymakers, and vendors; the identification of promising examples of RPM solutions to be featured as established case study reviews with assessment against a series of benefit hypotheses and other key factors to determine the potential for implementation at scale across the Canadian healthcare system. The study was undertaken in consultation with Infoway and an Expert Advisory Panel (Appendix A).

Evidence of Benefits

Using Infoway's Benefits Evaluation Framework, a series of benefit hypotheses were constructed to evaluate programs based on quality, access and productivity benefits realized. The hypotheses were constructed in collaboration with Infoway and members of the Expert Advisory Panel based on a literature review (Appendix E) and supported by key informant interviews with academics, program administrators, subject matter experts and industry representatives (Appendix H).

Overall, the literature review relied on meta-analyses, systematic reviews of peer reviewed RPM programs, program evaluations, evidence from large-scale Randomized Controlled Trials, such as the UK's Whole System Demonstrator project and a separate literature review conducted by Infoway. Although definitions, patient populations, outcome measures and evaluation quality vary widely in the literature, the cumulative benefits story of RPM programs for chronic disease patients is encouraging.

Table 3 provides a summary of the benefits against each of the hypotheses identified. Hypotheses that were validated with a moderate-to-high evidence base are displayed in bold, green text. The strength of the evidence was assessed with members of Infoway's Advisory Panel based on the availability of published evidence and discussion with key informants.

Table 3. Evidence of Benefits

	Benefits	Strength of evidence
Quality	▸ ↑ **Patient satisfaction** ▸ ↑ **Patient compliance** ▸ ↑ **Quality of life** ▸ Promote integrated care	O O O •
Access	▸ ↓ **Caregiver burden** ▸ ↑ Access to specialists ▸ ↑ Dissemination of health data	O • •
Productivity	▸ ↓ **ED visits/hospitalizations** ▸ ↓ **Per client health $** ▸ ↓ Per client care time	● O •

*● = High availability of evidence (>/= 10 published studies), O = Moderate availability of evidence supporting hypotheses, • = Low availability of evidence supporting hypotheses (</=2 published studies).

As illustrated in the table above, the strongest evidence supports reductions in emergency room visits, hospital admissions and bed days, patient satisfaction, and quality of life given appropriate patient selection into a program[26,27,28,29].

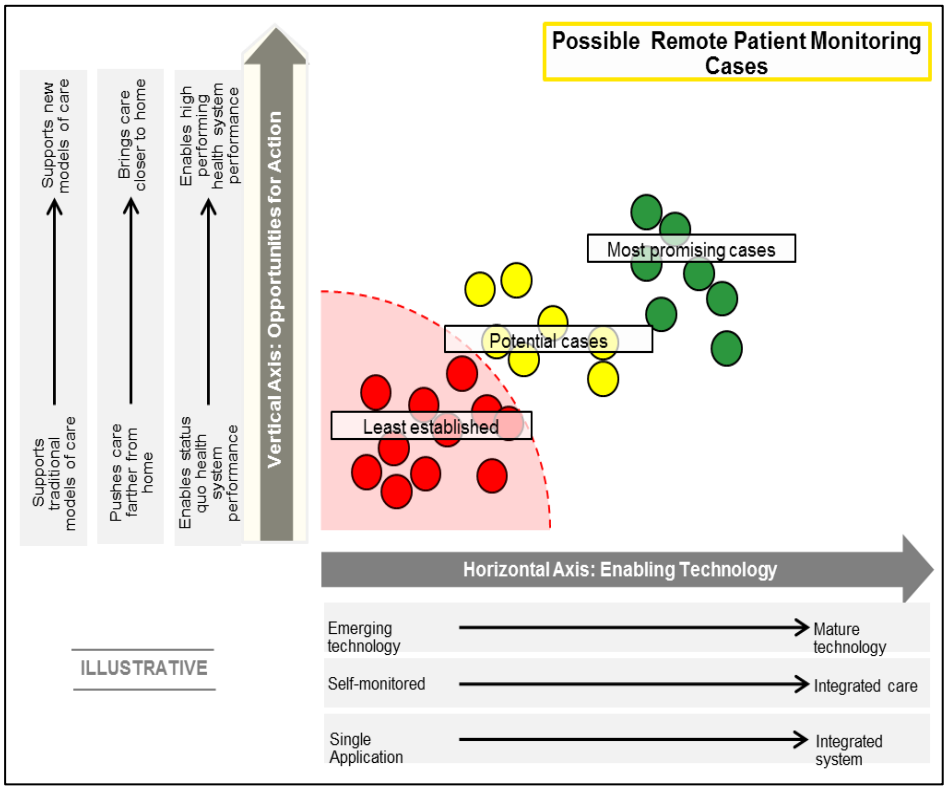
It is important to note that many of the existing evaluations have focused on smaller scale projects which have featured variability in the use of technologies, patient populations, chronic diseases and locations[30]. Nearly all the reviews and studies examined here, which collectively involve thousands of patients, span multiple years, cover multiple countries and include various RPM technologies and delivery models, consistently argue that additional research is needed to optimize the benefits of RPM, identify the right technology mix, and uncover the key drivers of sustainable RPM initiatives.

[26] Logan AG, Irvine MJ, McIsaac WJ, Tisler A, Rossos PG, Easty A, Feig DS, Cafazzo J.A. Effect of Home Blood Pressure Telemonitoring With Self-Care Support on Uncontrolled Systolic Hypertension in Diabetics. Hypertension. 2012 Jul;60(1):51-7.
[27] Seto, E., Leonard, K. J., Cafazzo, J.A., Masino, C., Barnsley, J., & Ross, H. J. (2012). Mobile Phone-Based Telemonitoring for Heart Failure Management: A Randomized Controlled Trial. Journal of Medical Internet Research. 2012 (Feb 16); 14(1):e31
[28] Home Telemonitoring for Chronic Disease Management: An Economic Assessment, HEC Montreal, August 2012
[29] Darkins A, Ryan P, Kobb R, Foster L, Edmonson E, Wakefield B, Lancaster AE. Care Coordination/Home Telehealth: the systematic implementation of health informatics, home telehealth, and disease management to support the care of veteran patients with chronic conditions. Telemed J E Health. Dec 2008.
[30] Mobile Computing in Health Care Delivery – White Paper. Canada Health Infoway Inc., 2013.

Case Study Selection

A series of criteria were developed to determine which RPM programs, identified by the Expert Advisory Panel and an independent review should be featured as case reviews. A two-dimensional model was created to inform the development of the criteria to ensure that the most promising RPM enabled care models were selected (Figure 6). The extent to which a program could demonstrate opportunities for action based on its realized benefits, in addition to its maturity and enablement of integrated care, provided for a favourable score.

Figure 6. Conceptual Model for Case Selection



Nineteen programs were independently assessed against each criterion. Programs that scored the most favorably were short-listed for inclusion as case studies. The short-list was then evaluated against a series of practical considerations, including data availability and reliability, geographic spread and program maturity, to ensure appropriateness for the modeling of costs and benefits. A listing of the 19 programs is found in Appendix F.

The final case selection process resulted in the identification of four programs:

1. Ontario Telemedicine Network Telehomecare Expansion Project (Ontario)
2. University of Ottawa Heart Institute Telehomecare Expansion Project (Ontario)
3. BreatheWELL at Home (British Columbia)
4. Jardins-Rousillon Health and Social Services Centre (JRHC) Telehomecare Program (Quebec)

Case Study Review

The Case Study Review provides a description of the benefits achieved through larger scale RPM implementations across Canada, and assesses cost and benefits across programs to understand sustainability and scalability.

Although benefits of these programs are readily available, they appear largely through subjective health variables, such as increased patient satisfaction, creating difficulties in quantifying impacts and comparing across programs. A discussion of performance measures aligning to the benefit hypotheses is included in Appendix G. As most of the programs captured system-level benefits in terms of reductions in emergency department (ED) visits and changes to hospital patient days, they were used to quantify program benefits.

The review provides a general overview of each program, their activity and performance to date, and highlights key success factors and lessons learned. It also includes two metrics to assess potential for sustainability and scalability based on findings from program evaluations:

1. **Patient "Break-Even"**, the minimum number of patients required for the program to cover its operating costs, and

2. **"Break-Even" Percentage of Current Maximum Capacity**, the proportion of patients required for a program to generate a positive return based on the maximum number of patients a program deems it is currently designed to support.

These metrics, coupled with an assessment of the benefits of each case study against the hypotheses aligned to Infoway's Benefits Evaluation Framework (Appendix G), provide implications, limitations and considerations for investing in similar programs across Canada.

Detailed methodology, including the variables used to calculate these metrics for each case study, is summarized in Appendix D.

Ontario Telemedicine Network Telehomecare Expansion Program

Project description and scope
Year program was established: 2007
Annual patients / Avg. time on service: 1,400 / 6 months
Condition(s): COPD, CHF
The OTN Telehomecare Expansion Program provides remote monitoring and coaching for patients living with chronic conditions, promoting self-management and engaging patients in their care plans to avoid unnecessary hospitalization and ED visits. The program is designed to be integrated into patients' circles of care. Funded by the Ministry of Health and Long-term Care, the program is aligned with provincial chronic disease and prevention management programs, ED/ALC and Aging at Home strategies. The program is a combination of goal setting through one-on-one health and education sessions with trained Telehomecare nurses and the remote monitoring of patient health status – transmitted by modem over a common phone line – allowing for early intervention when needed. Health coaching combines evidence-based techniques of motivational interviewing, goal-focused action planning, and problem-solving to identify and address a patient's individual barriers to change. The registered Telehomecare nurse partner with the patient's primary care team and other healthcare providers (formal and informal) the patient's circle of care to develop their care plan and keep them regularly informed of the patient's progress. Patients continue to have appointments with their existing healthcare providers as required.
Activity and performance to date
The Phase One Pilot was the largest THC program in Canada to date. 8 Primary Care Teams in urban and rural locations, consisting of monitoring 813 patients with COPD and CHF. Phase 2 incorporates the findings from the first phase in a scalable model designed for province-wide deployment and sustainability that is aligned with LHIN planning and service delivery. Through a LHIN-wide model, LHINs will fund a core group of Telehomecare Nurses in selected host organization(s) to work collaboratively with health service providers across the LHIN. The program rolled out to 2,000 patients enrolled in the North East, Central West and Toronto Central LHINs, will expand to upwards of 10,000 patients in additional LHINs by 2017.

Key success factors and lessons learned

- Engagement, stable funding, support and leadership at the provincial level down throughout the regions.
- Using the pilot to show benefits evaluated by a third party helped build the case for provincial, scaled deployment.
- Ramp up has been slow. Initial enrollment of 10,000 in the first year of phase 2 has been scaled back – recruitment of appropriate patients has taken longer than expected due to communication and collaboration barriers with other organizations.
- Lots of project management and planning up front is necessary, especially in large scale deployment – clearly defined business and clinical model and mechanisms in place to evaluate benefits.
- Focused communication plan to all stakeholders – LHIN, host organizations, OTN, primary care providers and patient's circle of care.

Program benefits evaluation results

Year of study	***No. of patients***	***Length of study – Months (pre/post)***	***Calculated Patient "Break-Even"***	***"Break-Even" as %of current max. capacity***
2011	129*	6/6	321	16%

University of Ottawa Heart Institute (UOHI) – Telehomecare Monitoring

Project description and scope
Year established: 2005
Annual patients / Avg. time on service: 300 / 3 months
Condition(s): Cardiac (incl. CHF)
The University of Ottawa Heart Institute (UOHI) provides an acute home monitoring program for cardiac patients in the Champlain LHIN. Patients are followed daily for 3-4 months by Telehome Monitoring and then are transitioned to an automated call follow-up system or interactive voice response technology that calls patients every 2 weeks for an additional 3 months to provide information relevant to self-care and offer opportunities to continued intervention based on their condition. The program uses a hub and spoke model in which monitors are allocated in local and rural communities. Physicians in those communities can locally determine which patients require the service based on set criteria. Each patient has an individualized plan in terms of vital signs which are transmitted over the phone using a modem, the frequency of transmission and alarm parameters for each of the vital signs are determined jointly by the patient and the clinician. In addition the monitoring system, the patient answers a series of pre-set symptom questions, which can trigger an alert if responses or results are outside of the set parameters. When this happens, a nurse contacts the patient for further assessment or changes to the regimen. Communication of health status and progress is maintained with the primary care physician, specialists and all healthcare providers involved in the patient's care. Regular reports of vital sign trends and adjustments to medications are provided to physicians through an electronic health record which is integrated into the system.

Activity and performance to date

The Heart Institute started in 2005 with 20 monitoring systems for patients to take home after discharge. Today, 158 monitors are available for distribution in nearly every hospital in the region.

Patients are closely followed by the Heart Institute for up to three months after they are discharged. They check and transmit their measurements daily at a prearranged time and data is transmitted by telephone to the Central Monitoring Station at the Heart Institute. A nurse will call immediately if any information is questionable or if a patient calls for help. To date, the program statistics include:

- 300 patients are monitored at home annually
- 158 monitors & scales, GPRS bridge modems for digital lines or no land lines, 35 pocket ECG, 20 glucose cables, 20 INR units
- 1 RN for ~100 patients/day (40-50 monitors and automated calls)
- Monitoring duration 3-4 months with plan to transitional to less intensive HF IVR follow-up (2 weekly automated calls)

The Integrated Voice Response (IVR) program contacts patients every 2 weeks for 3-6 months post telehome monitoring. The IVR algorithm is made up of 16 questions used to educate and potentially flag a telehome nurse of any potential threats to continued health of the patient. As part of a larger project, 47 heart failure Franco Ontarians were followed by IVR for 6 months. . Preliminary results at 3 months showed that a total of 125 calls were made by IVR. Of those, 18 were complete responses and did not require intervention, 56 were flagged as “callback” requiring further assessment by the nurse and 51 patients could not be reached by IVR. There were 58 requests to the system to hear information on heart failure medications and many patients made the request more than once. Seven medication adverse events or potential events were captured during the IVR monitoring period. Four patients presented to the ED for non-cardiac (3) and heart failure (1) reasons. The latter had been prescribed a contraindicated medication. Four patients were admitted for cardiac reasons such as MI. However there were no avoidable admissions related to CHF. Most patients (74%) found the IVR system to be very helpful and helpful and most (94%) would use this service again and believe it is a good way to follow patients in the community.

Key Success Factors and Lessons Learned

- The hospital did not wait for funding – when it saw a need present itself in the management of post-acute cardiac patients a case was made for the program to be funded out of the global budget.
- The program has had great documented outcomes and has become a showcase for 'hub and spoke' models of patient monitoring delivery.
- Being attached to a regional specialty centre enabled the program to identify and enrol appropriate patients for the program and the relationship with the physicians have been very positive – it is seen as an extension of care and not as a replacement.
- The program and its technology are built around the needs of the patient.

Program benefits evaluation results

Year of study	***No. of patients***	***Length of study – Months (pre/post)***	***Calculated Patient "Break-Even"***	***"Break-Even" as %of current max. capacity***
2008	121	3/3	104	22%

BreatheWELL at Home

Project description and scope
Year established: 2012
Annual patients / Avg. time on service: 300 / 3 months
Condition(s): COPD
BreatheWELL at Home is a service designed to help patients manage their chronic obstructive pulmonary disease (COPD) condition and symptoms after they are discharged home from hospital, or if they have difficulties managing their condition at home. Patients in the BreatheWELL program receive specialized clinical support including two to three initial home visits by a nurse and respiratory therapist who work with the patient and family doctor to develop a care plan. The patients also receive therapy services and are connected to services such as lung rehab, mental health and substance use, home support, rehabilitation therapy, and exercise programs. In addition, the program provides patient self-management education such as medication management and adherence and how to properly manage and prevent exacerbations. When appropriate, a technician installs in-home Telehealth monitoring technology to help patients manage and understand their condition by tracking vital measurements, such as blood pressure, pulse and oxygen levels, and providing health education. The BreatheWELL program does not replace community services or primary care – it is marketed and managed as a collaboration from representatives from FH Medicine, Primary Health Care, Home Health and Residential Care and includes the involvement and collaboration from General Practitioners, Hospitalists, Respirologists, and community respiratory services. With hospital staff aware of patients' participation in the program, they're more comfortable releasing patients a bit early knowing a respiratory therapist will be following up with them within 48 hours.

Activity and performance to date

The program has supported 277 unique patients to date in the community. The BreatheWELL program to date was comprised of a clinical practice framework, service delivery model, and Telehomecare monitoring system for patients with COPD.

Continued expansion and growth to the number of patients enrolled in BreatheWELL in New West, Burnaby, Langley and Chilliwack is targeted to:

- reduce the number of emergency room visits, the number of hospitalizations, readmissions and the average length of stay for affected individuals;
- improve and maintain the patient quality of life in this patient population by avoiding exasperation; and
- enable more coordinated, purposeful and timely discharges from hospital to community services.

Key Success Factors and Lessons Learned

- Very strong mechanisms in place to monitor and measure performance metrics, including economic parameters and physiological outcomes.
- Tightly integrated into current community services with collaboration from an interdisciplinary team of health professionals.

Program benefits evaluation results

Year of study	***No. of patients***	***Length of study – Months (pre/post)***	***Calculated Patient "Break-Even"***	***"Break-Even" as %of current max. capacity***
2012	297	12/12	156	52%

Jardins-Roussillon Health and Social Services Centre (JRHC) Telehomecare Program

Project description and scope
Year established: 2010 (Phase 2)
Annual patients / Avg. time on service: 180/4 months
Condition(s): CHF, COPD, Diabetes
The Jardins-Roussillon Health and Social Services Centre (JRHC) was established in 2004, serving an area south-west of Montreal with a population of over 192,000. Homecare encompasses a major service offering for JRHS, providing a range of high quality health services for the prevention and management of health conditions to vulnerable populations such as the elderly and those living alone, as well as care following surgery or palliative care to allow them to effectively manage their health at home. As 2011, the program employed 16 nurse practitioners (NP), 18 registered nurses (RN) and 6 licences practical nurses (LPN). To further this mandate, JRHC has deployed a home telemonitoring solution to serve patients with chronic conditions, such as CHF, COPD and diabetes. The program involves the patient documenting and submitting various health parameters (blood pressure, weight, etc.) using a touchscreen device with an integrated modem for the electronic submission of clinical data. Nursing case managers consult the data on a regular basis, remotely monitoring the patient's medical condition and compliance with their individually prescribed care plan. The device has built-in alerts that are automatically generated and pushed out to both the patient and the case manager when the submitted data strays outside predefined thresholds, allowing for proactive detection of decompensation and early intervention. The program is designed to empower patients to manage their illness by reinforcing the relationship between their health status and their daily activities. The three guiding principles of the program are: 1. Patient empowerment – enabling patients and their informal care givers to take charge of their health at home with the expert supervision of qualified health professionals with the goal of successfully self-managing their conditions. 2. Optimal use of health resources – allowing health professionals to successfully monitor and manage a larger number of patients and provide interventions at the right time while reducing the need for travel. 3. Complementary interventions that promote accessibility to care – remote patient monitoring must be integrated and not replace existing care pathways by adding to and not duplicating traditional service offerings.

Activity and performance to date

Phase 2 of the telehomecare cost minimization study started in 2010 and was completed in March 2011 in order to assess the economic viability of a like-program in Quebec. It is believed to be the first study to have examined the long-term effects of telehomecare following removal of the technology – following a cohort of patients not only pre and post-implementation of the solution but also post-removal. The study was able to sign up 184 patients over its course with the maximum number of patients simultaneously monitored being 102; there were almost 10,000 cumulative transmissions received and monitored.

Key Success Factors and Lessons Learned

- The two organizations managing the program (CSSS JR and SRSAD) had previous experience delivering remote homecare, allowing for a reduced learning curve – however nurses still had to become comfortable with the technology and responding to the alerts.
- The program also benefited greatly from having well defined objectives and a strong understanding of the current state of the environment from the outset.
- The technology was designed to promote patient empowerment and involvement – having the patient manually input their health information instead of automatic capture and transmission enables the patient the opportunity to understand and pay attention to the factors that promote or reduce health.

Program benefits evaluation results

Year of study	***No. of patients***	***Length of study – Months (pre/post)***	***Calculated Patient "Break-Even"***	***"Break-Even" as %of current max. capacity***
2011	95	12/12**	59	29%

Benefit Realization

The evaluations of each program indicated relatively small groups of patients, differences in the conditions of patients targeted, along with variations in a program's inclusion criteria. Given the extent of healthcare utilization of the patients targeted across each program, and relying on the assumption that the cohort is representative of the total patient base, these programs largely target patients with a medium-to-high risk of hospitalization – the stated "sweet spot" for RPM – representing a high potential for returns to the health system.

The inclusion criteria for each program are stated in Table 4.

Table 4. Case Study Inclusion Criteria

BreatheWELL at Home Program	Ontario Telehomecare Expansion Program - OTN	University of Ottawa Heart Institute (UOHI) Regional Home Monitoring Program	Jardins Roussillon (JRHC) Telehomecare Program
Patients who within the last 12 months have had COPD exacerbations resulting in: ► 2 ED visits and at least 1 hospital admission, or ► 3 or more ER visits	► Patients aged 18 or older ► Have a history of emergency visits and/or hospital admissions ► Have few current supports in place ► Have difficulty managing their medications and their condition(s) ► Have frequent primary care visits	► HF patients with 1 readmission /1 month or 2 / in 6 months (NYHA III/IV) ► Patients with new HF diagnosis ► Patients recovering from cardiac surgery ► Patients requiring vital sign, arrhythmia monitoring	► Adult patients with serious chronic condition (CHF, Diabetes, COPD) requiring frequent home visits ► Patients who have a regular physician ► Patients not suffering from psychological or psychiatric disorders

Break-Even – The Point of Sustainability

As calculated, each program shows strong net benefit realization. A necessary assumption was made that the patients and savings obtained were representative of the entire population that could be served by each specific RPM program. The patient "break-even" or "point of sustainability" calculation and the percentage of current maximum capacity takes into account the patient threshold required for a program to recover its costs and improve health system utilization. Each program demonstrated that they have ability to serve patients well over this point, with ranges from 16-52% of current maximum capacity as defined by each program.

Ultimately, the break-even point is dependent on the variables used to calculate costs and benefits. Changes to these can have a drastic effect on cost models and thus increase or decrease the demonstrated return. Unfortunately, this is heavily limited by the data available and how studies structure their performance measurement framework. This assumption aligns with literature findings[31], where the economic savings from Telemonitoring solutions compared to usual care for CHF patients in 10 studies showed significant differences according to what variables were used – ranging from 1.6-68.3% savings. This calculation offers a directionally valid assessment of the benefits gained through RPM implementation.

There are many factors that can affect the magnitude of this return, such as:

- Patient cohort – defined by chronic condition and target level of acuity
- One-time costs – the need and availability of capital (physical space, technology infrastructure etc.) to allow programs to support its targeted patient population in terms of acuity and to grow to capacity
- Ongoing operating costs – choice of care model, which influences the requirement for levels and type of clinical oversight and intervention, as well as administrative and overhead costs
- Reduction to healthcare spend – the calculated savings gained from the solution versus usual care

Analyzing the Costs

To appropriately detail the break-even or point of sustainability, it is imperative that programs adequately plan for their needs upfront and document their costs fully. The costs provided by each program for this analysis were according to one-time costs (equipment and infrastructure) incurred to grow to current capacity from program implementation and the most current operating budget. The detailed benefits calculations can be found in Appendix D.

Above all is the appropriate capture and illustration of benefits, specifically the reductions to healthcare expenditure. Setting an appropriate baseline and using standard performance measurement frameworks allows for the objective review of RPM health system benefits. As

[31] Seto, E. (2008). Cost Comparison Between Telemonitoring and Usual Care of Heart Failure: A Systematic Review. Centre for Global eHealth Innovation, University Health Network, Toronto, Ontario, Canada. *Telemedicine and e-Health, 14*(7) 679-686.

stated, this review used national cost data and health resource utilization reductions obtained from the provider-led evaluations. Going forward, future studies would benefit from capturing actual case costs for each patient in a study in order to remove any doubts related to the validity of the savings. For instance, using the national averages does not take into account the variability of comorbidities within patient groups, and if taken at a national level it doesn't take into account differences in provincial, acute facility type or other mixes of factors.

Considerations

It is well known that seasonality and time of year affects exacerbations of certain health conditions and utilization of health resources. Only BreatheWELL's evaluation study lasted a full year pre- and post-solution implementation while JRHC extrapolated annualized post-solution results to potentially take this variable into account. There are also questions of sustainability – the UOHI evaluation study showed that reductions in utilization started to decline with increased duration post-implementation. This aligns with literature findings.

Admittedly, the economic benefits may far exceed what has been calculated in this report. They are heavily skewed towards system factors and away from patient-level costs. However, indicators such as reduction in patient/provider travel (calculated in the JRHC study), potential increased provider care (higher frequency of home nursing visits), improvement to patient and caregiver quality of life and utilization of primary healthcare services have been inconsistently measured, analyzed and quantified.

BreatheWELL uses assessment tools to measure quality of life, ability to self-manage and patient satisfaction of patients on service, with a pre- and post-enrollment study, with results, as shown in Table 5. Similarly, JRHC utilized a patient satisfaction survey, however like BreatheWELL it assessed the patient's satisfaction with the use of the technology (potentially serving as a proxy for compliance) and not the increase or decrease of satisfaction with their health or their ability to better manage their conditions.

Table 5. BreatheWELL Assessment Tool Analysis

Indicator	Method	Pre- Upon enrollment	Post- After enrollment
Quality of life	COPD Assessment Tool (CAT) (out of 40, lower is more desirable)	18.78 (m)	17.97 (m)
Self-management	Patient Activation Measure (PAM) Survey	56.3067(m) Level 3	57.7500 (m) Level 3
Satisfaction with telemonitoring equipment	Survey (scale of 1-4)	N/A	3.5 3-agree

Translating these benefits into financial savings is met with many difficulties. Many interventions offer limited evaluation potential, moving away from attempting to measure the potential effects of the intervention on clinical outcomes such as quality of life and caregiver burden. Despite these limitations, each program reviewed provided anecdotal evidence that similar benefits have been realized and offer greater value to the patients they serve. Future emphasis on collecting and quantifying different patient and system benefits that take a detailed account of costs and benefits of a program in addition to quality of care and clinical outcomes, will facilitate an enriched discussion and comparison of programs to assess potentiality for scalability and national implementation.

Emerging Solutions

As RPM is a relatively new care delivery enabler in Canada, many programs were found to be within the pilot phase involving smaller sub-sets of patients and limited evidence of measurable benefits. These programs featured less complex technology, such as a patient's mobile device, enabling patients to effectively monitor their self-monitor their condition[32].

This study identified four RPM programs as examples of emerging solutions due to their potential to realize sustainable and scalable benefits based on program design and patient identification. The studies, aligned to the four streams of RPM programs (Figure 4) are:

1. WelTel (self-monitoring)
2. mDAWN (self-monitoring)
3. Virtual Cardiac Rehabilitation Program (enabling information)
4. myHomeHealth (self-monitoring)

A detailed summary of each program, including critical success factors, implementation considerations and lessons learned is found in the Appendix E. A brief overview of each program a summary of performance (either achieved to date or projected) is below.

1. WelTel

WelTel is a self-monitoring text messaging program originally developed in Kenya which led to two initial pilots in British Columbia, providing enhanced support to patients with HIV and tuberculosis, and a range of ongoing projects including an SMS-driven asthma management program. The WelTel service consists of weekly interactive check-ins in which participants are asked how they are doing via automated text message, with follow up phone calls made to those reporting a problem. The effectiveness of this RPM solution was initially demonstrated in a randomized controlled trial in Kenya in which the WelTel intervention significantly improved HIV treatment outcomes through improved medication adherence and viral load suppression.

Year Began	Number of Patients	Location	Performance
2010	863 across 6 programs (includes projected enrolment)	British Columbia	► Programs have found text messaging intervention to be valued by both healthcare providers and HIV positive participants as a consistent and easy to use method for facilitating and maintaining communication. ► Participants and healthcare providers positively responded to program. ► $239,000 in committed funding from provincial government and federal health agencies¸.

[32] Mobile Computing in Health Care Delivery – White Paper. Canada Health Infoway Inc., 2013.

2. mDAWN

mDAWN is a study being conducted by the eHealth Strategy Office, part of UBC's Faculty of Medicine, which explores how mobile technologies, including text messaging and monitoring devices can be used to help people with Type-2 diabetes get the health information they need.

mDAWN has the potential to change the way individuals receive and interact with chronic disease resources by increasing patient activation, eHealth literacy and engagement in self-management. A project framework is being developed that can be scaled up across study groups and a research design that evaluates the programs' impact on relevant health indicators such as patient activation, caregiver stress, eHealth literacy and quality of life.

Year Began	Number of Participants	Location	Performance
2013	26 (includes patients and participants)	British Columbia	► Project plans have been informed by provincial committees and working groups in British Columbia, Inter-cultural Online Health Network events, academic and practice-based partnerships and funding partnerships. ► Project has developed an extensive research and benefits evaluation framework intending to capture patient and caregiver satisfaction with the program, patient biostatistics, program usage, and a cost comparison of the program against other models of care. ► Supported by grant funding from the Lawson Foundation in Ontario and a private B.C. based foundation.

3. Virtual Cardiac Rehabilitation Project			
Project description and scope			
The Virtual Cardiac Rehabilitation Program (vCRP) uses an online interface to mimic the existing outpatient cardiac rehabilitation programs currently in use at hospitals across British Columbia. A randomized group of ischemic heart disease patients used the vCRP website over a four-month period (with a follow-up scheduled one year after completion). These patients lived in small urban and rural areas in which traditional cardiac rehabilitation programs do not exist. It is anticipated that their participation in this program will show significant improvement in exercise capacity, and will present Internet-based programs as a viable alternative for ischemic heart disease patients in rural or remote areas of British Columbia.			
Year Began	**Number of Patients**	**Location**	**Performance**
2011	78 recruited, 71 completed	British Columbia	► Improved exercise capacity. ► Reduction in risk of cardiovascular disease. ► Safe and effective in reducing risk by improving exercise capacity, cholesterol and dietary factors. ► Reduction in use of health human resources (less than 8 hours of staff time per participant).

4. Alberta MyHome Health program			
Project description and scope			
MyHome Health is a virtual care management program designed to support seniors living at home with Coronary Heart Failure (CHF) through an integrated care delivery process, home technology and IT. The project is supported in Alberta by the Sherwood Park – Strathcona County Primary Care Network. The drivers for establishing the project were the rising demand for healthcare from CHF patients, the physical environment of Strathcona County which is a large, rural geographic area relegating homecare staff has to drive to homes to care for CHF patients over considerable travel distances and poor winter road conditions which is an expensive use of skilled resources.			
Year Began	**Number of Patients**	**Location**	**Performance**
2011	23	Alberta	► The device helps collect daily health data that would normally go uncollected. ► The data provides a more complete picture of the patient's health status than the discrete data points that are collected in regular practice visits. ► The combination of an interdisciplinary team member and health information technology was able to catch adverse medical events.

The four programs represent innovative approaches to facilitate the delivery of high quality care. Both the Wel-Tel and the mDAWN program leverage low complexity technology (SMS) for patients that would not be typical candidates for the larger and formalized RPM programs reviewed in the case study review. Further, these programs target patients with the ability to self-manage their own condition that would comprise the medium-risk tier of the Risk Stratification Framework (Figure 5).

This not only represents a shift of RPM programs towards lower-cost technology, it also suggests that lower-acuity patients are being targeted to avoid progression towards a more complex stage of care. This broadens the target market for RPM solutions and underscores the potential for systemic health system benefits and cost avoidance as patients are less likely to be managed in a setting requiring significant healthcare resources.

These programs also demonstrate the utilization of information technology associated with lower complexity and costs towards medium and high risk patients traditionally associated with complex technology. For example, the vCRP program leverages an online interface to virtually monitor cardiac rehabilitation patients that is designed to replicate similar rehabilitation programs offered by hospitals in an outpatient setting. As this program leverages technology that a complex patient is likely to have in their own home, it can be offered as a lower cost alternative to the traditional programs with larger resource and monitoring requirements.

These findings are also validated with emerging literature and evidence. An American study demonstrated that a home blood pressure telemonitoring system, which provided self-care messages on the smartphone of hypertensive diabetic patients immediately after each reading, improved blood pressure control[33]. In addition to blood pressure control, less-complex technologies such as the Bant iPhone application created by the University Health Network Centre for Global eHealth Innovation, can be used to monitor blood glucose levels for patients with Diabetes[34]. Such solutions are designed to ensure patients consistently monitor their health through minimally invasive and cost effective technology, and demonstrate promise at ensuring patients remain on their prescribed regimes, potentially avoiding the use of costly healthcare resources downstream.

While evidence from these innovative solutions continues to emerge, program managers and provincial planning bodies should recognize a fundamental shift in RPM towards less complex and invasive technologies that can be used to monitor acute patients with chronic conditions that would have been monitored through a program traditionally associated with a higher cost structure.

[33] Logan AG, Irvine MJ, McIsaac WJ, Tisler A, Rossos PG, Easty A, Feig DS, Cafazzo J.A. Effect of Home Blood Pressure Telemonitoring With Self-Care Support on Uncontrolled Systolic Hypertension in Diabetics. Hypertension. 2012 Jul;60(1):51-7.
[34] Mobile Computing in Health Care Delivery – White Paper. Canada Health Infoway Inc., 2013.

Critical Success Factors

The review of both established and emerging RPM programs discussed in this study contain a series of critical success factors. These interrelated factors can be conceptualized as a common thread between programs targeting different groups of patients along different stages of the continuum of care that leverage technology of varying complexity. The four factors presented below should be considered by RPM program managers, healthcare providers, vendors and patients to support the appropriate design, implementation and uptake of RPM programs across Canada.

1. Engagement and collaboration,
2. Patient recruitment and retention,
3. Benefits measurement, and
4. Integrated care and care-coordination.

These factors were identified and validated with members of Infoway's Expert Advisory Panel. A detailed description of the critical success factors emerging from the international solutions, case studies and innovative solutions can be found in Appendices C-E.

Engagement and Collaboration

Engaging clinicians throughout the development and implementation of an RPM program either as leads (e.g., mDAWN, JRHC) or in an advisory capacity (e.g., Ontario Telehomecare Expansion Project) was consistently identified as a critical success factor. The opportunity to leverage the clinical expertise of practitioners assisted in the design of programs and the selection of an appropriate level of technology aligned to a patient's disease profile. Clinicians engaged in the program also demonstrated the ability to better understand the technology component of the solution, enabling them to effectively communicate the benefits of home monitoring to patients, as found in the JRHC Telehomecare Program.

Clinician engagement was also found to improve patient recruitment and retention. Formal RPM programs embedded into the model of care (e.g., BreatheWELL, UOHI) in which all patients within a disease profile were cared for through RPM were associated with high patient retention. A possible driver for this is the reliance on an interdisciplinary team of health professionals across different levels of care, consistently engaging with patients throughout their care journey. Programs facilitated engagement through a variety of means. For example, the Ontario Telehomecare Expansion Project developed a focused communication plan to all stakeholders, including primary care providers and clinicians within the patient's circle of care.

Clinicians offer a blend of subject matter expertise which can assist RPM programs in design and aligning technology to the target population. Further, clinicians are uniquely positioned to deliver a compelling value proposition to potential patients, facilitating greater recruitment and retention. The continued engagement of clinicians both as program 'champions' and as a clinical advisors will assist in strengthening the evidence base for RPM programs in Canada.

While clinician engagement emerged as a critical factor to ensure the appropriate design and implementation of a RPM program, collaboration between organizations was consistently identified to ensure program sustainability. Collaboration with providers within regional groups such as Regional Health Authorities (RHAs) or Local Health Integration Networks (LHINs) is critical for driving recruitment through the delivery of remote care to a critical mass of patients necessary to realize benefits. Engaging fund-holding organizations, such as LHINs in Ontario, also ensures that programs have sufficient resources to ramp-up their operations, enabling other providers within geographic boundaries to offer the RPM program to patients.

Patient Recruitment and Retention

Strengthening recruitment practices assisted in establishing a critical mass of patients necessary to effectively demonstrate system, access and productivity benefits across the programs reviewed. While securing sufficient levels of patients was identified as a barrier to realizing benefits and facilitating larger implementations in all of the innovative solutions reviewed, it was consistently recognized as a priority area for managers to address throughout the progression of the program.

Many of the larger programs reviewed demonstrated the ability to sufficiently and efficiently recruit patients. For example, the UOHI program achieved positive patient outcomes largely due to its attachment to a regional speciality centre, enabling the program to consistently identify and enrol patients that aligned to specific inclusion criteria. This strategic alignment also created a level of familiarity between the patient and the established facility, contributing to an improvement of the patient experience.

While the ability to secure alignment with a regional or provincial organization is not always possible for smaller programs, effectively communicating the specific facets of the program was identified as an effective enabler for patient recruitment. For example, the Wel-Tel program clarified that the service was not designed to replace clinical care. Instead, it emphasized the ability of the program to facilitate self-managed care through non-complex technology. Patient engagement is therefore a critical enabler of successful patient recruitment and retention that relies on demonstrating value to potential patients. Both the smaller scale projects such as Wel-Tel and the more established programs such as the Ontario Telehomecare Expansion Program engaged patients early on in their recruitment processes while the projects were in their developmental phase. This approach ensures that elements of program design are calibrated to both the clinical capability of the patient and their overall expectations of the service.

Patient recruitment and retention is critical to generating a sufficient evidence base for any RPM program. The alignment of recruitment and retention practices to appropriate patient cohorts can be enabled through the use of risk stratification tools. Providers and program managers can use stratification tools as a foundation for aligning the inclusion and exclusion criteria necessary to participate in the program.

Additionally, as demonstrated by the case reviews, achieving a critical mass of appropriate patients is required for an RPM program to recover costs and maximize benefits. While the number of patients required for a program to 'break-even' is heavily dependent on the scope of the program, it is clear that different programs will have different patient thresholds. Further, the absence of detailed, per-patient information featuring both direct and indirect costs, as found in many of the programs reviewed in this study, presents a key barrier in calculating a program's cost and benefit. Emerging solutions in the pilot phase can benefit from capturing detailed cost information as it can provide patients, providers and funders with a key indicator for the program's future sustainability

Tied to this, alignment between a risk stratification tool and appropriate patient identification ensures that the technology selected for a particular RPM program will produce an appropriate level of benefits. For example, a solution relying exclusively on patient self-management should not be aligned with complex patients presenting a high rate of health system utilization. The stringent application of a risk stratification framework to potential patients will assist in the accurate validation of benefits received and will support further program optimization.

Benefits Measurement

Measuring benefits and outcomes is the critical success factor found in each program reviewed, regardless of complexity, maturity and design. The appropriate measurement of benefits provides for a clear understanding of the value the RPM program has delivered to the patient and the healthcare system. The measurement of physiological outcomes was typically embedded into a program's design to ensure that the RPM was effectively fulfilling its mandate of improving care. Measuring physiological outcomes however, was not often considered as a measure of overall program performance, compared to the measurement of system-level benefits such as a reduction in ED admissions or hospitalizations.

Many programs included system-level outcome measures as a component of program design. However, these measures were commonly seen when programs were at the tipping point of large scale implementation, such as the Ontario Telehomecare Expansion Program and the JRHC Telehomecare Program. As programs progressed in maturity, it was apparent that the measurement of system-level benefits became less central to formally evaluating the program's performance. As such, the evidence from the larger RPM programs suggests that consistent monitoring of system-level benefits is less critical once the program has been formalized and accepted as the model of care.

The RPM programs reviewed in this study all included different performance metrics aligned to a combination of system, access and quality benefits. The absence of standardized benefits measurement among each program impacts the ability to assess the potential for programs to be scalable across Canada. Establishing standardized RPM performance metrics aligned to evidence-based practice to be adapted by providers ensures that quality, access and system level benefits can be consistently realized while allowing for programs to be compared across different provinces and territories. Coupling standardized metrics with a benefits evaluation framework and business framework articulating the minimum requirements for solutions, will assist in ensuring programs remain sustainable.

Integrated Care and Care-Coordination

Striking an appropriate balance between integrating an RPM program into a patient's clinical pathway and supporting a patient through consistent care-coordination was identified as a critical success factor across many of the case studies and innovative solutions. While evidence from the Whole System Demonstrator Project strongly suggests that following a pathway-led approach enables a patient to routinely consider monitoring as a component of their care plan, and thus facilitates program compliance, it effectively minimizes the self-management component. As such, full integration of an assisted or environmental monitoring RPM program into a patient's care pathway is ideal for complex, high-risk patients that were not found to be ideal candidates for RPM programs, demonstrating benefits and effectively controlling costs. For example, the JRHC RPM program in Quebec clearly indicates that the interventions associated with the program are complimentary to the patient's course of care – there is a need for RPM to be integrated into a patient's care, but the program is not designed to replace existing care pathways by adding to and potentially duplicating service offerings.

In contrast to RPM programs that require patients to follow a prescribed care pathway, models that favour care coordination as a means to achieve benefits emerged from the case studies and innovative solutions reviewed. Integrating an RPM program into a patient's model of care that allows for coordination of care between a patient's primary, secondary and tertiary care providers, was common in the self-management programs reviewed focusing on patients possessing a moderate risk of hospitalization. For example, the Alberta myHomeHealth program relies on a balance of patient self-management and assisted monitoring involving consultation with members of a patient's primary care team. This allows for coordinated care delivery across multiple providers with different specialties to support the patient's need. Additionally, the Ontario Telehomecare Expansion Program relies on a model that balances care integration and coordination across a patient's circle of care, enabling the collaborative development of a patient's care plan while allowing providers to share information electronically to support consistent monitoring and necessary intervention.

Appropriate design of an RPM program should recognize the acuity of the targeted patient cohort when considering if a pathway-led or care-coordinated approach is required. While pathway-led approaches facilitate standardized benefits measurement and in turn, evidence for broad scalability, they may require patients to fundamentally shift their current course of care. Some complex and high-risk patients undoubtedly require this shift, whereas others utilizing RPM programs as a means to self-manage their condition or practice preventative health, can benefit from a model that compliments their current care pathway, such as through a coordinated care model.

Conclusion

This study demonstrates the growth in the activity of RPM programs across Canada, some of which have been formalized into regional and provincial models of care, while others continue to explore emerging solutions through pilot projects. While the use of RPM solutions remains at the innovation end on the scale of implementation maturity, many programs have or intend to realize benefits. As the evidence for RPM continues to develop, a burning platform for further research and benefits measurement has been created, supporting the future uptake and adoption of RPM across Canada.

While chronic disease patients remain to be the primary candidates of established RPM programs, smaller-scale emerging solutions have begun to target chronic disease patients, in addition to lower acuity patients, through the use of enabling and self-monitoring technologies. This illustrates a realization among providers that patients should be managed to avoid progressing towards a more complex model of care. This is coupled with the growth of grass-roots RPM programs that leverage less complex technologies with which patients are likely to be familiar. While the benefits of these programs are less defined, they represent a shift towards the management of acute and chronic disease patients with simplistic, non-invasive and less costly technologies that offer the potential to offer patient and system level benefits.

A variety of considerations to growing and investing in promising examples of RPM programs should be noted. Despite the reductions in health system utilization found across some of the established RPM programs featured as case studies, extrapolating benefits to specific sub-sets of patients is limited due to the variations in program design such as patient cohort identification. While the larger RPM programs demonstrated the ability to achieve sufficient return-on-investment, the significant range of total patient capacity required to break-even (16-52%), along with limited evaluation of qualitative benefits and evidence of long term sustained benefits, demonstrates the need for further evaluation and growth of programs in the market.

The role of information technology is a critical enabler to improving health services delivery. As decision-makers consider options to deliver high quality care at the lowest possible cost, there is considerable opportunity for innovative solutions that leverage technology to complement and transform models of care. RPM in Canada can and should be a critical enabler for this transformation with the potential to support patient self-management while helping to keep patients closer to home. The continued realization of benefits through engagement and collaboration, patient recruitment and retention and striking a balance of integrated care and care coordination will be critical to formalize RPM as a model of care across Canada.

Appendix A – Expert Advisory Panel

Name	Title	Organization
Joseph Cafazzo	Lead, Centre for Global eHealth Innovation	University Health Network Toronto General Hospital
Grant Gillis	Executive Director, Forums & Practices	COACH: Canada's Health Informatics Association
Cheryl Hansen	Executive Director Innovation, e-Health, The Office of Sustainability	Government of New Brunswick
Kendall Ho	Director, eHealth Strategy Office, Faculty of Medicine	University of British Columbia
Scott Lear	Professor, Faculty of Health Sciences	Simon Fraser University, Healthy Heart Program, St. Paul's Hospital
Nancy Lefebre	Co-Chair, OHCA-OCSA Nursing Practice Council; Chief Clinical Executive, SVP, Knowledge & Practice	St. Elizabeth Healthcare
Guy Pare	Canada Research Chair, Information Technology in Health Care	HEC Montréal
Laurie Poole	Vice President, Telemedicine Solutions	Ontario Telemedicine Network
Heather Sherrard	Vice President of Clinical Services	University of Ottawa Heart Institute

Appendix B – RPM Activity in Canada

Province	Program	Year Begun	# of Patients Enrolled	Primary Diagnoses
British Columbia	Vancouver Island Health Authority Telehomecare Monitoring	2009	87	CHF
	BreatheWELL at Home Program	2011	170	COPD
	Virtual Cardiac Rehabilitation Program	2011	149	Ischemic heart disease
	mDAWN	2013	20	Type 2 Diabetes
	WelTel Oak Tree	2013	100	HIV/AIDS
	WelTel LTBI	2013	486	Latent tuberculosis infection
Alberta	Alberta MyHomeHealth Program	2011	23	CHF
Saskatchewan	Kelsey Trail Telehomecare Pilot Program	2009	NA	Hypertension, diabetes
Yukon	Yukon Telehomecare Mobile Data Project	2009	NA	NA
Ontario	Ontario Telehomecare Expansion Project	2010	2,000	CHF, COPD
	Black Creek Community Health Centre	2010	118	Diabetes
	University of Ottawa Heart Institute Regional Cardiac Program	2005	500	CHF, acute arrhythmia, complex cardiac surgery

Province	Program	Year Begun	# of Patients Enrolled	Primary Diagnoses
Quebec	Maisonneuve Rosemont Hospital Telehomecare Program (Montreal RUIS)	2011 (Dec)	120	CHF, COPD, diabetes, hypertension
	CSSS Desjardins Roussillon Telehomecare Program (Montreal RUIS)	2011 (Dec)	100	COPD
	Hospital Center Univ. of Montreal (CHUM) – High Risk Pregnancy (Montreal RUIS)	2013	44	High Risk Pregnancy
	Hospital Center Univ. of Montreal (CHUM) – Diabetes Clinic (Montreal RUIS)	2013	33	Diabetes
	Ste-Justine Hospital – Cystic Fibrosis Clinic (Montreal RUIS)	2013	23	Cystic Fibrosis
	RLS de Champlain; RLS Pierre-Boucher; RLS Pierre-De-Saurel; CSSS Sud Lanaudière; CSSS Trois-Rivières; CSSS Laurentides; CSSS Laval (Montreal RUIS)	2013	479	COPD
	CSSS Vaudreuil Soulanges (McGill RUIS)	2013	38	COPD
	Ste-Mary's Hospital (McGill RUIS)	2013	209	High Risk Pregnancy
	Montreal University Hospital Center – Women Health Mission (McGill RUIS)	2013	193	High Risk Pregnancy
	7 CSSS within the Eastern Township region (Sherbrooke RUIS)	2013	200	COPD

Province	Program	Year Begun	# of Patients Enrolled	Primary Diagnoses
New Brunswick	VITAL Program	1998	NA	Cardiac surgery

Appendix C – International Examples

This Appendix contains eight examples of RPM initiatives from international jurisdictions. Each initiative contains a project description and scope, a summary of the main benefits realized to date and/or a discussion of critical success factors.

1. National Program for Telemedicine and Home Monitoring (Denmark)

Project description and scope

The National Telemedicine Program was initiated in 2007 and has developed a number of projects targeted at reducing the high volume of "revolving-door-hospitalizations". The most advanced project is the COPD and Diabetes Box where the patient is given a box containing monitoring equipment for reading and submission of medical data, as well as a built in video conferencing unit as an alternative to either (i) staying in hospital or (ii) being accompanied home/visited by a nurse who would perform the measurements that the COPD box enables the patient to do this themselves.

The learning from Denmark is that a successful roll-out is dependent on support from frontline practitioners, and that clinical evidence is key to getting their buy-in. Training, to support replication, is based on a "super-user" model where standard material and "train-the-trainer" courses are provided centrally, while training of frontline practitioners and patients is carried out locally.

Quality: Appropriate & Effective	Quality: Health Outcomes	Access	Productivity and Efficiency
► Support secured from frontline clinicians based on clinical evidence ► Training based on "super-user" model supports replication and uptake ► Combination of Telehealth and Telemedicine in one box	► Pro-active management of care with support for self-management ► More care provided in home settings	► Improved access to services in a home setting ► Access to professional (nurse) as required based on triage of clinical monitoring data. ► Avoidance of unnecessary ER attendances and acute bed stays	► Reduction in avoidable ED admissions ► Reduction in acute bed days

2. The SOPHIA Telecare Service (Germany)			
Project description and scope			
The SOPHIA is a fully operating service offering that has been commercially available in Germany since 2004. Their service provides social and remote Telecare monitoring support to older people living in their own home environment, including the management of age-related risks which might otherwise result in admission to a nursing home. SOPHIA is based on a franchise model where housing associations owns the relationship with the customer and pays a fixed fee to SOPHIA for the right to use the concept. Regional service organizations are now operating in Berlin, Franconia, Hessen, North Rhine-Westphalia and South Bavaria. The service is operated by a network of 24/7 service centres, owned and operated by the housing organizations, that aggregate information from the customers' technical equipment, respond to alarms, coordinate professional care givers and can organize on-demand support in relation to a wide spectrum of personal needs. For example, the service can provide help with daily shopping, repair services, escorts for medical appointments or offer peace of mind if customers simply want to chat. Customer surveys show the most appreciated of those services is the "godfather volunteer" – a dedicated contact person who knows the customer well and who calls them at least once a week to talk and check whether they need any kind of assistance. In addition to providing a sense of security and friendship to the customers, this network of volunteers has an important role in the quality assurance of the service as well as providing objective feedback on customer needs to support future development of the service.			
Quality: Appropriate & Effective	**Quality: Health Outcomes**	**Access**	**Productivity and Efficiency**
► Holistic service model where Telecare is an enabler rather than technology led ► Fully integrated with housing support services ► Effective use of volunteers which supports social inclusion and well-being ► Highly replicable business model	► Promotes on going care at home and prevents/delays admission to nursing homes – safety risks are managed through the 24/7 service centres ► Promotes social inclusion and well-being through the "godfather" volunteer model	► Improved access (24/7) to a range of practical and personal support services in a home setting supported by a network of volunteers	► Increase in length of tenancies by residents aged over 75 years with a reduction in nursing home admissions.

3. The North Yorkshire Telecare and Telehealth Service (UK)			
Project description and scope			
With a population of 800,000, North Yorkshire County Council (NYCC) the key driver for developing a Telecare service has been the need to find cost-efficient solutions to address the surge in demand caused by an ageing population (demographic projections indicate that from 2009 to 2020, the proportion of people aged over 65 will increase by 50%) and there will be a particularly marked increase in the number of patients with dementia (+54%). Non-elective Emergency Room admissions have also been increasing by 5-10% per year. A key success factor for NYCC is having four dedicated Telecare co-ordinators, who are responsible for ensuring processes and performance monitoring systems are in place, to assist Social Care Assessors and to raise awareness around Telecare among key stakeholders. An extensive training program covering NYCC staff, independent sector, third sector, health and social care as well as housing providers using demonstration cases to bring the content to life is an integrated element of the implementation. In addition to older people, Telecare is now provided to individuals with learning/intellectual disabilities. In 2010/11, the Telecare service was expanded to provide patients suffering from CHF and COPD with Telehealth monitoring and NYCC is continuing to work with local NHS commissioners to ensure that over the next 5 years, all clinical pathways are supported by some kind of remote care solution. Since 2010, up to 2,000 Telehealth units have been deployed enabling the provision of the service for up to 12,000 people.			
Quality: Appropriate & Effective	**Quality: Health Outcomes**	**Access**	**Productivity and Efficiency**
► Inclusive care at home model where the objective is for all patients to be considered for a remote care solution. ► Integrated service across social care, housing, not for profit sector, health ► Robust performance management processes are in place	► Promotes on going care at home and prevents/delays admission to nursing homes and avoidable acute admissions.	► Improved access through robust training and performance management processes – assessment for Telecare/ Telehealth is mandatory ► Single assessment approach for optimal remote care solution	► Telecare: 38-45% reduction in care costs. In year 1 NYCC saved over £1m that would have been spent on domiciliary or residential care ► Telehealth: 40% reduction in non-elective acute admissions ► 28% drop in ED admissions

4. Scotland 2006-2011 Telecare Development Program (UK)			
Project description and scope			
Projections for Scotland are characterized by a population age structure set to change markedly between 2006 and 2031. Over the next 10 years, the Scottish population aged over 75 years will increase over 25% and by 2030 it will increase by over 60%. In 2007-08, healthcare and social care expenditure for those over 65 was $7bn with two thirds going to hospitals and care homes. Moreover a third of the total spend was on emergency admissions symptomatic of a reactive system rather than a pro-active one focused on prevention and early intervention. The Scottish Government developed a 2006-11 Telecare Development Program to support through pump prime grant funding of $30m 32 Local Partnerships to develop and implement Telecare and system redesign and for the services to be sustainable, effective and relevant to the needs of users. Partnerships consisted of local authorities, housing associations and not for profit organizations. The guidance for funding supported the move towards convergence of Telecare and Telehealth. The services offered varied depending on the Partnerships involved and included 1. Personal pendent that can trigger an alarm or answer the phone. 2. Mobile assessment kits that can be quickly installed to monitor the user to determine their personal Telecare equipment needs. This included ruggedized alarms which use a SIM Card and can be fitted on a short-term basis in properties without a telephone landline. 3, A core package including neck or wrist pendants, passive infrared sensors and extreme temperature sensors. 4. An enhanced package including all the elements of core package above but also including fall, flood and gas detectors.			
Quality: Appropriate & Effective	**Quality: Health Outcomes**	**Access**	**Productivity and Efficiency**
► Tailored packages of care in response to individual assessed needs ► Government strategy to drive standardization, interoperability; stimulating smart procurement of new technologies, establishing service standards for these new technologies and encouraging collaborative working.	► Service users have reported a significant improvement in their quality of life. ► An independent review of the Telecare program in 2008 revealed that 74% of caregivers reported reduced stress.	► Support for staff training so all older people assessed as benefiting across health and social care could receive a Telecare service	► Cost savings estimated for the entire period 2006-11 following an external evaluation were: ► C$120m savings through cost avoidance. ► Break down was $12m from reduced acute bed days, $40m from reduced ER visits $60m from reduction in care home admissions

5. The ESOPPE Service (France)

Project description and scope

As with many other European countries, France is faced with an ageing population and falls are the number one cause of domestic accidents among Frances older people: 85% of falls occur in the over 65 age group and they result in 10,000 deaths each year. The ESOPPE services are an integrated Telecare service, funded via the regional social care budget, which is located in the Correze rural are of France. The district is characterized by a small population of 240,000 inhabitants. However, there are a higher proportion of older people than in the rest of France: 30% of Correze's population is composed of people over 60 years old, versus 23% in the whole of France.

The ESOPPE program is part of a long-term strategy sponsored by the Limousin regional authorities. It is also based on the 2006-2011 healthcare plan, which states as an objective that every person aged 75 years and over should be entitled to access Telecare and alarm services in their homes – the target to be achieved by the end of 2014 is to equip 3,200 homes in Correze with the "home automation pack". The solution "home automation pack" is installed in the home of an older person assessed as being at risk of falling. The pack consists of a series of technology solutions including a remote intercom, an electronic bracelet or pendent, a shower alarm, smoke and gas detectors, activity/movement detectors and sensors, a Telecare centre and a photophone.

Quality: Appropriate & Effective	Quality: Health Outcomes	Access	Productivity and Efficiency
► Excellent technology acceptability – accepted by over 97% of the population	► Improved mood of older people: 26% fall in the number of older people suffering from depression	► Explicit commitment that every person aged 75 years and over should be entitled to access Telecare and alarms in their own homes	► # of falls and hospitalizations due to falls in the home decreased : reduction in falls by a factor of 1.6 and reduction in the number of hospitalizations by a factor 2.6 ► 5% reduction in the number of emergency calls to caregivers

6. VieDome Total Community Platform (The Netherlands)			
Project description and scope			
The Netherlands like most developed countries has a looming demographic challenge consisting simultaneously of an increase in the proportion of older people over retirement age who live longer than ever before, coupled with a relatively smaller working age population. The VieDome solution (supplied by Mextal) currently provides up to 123 product and service types, ranging from infrastructures, TV touch screen, PC, mobile, sensor, cameras etc. as well as appropriate software and content. VieDome is broadly applicable in houses as well as in care homes and is different in many ways from other domestic systems. The solution has a modular set-up and can therefore be customized completely as desired. VieDome Community as a part of the VieDome platform is a community platform specially designed for each individual municipality or local society. The model upon which the solution was created is aimed at covering eight pillars of independent living, namely: care, comfort, security, information, advice, communication, entertainment and commerce. The independent living services offered involve not only the relationship between the user and the service provider but also a relationship between users themselves.			
Quality: Appropriate & Effective	**Quality: Health Outcomes**	**Access**	**Productivity and Efficiency**
► Tailored technology packages for individual users and communities	► Improved mental well-being through use of social media and developing relationships between users	► Accessed via person budgets issued by the social health insurance scheme and can be directly purchased from retailers	► Reduction in home care costs by providing a highly cost effective platform ► Reductions in nursing home admissions

7. Telecare and remote monitoring solution – TESSAN (Italy)			
Project description and scope			
The Providing services to more than 24,000 households, the Veneto region in Italy has led the way in Italy to integrate health and social care services and to the large scale introduction of assistive and Telecare technology. The initiative began in 1987 with the introduction of telemonitoring and alarm systems with a response centre and intervention to the patient's home within 20 minutes. In 1997 that was subsequently extended to create "Famiglia Sicura" (Safe Family) program, by optimizing, linking and integrating the total support network – public sector health and social services, housing and benefits, independent and charity sectors, family members – supported in a standard service with twice-weekly calls from the Response Centre. In 2003, the third phase started and the service expanded to address specific disease management with projects for telecardiology and hypertension management with trans-telephonic electrocardiographs and blood pressure measurement provided for patients. Most recently, in 2005, the service was extended again to complete sets of assistive and biomedical technologies for prevention and monitoring services, especially for age-related pathologies. Since 2009, the region has procured through TESSAN, a service for teleassistance and remote monitoring of basic vital parameters ensuring for five years the capability to reach everyday a total of 25,000 users. The main service modules are: 1. Teleassistance – periodic web and telephone checks to monitor psycho-social state and identify appropriate interventions. 2. Telealarm (TSO): based on a device with a button which when activated sends an alert and emergency assistance is provided. 3. Telemonitoring which allows remote monitoring of vital signs			
Quality: Appropriate & Effective	**Quality: Health Outcomes**	**Access**	**Productivity and Efficiency**
► Very high rates of customer satisfaction (90% +) for all 3 services	► Improved mental well-being through use of Teleassistance	► Accessed via single gateway across health and social care with deployment of tailored combination of each or all of the three services	► Reduction in waiting times and avoidable Emergency Room admissions ► Elongation of care at home delaying nursing home admissions

8. Whole System Demonstrator Program (UK)

Project description and scope

The Whole System Demonstrator (WSD) program was launched in May 2008. It is the largest randomised control trial of Telehealth and Telecare in the world, involving 6191 patients and 238 GP practices across three Whole System Demonstrator Program sites in England: Newham, Kent and Cornwall. Its purpose was to establish "a clear evidence base to support important investment decisions and show how technology supports people to live independently, take control and be responsible for their own health and care." Three thousand and thirty people with one of three conditions (diabetes, heart failure and COPD) were included in the Telehealth trial. The study was set up in such a way that there was at least 12 months data on all participants by the end of September 2010.

Evaluation of the data from the program has been undertaken by six of the major academic institutions in the UK - City University London, University of Oxford, University of Manchester, Nuffield Trust, Imperial College London and London School of Economics. The study looked at the data under five themes (service utilisation, participant reported outcomes such as quality of life; cost effectiveness; user and professionals experience; and influence of organisational factors to adoption)

The early findings are very positive, with:

• 45% reduction in mortality rates

• 20% reduction in emergency admissions

• 15% reduction in ED visits

• 14% reduction in elective admissions

• 14% reduction in bed days

• 8% reduction in tariff costs

These early findings will be followed up by the peer review for the Telehealth results, and the findings from the Telecare element of the trial. Some of the WSD findings were less positive in relation to health outcomes. Second generation, home based Telehealth as implemented in the WSD Evaluation was not effective or efficacious compared with usual care only. Telehealth did not improve quality of life or psychological outcomes for patients with chronic obstructive pulmonary disease, diabetes, or heart failure over 12 months. The key lessons emerging from the experiences of the 12 WSD sites point to a number of areas that need to be addressed for the successful adoption of Telehealth and Telecare at scale in a local health economy:

Undertaking fundamental service redesign. The logic of Telehealth rests on the principle that enrolled patients can be monitored remotely and visits can be targeted. It will not be possible to scale up Telehealth services without increasing individual caseloads, and individual caseloads cannot increase unless professionals are prepared to work differently.

Ensuring that technology meets service needs. Some sites procured equipment from vendors (or were given equipment) before undertaking any structured analysis about how they wished to redesign care services. Neglecting the analysis and design phases often leads to a costly waste of resources, with equipment procured being either underused or not used at all. Interoperability and connectivity problems (both technical and service aspects) severely restrict the potential to provide seamless integrated care to patients and users.

Applying and developing quality standards. Applying standards to data and information that are generated, and the procurement and interoperability of technologies, should be a key feature of future Telecare and Telehealth programs.

Encouraging decision-making based on available data and evidence. Given the limitations of the evidence, health and social care teams need to learn from experience when developing new services through continuous monitoring and quality improvement processes. Using data and evidence collected from sites currently deploying new technologies can help to open up a variety of solutions and approaches that might otherwise remain hidden.

Developing an integrated governance structure. As Telecare and Telehealth services grow in the future – and as more people benefit from them – there needs to be a governance structure that ensures each program's goals are achieved. This needs to be integrated, involving all stakeholders, with a clear remit to meet the needs of users and patients.

Quality: Appropriate & Effective	**Quality: Health Outcomes**	**Access**	**Productivity and Efficiency**
► High rates of customer uptake, acceptance and satisfaction	► 45% reduction in mortality rates	► Accessed to Telehealth and Telecare via single gateway across health and social care	► 20% reduction in emergency admissions ► 15% reduction in ER visits ► 14% reduction in elective admissions ► 14% reduction in bed days ► 8% reduction in tariff costs

Appendix D – Case Benefit Analysis

 # Patients for sustainability "Break-Even" =
Solution costs ÷ Savings / patient
(where Savings = ∑Δ in hospital utilization costs)

1. Per-capita utilization data for pre- and post-implementation was annualized
2. ED and hospital bed day (LOS) costs were derived from the 2005/06 CIHI cost survey and 2012 Patient cost estimator, respectively.
3. Savings were derived from the difference between pre- and post-implementation total costs (ED + LOS)

National Statistics

These variables were used in the cost/benefit analysis for assessing healthcare utilization costs:

	CHF	COPD
ED Visit Cost	$150	$150
IP Cases	38,564	61,001
IP Cost	$6,687	$6,335
ALOS	7.3	6.7
Avg IP Cost/Day	$918	$952

Source: CIHI Patient Cost Estimator, 2012; CIHI ED cost survey; 2005/06

- Savings were derived from the difference between pre- and post-implementation total costs (ED + LOS)

Cost/Benefit Calculations

The following cost/benefit calculations are based on provider-led evaluations of RPM programs. The year of the evaluation is stated in brackets.

	BreatheWELL (2012)			OTN (2011)			UOHI (2008)			JRHC (2011)		
Study statistics	**Pre**	**Post**	**%Δ**	**Pre**	**Post**	**%Δ**	**Pre**	**Post**	**%Δ**	**Pre**	**Post**	**%Δ**
Patients	297	297		129	98		121	121		95	95	
Months	12	12		6	6		3	3		12	12*	
ED visits/pt/yr	1.3	0.3	-75%	2.8	1.6	-42%	NA	NA		1.0	0.6	-34%
LOS/pt/yr	17.1	5.0	-71%	18.3	4.8	-74%	15.0	10.8	-28%	13.5	2.6	-81%
ED costs	$200	$50		$419	$242		NA	NA		$144	$95	
LOS costs	$16,121	$4,699		$17,052	$4,440		$13,740	$9,893		$12,556	$2,383	
Total cost	**$16,321**	**$4,749**	**-71%**	**$17,470**	**$4,681**	**-73%**	**$13,740**	**$9,893**	**-28%**	**$12,700**	**$2,477**	**-80%**
Savings/pt/yr	**$11,572**			**$12,789**			**$3,847**			**$10,223**		

* Post-study includes 4 months per-implementation and 8 months extrapolated post-study discharge data

Operating Costs	**BreatheWELL**	**OTN**	**OHI**	**JRHC**
Capacity (patients/yr)**	300	2000	475	200
One-time costs****	$570,000	$2,300,000	$820,000	$600,000
Ongoing operating costs	$1,800,000	$4,100,000	$400,000	$600,000
Patients to Break Even***	**156**	**321**	**104**	**59**
% of current capacity	52%	16%	22%	29%
Total Net Savings @ capacity	**$1,671,573**	**$21,478,000**	**$1,427,475**	**$1,444,574**

** Using data from most recent year of operation

*** Based on ongoing operating costs

**** Incurred the year of program establishment, as well as other one-time fees to present (e.g. equipment purchases to get to current scale)

Appendix E – Literature Review

Clarifying Remote Patient Monitoring

Remote patient monitoring (RPM) is a relatively new care delivery enabler. In the context of this analysis, RPM refers to the range of information and communication technologies (ICTs) that record and transmit patients' physiological data e.g. blood pressure, weight, respiratory rate, pulse oximetry and other data to a secured database for retrieval and analysis by a clinician in addition to other enabling platforms and care supports. The focus of this work is on non-invasive (not-implanted) technologies with varying degrees of wireless capabilities, alert automation, electronic medical record (EMR) integration, analytics capabilities, and clinical monitoring patterns.

RPM is an emerging area of medical technology and research with applications in chronic care, palliative care, mental health, geriatric care, and wound care.[35] Telehomecare, Telehealth and Telemonitoring are common, at times overlapping areas of remote patient monitoring. Typically, Telehealth refers to initiatives involving devices capable of remote data exchange between a patient and healthcare professionals to enable diagnoses or management of patient conditions. Telecare (including Telehomecare) generally refers to remote monitoring of an individual's environment or condition, supporting efforts to keep patients in their homes and greater degrees of self-care through remote sensing technologies.[36]

Given wireless technology's rapid expansion, defining boundaries for this study is important. Beyond the scope of this evaluation are initiatives, studies or programs related to exclusive use of telemedicine (video interface between patient and specialist), structured telephone support (STS), Telehealth as it relates to telephone or cellular phone-based exchanges with clinicians for diagnostic support, and other web-enabled platforms for communicating health information.[37]

Introduction

RPM literature examined for this evaluation identifies a promising, but uneven record of benefit realization. As described below, RPM has produced generally favorable outcomes for patients suffering from a variety of chronic conditions such as chronic obstructive pulmonary disorder (COPD), congestive heart failure (CHF), diabetes, hypertension and asthma. Compared to usual care, RPM interventions generate consistent quality and productivity benefits including:

[35] G. Clifford and D. Clifton. 2012. Wireless technology in disease management and medicine. Annu. Rev. Med. 63:479–92; Gaikwad R, Warren J: The role of home-based information and communications technology interventions in chronic disease management: a systematic literature review. Health informatics journal 2009, 15:122-146.

[36] These include sensors designed to monitor and detect falls, daily routines, sleep patterns, and environmental changes in one's home. Bower P, Cartwright M, Hirani SP, Barlow J, Hendy J, Knapp M, Henderson C, Rogers A, Sanders C, Bardsley M, et al.: A comprehensive evaluation of the impact of telemonitoring in patients with long-term conditions and social care needs: protocol for the Whole Systems Demonstrator cluster randomised trial.
BMC Heal Serv Res 2011, 11(184)

[37] Video and telephone technologies do, however, accompany various RPM initiatives and are including in this survey. We exclude studies that focus solely on those technologies because they were covered in previous Infoway evaluations.

- Reductions in secondary (acute) healthcare utilization
- Improvements in surrogate outcome measures such as blood pressure and glycemic levels
- Reductions in mortality rates

The table below captures the high level findings in relationship to Infoway's benefits evaluation framework and initial hypotheses.

Table 6: Benefits evaluation framework, hypotheses and high level findings

Benefit area	Benefit sub-area	Initial hypothesis	Findings from literature for RPM interventions compared to usual care
Quality	Appropriateness/ effectiveness	► ↑ patient satisfaction ► ↓ utilization (ER visits/hospitalization)	► Limited evidence; inconsistent methods[38] ► Consistent reductions in ER visits and hospitalizations for CHF and COPD indicated
	Health Outcomes	► ↓ all-cause mortality ► ↑ quality of life	► Consistent reductions in all-cause mortality in CHF shown; less compelling evidence for COPD ► Some indication of QoL improvements found; inconsistent methods
Access	Ability of patients/providers to access services	► ↑ Access to specialists ► ↑ dissemination of health data	► No findings ► No findings
	Patient and caregiver participation	► ↓ Caregiver burden	► No findings
Productivity	Efficiency	► ↓ per client care time ► ↑ Promotion of integrated care between formal and informal networks ► ↓ per capita health expenses	► No findings ► No findings ► Cost effectiveness in QALY evidence mixed.

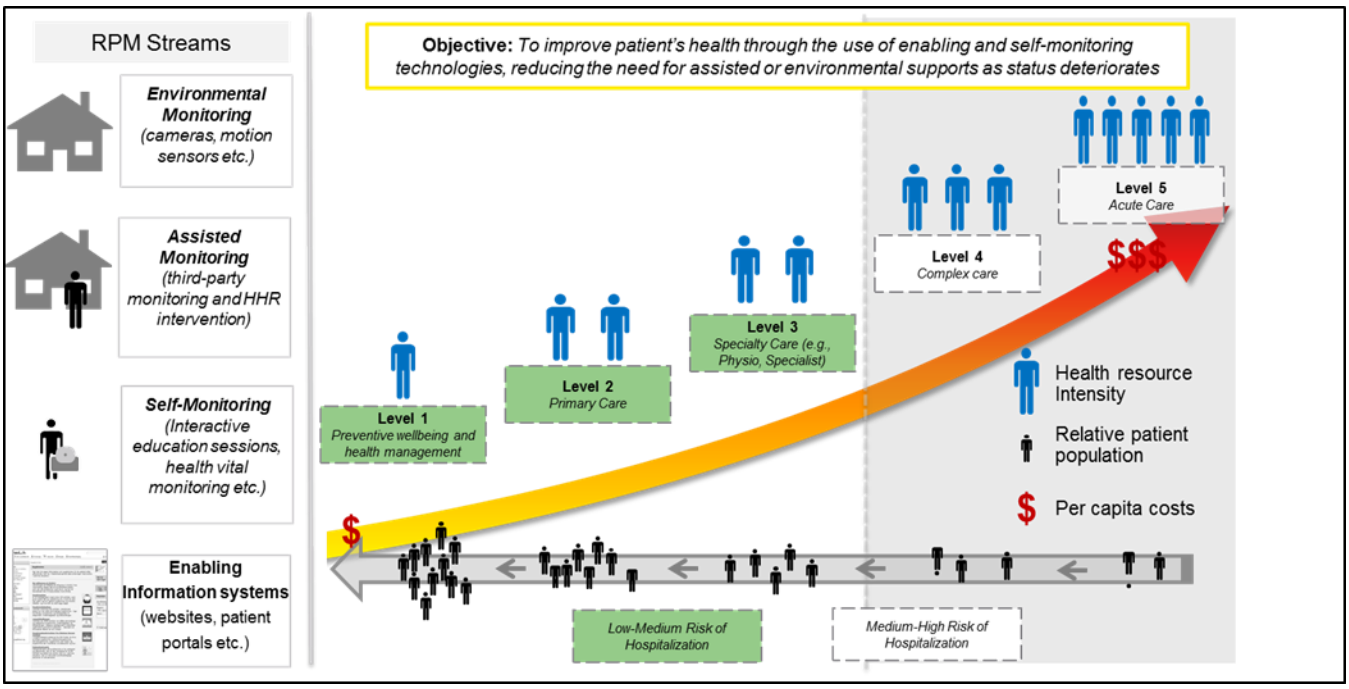
[38] Kraai, I. H., Luttik, M. L. A., de Jong, R. M., Jaarsma, T., & Hillege, H. L. (2011). Heart failure patients monitored with telemedicine: patient satisfaction, a review of the literature. *Journal of Cardiac Failure*, 17(8), 684-690.

Although the findings of this survey trend positive, there are limitations. The magnitudes of the reported benefits vary substantially and are at times equivocal. Compared to usual care, RPM interventions consistently reduced hospital admissions and emergency room visits for patients with CHF and COPD in a majority of the meta-analyses reviewed, but the size of the reductions varied widely. Further, impacts on quality of life and cost-effectiveness are not consistent and vary across study, patient population, and technology used.

This survey reviews RPM studies in the medical literature with an emphasis on recent (since 2008) meta-analyses. EY worked with Canada Health Infoway to identify relevant studies using a range of academic databases and search criteria. We rely relied on meta-analyses, systematic reviews of peer reviewed RPM trials, and meta-reviews (reviews of reviews) that use established quality control frameworks, but also engaged with recent, large-scale RCTs such as the UK's Whole System Demonstrator where relevant. RPM remains a maturing area of medical science. Although definitions, patient populations, outcome measures and evaluation quality vary widely in the literature, the cumulative benefits story of recent remote patient monitoring interventions for chronic disease patients is encouraging.

As the graphic below indicates, we expect benefits will be realized as patients exit acute and complex care facilities, enabling them to return home sooner and to stay out of hospital longer.

Figure 4: RPM across levels of care



Patients with chronic conditions consume a larger proportion of Canadian healthcare resources than other patients: they are more likely to be readmitted to hospital within 30 days of initial discharge and more likely to return to emergency rooms within 7 days of last visit than their healthier counterparts.[39] RPM interventions for chronic care patients could help address these challenges.

Despite calls for alternative care models, peer reviewed RCTs of Canadian RPM initiatives are relatively rare. For instance, Pare et al 2010 reports 6% of 62 Telehealth-related studies included in their meta-analysis took place in Canada.[40] Nevertheless, RPM activity overall in Canada is expanding.[41] Mirroring RPM uptake and expansion patterns in the U.S. and Europe, Canadian RPM initiatives are slowly moving from a disparate collection of small pilot studies run through a range of health authorities to larger, province-wide programs. Given that the majority of peer-reviewed RPM initiatives are international, the case studies of RPM initiatives will help validate benefits identified below in the Canadian context.

[39] Canadian Institute for Health Information. 2012. *All-Cause Readmission to Acute Care and Return to the Emergency Department*. 1-64. Accessed on 19 November 2013. https://secure.cihi.ca/free_products/Readmission_to_acutecare_en.pdf
[40] 79% of studies reviewed came from the U.S. (46%) or Europe. Paré, G., Moqadem, K., Pineau, G., & St-Hilaire, C. (2010). Clinical effects of home telemonitoring in the context of diabetes, asthma, heart failure and hypertension: a systematic review. *Journal of medical Internet research*, 12(2). Table 2.
[41] See Coach Report 2013. Accessed on November 19, 2013 http://www.coachorg.com/en/resourcecentre/Telehealth_Report.asp

RPM literature selection

Literature reviewed to inform this study was gathered in collaboration with Infoway. Infoway identified 15 meta-analyses of RPM by searching their Virtual Library, Pubmed, Cochrane Database of Systematic Reviews, and general internet searches using the following terms: Telehomecare, home Telehealth, patient monitoring, mobile health (mHealth), and remote monitoring. EY augmented this scan through Google Scholar and Pubmed's indexing function using the additional terms: remote patient monitoring, remote monitoring system, and chronic disease monitoring. This process yielded five additional meta-analyses or meta-reviews related to RPM. The time period selected for both search processes was 2007 – 2013 inclusive.

This review is organized into five sections. The first two examine RPM benefits related to heart failure and other chronic conditions. Then we review the UK's Whole System Demonstrator Project, one of the largest, multi-site RPM implementations in the world. The last section discusses some of the key lessons extracted from the RPM literature review.

RPM and heart failure

Reviews of RPM interventions to support post-discharge heart failure patients are prominent in the literature. Conway et al 2013's meta-review of heart failure RPM excludes trials or studies involving any additional home-based supports such as visitation by clinical professionals for the purposes of coaching, education or clinical assessment, focusing only on RPM interventions.[42] The meta-review design, therefore, offers a glimpse into the benefits associated with RPM for heart failure patients independent of additional factors. Conway et al 2013 also weight by quality the meta-analyses reviewed. Key findings in the highest quality meta-analysis appear in the table below.

[42] Conway et al 2013 uses AMSTAR, Revised Assessment of Multiple Systematic Reviews, a quality review framework similar to PRISMA for meta-analyses, to evaluate the quality of the 17 RPM meta-analyses included in the review. Thus, the authors do distinguish between high quality and poor quality systematic reviews with meta-analysis and without meta-analysis based on AMSTAR criteria and separate reporting by high quality vs. low quality reviews. Many of the RPM meta-analyses reviewed included both telemonitoring and structured telephone support (STS). Conway et al 2013 found the relative risk of patient mortality for all RPM treated patients ranged from 0.53 to 0.88. The reductions in the relative risk range of all-cause mortality was slightly wider (0.52 to 0.96) and hospitalization due to heart failure ranged from 0.72 to 0.79.

Table 7: (Reproduced from Conway et al 2013) Findings from Top Quality RPM meta-analyses

Author (year)	Number of studies	Participants	Intervention	Authors' conclusions
Clark (2007)	14 RCTs	4,264	► Telemonitoring (TM) ► Structured Telephone Support (STS)	► Reduced CHR-related admissions and all-cause mortality ► Mixed results for QoL and costs
Inglis (2010)	25 RCTs in total (16 in STS and 11 in telemonitoring)	5,613 STS 2,710 Telemonitoring	► TM ► STS	► STS and telemonitoring effective in reducing risk of all-cause mortality and CHF-related hospitalizations ► Improves QoL, reduces costs and evidence-based prescribing
Polisena (2010)	21 studies included 8 RCTs telemonitoring vs. usual care; 4 telemonitoring, STS, usual care; 9 cohort)	3082	► TM ► STS	► Reduced mortality (6 studies) ► Reduced hospitalizations (4 studies)
Klersy (2011)	21 RCTs	5715	► TM (includes data from invasive technologies) ► STS	► Remote-monitoring reduces costs compared with usual care
Lee (2010)	10 RCTs	2148	► Only included telephone-based post discharge nursing care	► 4 studies included in meta-analysis at 3 and 6 months follow-up ► 5 studies included in meta-analysis at 12 months follow-up ► Intervention decreases readmissions
Klersy (2011)	20 RCTs 10 cohort studies	6258 in RCTs 2354 in cohort studies	► Telemonitoring (includes data from invasive technologies) ► STS	► Significant protective clinical effect ► Decrease in events greater in cohort ► studies than RCTs

Conway et al 2013 note that the high quality reviews of RPM are promising in mortality and hospitalization. More specifically, after pooling results from only the high quality meta-analyses they estimated reductions in risk ratios[43] for the following outcomes:

- all-cause mortality for all RPM treated patients ranged from 0.53 to 0.88
- hospitalization due to heart failure ranged from 0.72 to 0.79.
- all-cause hospitalization ranged from 0.52 to 0.96

Beyond these outcomes, measurement limitations make drawing clear conclusions in RPM heart failure space difficult. RPM reduced the risk of heart failure-related hospitalizations more than it did for all-cause hospitalizations, but it is unclear why. Although four systematic reviews reported statistically significant quality of life improvements associated with RPM, no meta-analyses examined quality of life.[44]

RPM with medical supports also showed beneficial trends, but are not conclusive. Focusing on recently discharged (< 28 days) HF patients across roughly 21 RCTs with roughly 6,300 patients receiving home telemonitoring with medical supports during office hours or 24/7 STS support, Pandor et al 2013 report equivocal findings on all-cause mortality, noting that no effect was found for human-to-machine based support cohorts. Human-to-human RPM reduced all-cause mortality risk, but the findings were statistically significant only after removal of an RCT that had unusually high control arm patient outcomes. In direct conflict with Conway et al 2013's findings, RPM with medical supports reduced the risk of all-cause hospitalization more than it did for heart failure-related hospitalizations. The most promising findings were around reductions in mortality for STS in conjunction with medical supports provided during primary care office hours, but the results were "statistically inconclusive".[45]

The RPM technology employed and study size can also affect benefits in heart failure studies. For instance, Chaudhry et al 2010 and Koehler et al 2011 found no observable impact associated with types of monitoring that required participants to measure, record and key-in vital signs information into a telephone.[46] In addition to the type of technology involved, RPM studies that have found negligible or negative effects are often product of smaller pilots rather than larger RCTs, a challenge we address by examine findings around the UK's Whole System Demonstrator Project.[47]

RPM and other conditions

43 Risk ratios estimate the chance of a particular outcome (mortality or hospitalization for example) relative to usual care. A risk ratio (also known as relative risk) of 1 indicates no effect of the intervention between treatment and control groups. At the lower bound of all-cause mortality (relative risk of 0.53), RPM treated patients were nearly twice as likely not to die during the trial period than were patients in the control arm.

[44] Clark 2007; Inglis 2010; Polisena 2010; Maric B, Kaan A, Ignaszewski A, Lear SA. A systematic review of telemonitoring technologies in heart failure. *Eur J Heart Fail* 2009;11:506–17.

[45] Pandor, A., Thokala, P., Gomersall, T., Baalbaki, H., Stevens, J., Wang, J., ... & Fitzgerald, P. (2013). Home telemonitoring or structured telephone support programmes after recent discharge in patients with heart failure: systematic review and economic evaluation. *Health Technol Assess*, 17.

[46] Chaudhry SI, Mattera JA, Curtis JP, et al. Telemonitoring in patients with heart failure. *N Engl J Med* 2010;363:2301–9.Koehler F, Winkler S, Schieber M, et al. Impact of remote telemedical management on mortality and hospitalizations in ambulatory patients with chronic heart failure: the telemedical interventional monitoring in heart failure study. *Circulation* 2011;123:1873–80. Note: these studies were not included in Conway et al 2013's meta-review, but they are mentioned in the discussion.

[47] Steventon A ,Bardsley M ,Billings J ,Dixon J ,Doll H ,Hirani S ,et al. (2012) Effect of telehealth on use of secondary care and mortality: findings from the Whole System Demonstrator cluster randomised trial. *BMJ*;344:e3874

Although RPM's effect on heart failure patients' health is one of the most commonly studied applications of RPM, numerous studies of RPM on other chronic conditions such as COPD, diabetes, and hypertension have also been conducted.[48]

COPD

Meta-analysis findings in the benefit areas related to COPD are mixed. They report consistent reductions in hospitalization rates and ER visits for a range of RPM interventions, but found conflicting evidence around length of stay and no clear benefit in terms of quality of life or mortality.[49] For example, McClean et al 2012 pool results from four COPD studies and use a random effects model to estimate that the chance of hospitalization within 12 months is nearly double for those in the control group (odds ratio of 0.46 (95% CI 0.33 to 0.65)).[50] McClean et al 2012 also calculate significantly better outcomes for RPM treated COPD patients in terms of ER visits, estimating an odds ratio of 0.27 (95% CI 0.11 to 0.66).

Mortality and length of stay patterns were not different between the intervention and control groups across the studies surveyed. Sciotte et al 2011 found, however, that telemonitoring empowered both patients and care providers. Patients' demonstrated improved self-management and favorable disposition toward telehomecare; providers attitudes toward telemonitoring were also positive.[51] Heterogeneous patient populations, lack of a standardized definition of "usual care", lack of clarity on accompanying care supports such as education and coaching, inconsistent outcome measures and limited attention to cost-effectiveness were challenges identified across the reviews.

[48] Omboni S, Gazzola T; Carabelli, G; Parati, G. Clinical usefulness and cost effectiveness of home blood pressure telemonitoring: meta-analysis of randomized controlled studies. *J Hypertens*. 31(3):455-67. See also Omboni S, Guarda A (2011). Impact of home blood pressure telemonitoring and blood pressure control: a meta-analysis of randomized controlled studies. *Am J Hypertens.* 24(9):989-98.

[49] Polisena J et al. 2010. Home telehealth for chronic obstructive pulmonary disease: a systematic review and meta-analysis. *J Telemed Telecare*. 16: 120. An error in the risk ratio calculation around mortality later uncovered that mortality rates were in fact better (lower) for the intervention group in one of the studies, which would affect Polisena et al 2010's findings. See McLean, S. C., & McKinstry, B. (2012). Meta-analysis on COPD: Comment on 'Home telehealth for chronic obstructive pulmonary disease: a systematic review and meta-analysis. by J Polisena et al.'. *Journal of Telemedicine and Telecare*, 18(4), 242-242; McLean, S., Nurmatov, U., Liu, J. L., Pagliari, C., Car, J., & Sheikh, A. (2012). Telehealthcare for chronic obstructive pulmonary disease: Cochrane Review and meta-analysis. *British Journal of General Practice*, 62(604), e739-e749.

[50] In an earlier study, Pare et al 2006 report a mean number of all-cause hospitalizations of 0.10 versus 0.60 for usual care ($p<0.05$). Pare G, Sicotte C, St-Jules D, Gauthier R. Cost-minimization analysis of a telehomecare program for patients with chronic obstructive pulmonary disease. *Telemed J E Health*. 2006 Apr;12(2):114–21.

[51] The authors also found mixed results for length of stay and mortality. Sicotte, C., Pare, G., Morin, S., Potvin, J., & Moreault, M. P. (2011). Effects of home telemonitoring to support improved care for chronic obstructive pulmonary diseases. Telemedicine and e-Health, 17(2), 95-103.

Diabetes

Diabetes care supported by RPM initiatives has also shown somewhat mixed benefits depending on a number of factors. Polisena et al 2009 reviewed 26 studies covering 5069 patients.[52] The studies focusing on home telemonitoring (as opposed to telephone support) found reductions in glycaemic measures compared with usual care. Paré et al 2010 identified similar benefits in the two large RCT telemonitoring programs they reviewed, including improved glycemic control and blood pressure.[53] Consistent with findings across other chronic conditions, RPM interventions associated with diabetes care reduced hospital admissions and length of stay (bed days of care), but did not perform better than usual care in terms of improving quality of life or patient satisfaction.

Asthma

Support for asthma relief through RPM interventions have demonstrated benefits compared to usual care. Pare et al 2010 reports statistically significant findings in 7 of 8 RCTs they reviewed in favour of RPM initiatives. In one large RCT performed in Denmark, the internet-based RPM reduced asthma symptoms more than monitoring by a specialist and GP and reported better quality of life.[54]

Multiple Chronic Conditions

RPM interventions covering a range of chronic conditions (as opposed to single diseases) have also been the subject of analysis and review. Gaikwad and Warren 2009 reviewed 27 studies of a variety of home-based telemonitoring for patients with various chronic conditions, finding that home-based information and communication technologies (HBIs) can improve "functional and cognitive patient outcomes and reduce healthcare spending", but additional research into patient outcomes and sustainability is needed.[55] Paré et al 2010 also observed benefits in surrogate outcome measures such as reductions in systolic and/or diastolic blood pressure and improved antihypertensive medication adherence for RPM participants.[56] Despite finding improvements in a range of patient outcomes and reductions in healthcare spending, authors consistently indicated that further research is need to determine whether the benefits identified are sustainable.[57]

[52] Polisena, J., Tran, K., Cimon, K., Hutton, B., McGill, S., & Palmer, K. (2009). Home telehealth for diabetes management: a systematic review and meta-analysis. *Diabetes, Obesity and Metabolism*, 11(10), 913-930.
[53] Both the large RCTs reviewed included coaching and educational support, either through recorded messages played over the telephone or via an educational website established for the project to support patient care. The authors note that the findings may not be generalizable beyond patients suffering from insulin-dependent diabetes mellitus (IDDM), who were the largest participants in the diabetes studies. Paré, G., Moqadem, K., Pineau, G., & St-Hilaire, C. (2010). Clinical effects of home telemonitoring in the context of diabetes, asthma, heart failure and hypertension: a systematic review. *Journal of medical Internet research*, 12(2).
[54] See Rasmussen, L. M., Phanareth, K., Nolte, H., & Backer, V. (2005). Internet-based monitoring of asthma: a long-term, randomized clinical study of 300 asthmatic subjects. *Journal of Allergy and Clinical Immunology*, 115(6), 1137-1142.
[55] Gaikwad, R., & Warren, J. (2009). The role of home-based information and communications technology interventions in chronic disease management: a systematic literature review. *Health informatics journal*, 15(2), 122-146.
[56] Artinian NT, Flack JM, Nordstrom CK, Hockman EM, Washington OG, Jen KL, Fathy M. (2007). Effects of nurse-managed telemonitoring on blood pressure at 12-month follow-up among urban African Americans.
Nurs Res. Sep-Oct; 56(5):312-22.
[57] Gaikwad and Warren 2009

UK Whole System Demonstrator Project

Although benefits in the quality, access and productivity space have been identified across disease types and technological solutions, large-scale, evidence-based benefits evaluations have been limited due to the proliferation of smaller pilots, variability RPM solutions, and the limited number of any broad-based RPM interventions. The UK's Whole System Demonstrator Project, initiated in 2006 by the Department of Health, developed a series of large-scale RCTs designed to measure the effect of a range of Telehealth and Telecare technologies for patients managing COPD, heart failure or diabetes. In the Telehealth trial, over 15,000 eligible patients at three sites (Cornwall, Kent and Newham in east London) were identified, and over 3,000 were subsequently randomized into intervention or control groups following an initial at-home needs assessment.[58] Patients in the Telehealth trial self-monitored, recorded and transmitted their pulse oximetry, glucose levels, and weight to a monitoring centre staffed by specialist nurses and community "matrons", responsible for customizing responses based on data transmitted.[59] Telecare patients received in-home sensors capable of detecting changes in gas levels, water overflow and movement (including falls). The project also included electronic exchanges inquiring about patients' symptoms or educational guidance. Although the project design randomized patients into treatment and control groups across technology types and site locations, it was not designed to assess differences in clinical outcomes based on device types or monitoring technology employed.

Benefits in the WSD were shown around patient outcomes, but were generally not cost-effective. On the outcomes side, the intervention group was admitted to hospital at a lower rate (0.54 admissions per head vs. 0.68), stayed in hospital a shorter amount of time (mean bed days per head 4.87 vs 5.68) and demonstrated a lower overall mortality rate (4.6% vs. 8.3%) than the control group.[60] Separate cost-effectiveness analysis reveals that excluding direct intervention costs, costs in the treatment group were on average 12% lower than the control group, but based on estimates around willingness to pay for additional quality adjusted life year (QALY), Telehealth in the WSDS was not cost effective relative to usual care under most modelling scenarios.[61] Further, no differences were found in primary care utilization rates, reported quality of life, psychological well-being between the participants in the study arms.[62]

[58] Eligibility required an "at risk" assessment for independent living in addition to suffering from diabetes, COPD, or HF. Patients randomized into control groups were given the option of telehealth or telecare following the 12-month study period following a re-assessment.

[59] The number and type of devices varied and were based on the initial needs assessment.

[60] Steventon, A., Bardsley, M., Billings, J., Dixon, J., Doll, H., Hirani, S., ... & Newman, S. (2012). Effect of telehealth on use of secondary care and mortality: findings from the Whole System Demonstrator cluster randomised trial. *BMJ*, 344.

[61] Cost-effectiveness sensitivity scenarios included reductions in technology costs by 50% and 80% and variation in utilization measures of health professionals here refers to a willingness to pay likelihood per Quality Adjusted Life Year (QALY) above 50%. Henderson, C., Knapp, M., Fernández, J. L., Beecham, J., Hirani, S. P., Cartwright, M., ... & Newman, S. P. (2013). Cost effectiveness of telehealth for patients with long term conditions (Whole Systems Demonstrator telehealth questionnaire study): nested economic evaluation in a pragmatic, cluster randomised controlled trial. *BMJ*, 346. Cartwright, M., Hirani, S. P., Rixon, L., Beynon, M., Doll, H., Bower, P., ... & Newman, S. P. (2013). Whole Systems Demonstrator Evaluation Team Effect of telehealth on quality of life and psychological outcomes over 12 months (Whole Systems Demonstrator telehealth questionnaire study): nested study of patient reported outcomes in a pragmatic, cluster randomised controlled trial. *BMJ*, 346, f653.

[62] Bardsley, M., Steventon, A., & Doll, H. (2013). Impact of telehealth on general practice contacts: findings from the whole systems demonstrator cluster randomised trial. *BMC health services research*, 13(1), 395.

Customizing the approach

Innovations in the processing of health information and in patient recruitment may enhance a number of benefit areas reviewed. This section examines data analytics and patient recruitment improvement before moving into key takeaways from this survey.

Data analytics

Conventional approaches to RPM involve one of two processes. Either physiological data is remotely transmitted to a secure database for storage, processing and monitoring by healthcare professionals or (based on the same data flows) an automated system generates an alert if a patient's vital signs or environmental data fall outside a predetermined range, triggering a potential intervention designed to avoid readmission. In the WSD study, for instance, the core features of the intervention included: "store and forward systems, patient education protocols, computerised risk based classification of vital signs data, and central monitoring teams."[63] A burgeoning analytics-based approach combines the alert system (generally high, medium, and low) of conventional RPM systems with machine learning algorithms to identify alert patterns associated readmission. These models predict readmission based on statistical patterns of alert severity (high to low), recent history of alerts, weight gain and heart rate. Although only experimental results are currently available, analytics-based RPM models saved between 40% and 60% of total medical costs compared to conventional RPM, promising a potentially more cost effective and targeted intervention strategy in the years to come.[64]

[63] Ibid.
[64] Lee, S. I., Ghasemzadeh, H., Mortazavi, B., Lan, M., Alshurafa, N., Ong, M., & Sarrafzadeh, M. (2013). Remote Patient Monitoring: What Impact Can Data Analytics Have on Cost? *Wireless Health Conference 2013*, Nov 1-3, 2013 Baltimore MD. Accessed on 19 November 2013: http://cs.ucla.edu/~silee/pub/acm_wh_2013.pdf.

Recruitment and participation

Participant recruitment is a leading challenge to the success of smaller pilots and large-scale implementations alike.[65] Studies have identified a host of reasons that potential participants refused to join RPM studies. These include time constraints (too busy), difficulty with technology (too complicated), disbelief in capacity of technology to help or a preference for traditional care; evaluations and other studies in this area have reported up to an 80% refusal rate.[66] Perhaps the clearest understanding of why patients decline to participate comes from the UK's Whole System Demonstrator Project, which qualitatively investigated the motivational patterns of potential participants who declined to take part in the Project, but agreed to be interviewed about why they declined.[67]

Sanders et al 2012 finds that reasons potential participants used to explain their decision to opt out cluster around three main themes: overwhelming demands for technical competence, threats to personhood or independence, and service disruption concerns. Non-participants expressed concerns about introducing monitoring technology into their home because of what it would signify: "being very sick, very old or highly dependent." Although a minority of respondents suggested they were too old or frail for the program, most non-participants declined because they understood themselves to be too self-sufficient and independent for the Project.

> *I stood at my front door the other day and I thought, 'really, truly, this world's not for me now, it's too complicated,' … you don't speak to anybody now, you get buttons you push and press and, just a nightmare… - Non-participant in UK's Whole System Demonstrator Project*

The implications of these findings on patient recruitment and retention are threefold. First, threats to personal autonomy, lifestyle and identity by virtue of RPM participation need to be squarely addressed and must align closely with patients' understanding of their role in self-management. Second, the psychological impact of consistent health monitoring needs to be considered. Echoing earlier findings in this area, the more disruptive and invasive the monitoring, the bigger the barrier to uptake there is likely to be.[68] Third, setting very clear, but personalized guidelines around program participation is important. Clarity around patients' responsibilities, what program participation resource requirements (time and money), and minimizing disruptions in otherwise stable care relationships each support larger uptake efforts.[69]

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[65] May C, Finch TL, Cornford J, Exley C, Gately C, Kirk S, Jenkings KN, Osbourne J, Robinson AL, Rogers A, et al.: Integrating telecare for chronic disease management in the community: What needs to be done?
BMC Heal Serv Res 2011, 11(131):. In addition to the literature, key informant interviews revealed patient recruitment as an important challenge. Cheryl Beach and Susan May (need full sourcing).

[66] Sanders, C., Rogers, A., Bowen, R., Bower, P., Hirani, S., Cartwright, M. et al. (2012). Exploring barriers to participation and adoption of telehealth and telecare within the Whole System Demonstrator trial: a qualitative study. *BMC health services research*, 12(1), 220. On the refusal rate, see Subramanian, U., Hopp, F., Lowery, J., Woodbridge, P., & Smith, D. (2004). Research in home-care telemedicine: challenges in patient recruitment. *Telemedicine Journal & e-Health*, 10(2), 155-161.

[67] Roughly two-thirds (42 of 61) of those who declined to participate in the Whole System Demonstrator Project also declined to be formally interviewed, but they indicated their reasons for declining Project participation as illness or incapacitation (8 total), lack of understanding of the intervention or why they were invited to participate (8), and most indicated they simply did not need or want telehealth or telecare (11). Also listed were trial was too disruptive or personal reasons (going away or work). Sanders et al 2012.

[68] May C, Montori V, Mair F: We need minimally disruptive medicine. *Br Med J* 2009, 339:485-487

[69] Additionally, anxiety generated by routine health monitoring outweighed privacy concerns for most respondents. Also important to note, the authors indicate that due to the small sample size, more research in the area of intervention fit (customization), whom

Lessons

A number of lessons relevant for the future of RPM in Canada emerge from the literature.

Identifying the right patients and the right technologies is a major challenge Chaundry et al 2010 and Koehler et al 2011 found no benefit to the key-in telephony intervention they examined. The technology type seems to matter, but so does selecting the right patients. Patients with cognitive impairments or serious physical disabilities were typically excluded from the studies reviewed here. Patients with an expressed interest in self-managing their condition, patients with relatively more serious conditions, patients less apprehensive about involving technology in their care regimen comprised the largest user groups.[70] Attention to fitting the right technology with the right patient population is important.

Integrating RPM into chronic care management is a major challenge. Secondary research reveal a key challenge for RPM initiatives centers on integrating RPM into chronic care management in a sustainable manner. Critical success factors for small-scale pilots have been studied,[71] but research has recently expanded to focus on challenges around large-scale implementations. Stakeholder uncertainty around sustainable business models and solution adequacy combined with a lack of coordination across primary and secondary care to diminish broad-based expansion of RPM projects. RPM initiatives must "reduce uncertainty about the ownership of implementation processes that lock together health and social care agencies; and…ensure user centred rather than biomedical/service-centred models of care."[72]

Implementation planning is under studied. Related to integration ownership is planning. Project management, process re-engineering, primary and secondary care transition planning and other implementation planning activities were generally not explicitly examined. In general, processes around change management initiatives remain an ongoing area of debate in the field. If ownership of integration processes and viability matter, clear planning around implementation management and care processes should matter, too.

Managing uncertainty and trade-offs is important. The literature on RPM paints a complex and at times conflicting benefits story. While benefits in quality and productivity have been realized, the variability of the interventions, outcome measures, patient populations, jurisdictions, educational supports, funding models, and diseases make portable lessons limited.[73] RPM has demonstrated outcome benefits in a variety of contexts for different types of patients. Figuring out how to make those approaches more cost effective, broadly attractive and integrated into existing care pathways requires identifying cases in Canada that have shown the broad-based implementation potential.

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telecare and telehealth work best for, and perceptions of impacts on care quality as a consequence of Program participation were noted as potential areas of future research.

[70] See Pare et al 2010.

[71] Broens, T. H., Vollenbroek-Hutten, M. M., Hermens, H. J., van Halteren, A. T., & Nieuwenhuis, L. J. (2007). Determinants of successful telemedicine implementations: a literature study. *Journal of telemedicine and telecare*, 13(6), 303-309.

[72] May, C. R., Finch, T. L., Cornford, J., Exley, C., Gately, C., Kirk, S., ... & Mair, F. S. (2011). Integrating telecare for chronic disease management in the community: what needs to be done?. *BMC health services research*, 11(1), 131.

[73] Kitsiou, S., Paré, G., & Jaana, M. (2013). Systematic Reviews and Meta-Analyses of Home Telemonitoring Interventions for Patients With Chronic Diseases: A Critical Assessment of Their Methodological Quality. *Journal of medical Internet research*, 15(7).

Appendix F – Program Selection

Program	Province	Target Population(s)
Vancouver Island Health Authority Telehome Monitoring	British Columbia	Heart failure
Alberta Virtual Care Management Pilot (Sherwood Park)	Alberta	Heart failure
Medtronic Carelink system	Calgary	CHF
BreatheWELL at Home	British Columbia	COPD
Ontario Telemedicine Network Telehomecare Expansion Project	Ontario	CHF, COPD
Re-ACT (Remote Access to Care Technology)	Ontario	Seniors with chronic diseases
Trial of an Internet-based Platform for Managing Chronic Diseases at a Distance (iCDM)	British Columbia	Ischemic heart disease, heart failure, diabetes, chronic kidney disease, COPD
eWound Management System (Pixalere)	British Columbia	Wounded, post-operative patients
The 'Virtual' Cardiac Rehabilitation Program (vCRP)	British Columbia	Ischemic heart disease, heart failure
mDAWN	British Columbia	Diabetes
Jardins-Rousillon Health and Social Services Centre Telehomecare Program	Quebec	Heart failure, diabetes, COPD, hypertension
WelTel HAARTBC2	British Columbia	HIV
WelTel Cedar	British Columbia	HIV, hepatitis-C
Black Creek Community Health Centre Telemonitoring Program	British Columbia	Diabetes, CHF
WelTel LTBI	British Columbia	Tuberculosis

Program	Province	Target Population(s)
Medication Dispensing System	British Columbia	NA
Care mobilization ("CellTrak")	British Columbia	Home-based patients
InspireLIFE BC	British Columbia	Cancer recovery
VITAL Program	New Brunswick	Cardiac Rehabilitation

Appendix G – Alignment of Cases with Benefit Hypotheses

In alignment to the constructed hypotheses and literature findings, the strongest evidence supporting health system benefits from each case stem from the measured and documented marked reductions in hospital utilization metrics. A brief summary of the overall alignment to hypotheses alignment is described below.

	Benefit Sub-Area	**Hypotheses – Use of RPM would result in…**	**Summary**
Quality	Appropriateness/ Effectiveness	Increased patient satisfaction Increased patient compliance	A formal evaluation of Phase 1 of the Ontario Telehomecare Expansion Program showed positive impacts on patient quality of life and ability to self-manage their condition BreatheWELL and JRHC included metrics around patient satisfaction with the use of the technology and not with satisfaction or confidence in managing their condition. Improving patient compliance was an objective in the JRHC study; however no data were submitted for the evaluation. BreatheWELL utilized the Patient Activation Measurement (PAM) tool to determine improvement in self- management – showing slight improvement in scores pre to post study enrollment.
	Health Outcomes	Improvements in physiological health outcomes	Very slight quantification of this improvement throughout the studies. BreatheWELL used a tool to determine changes to quality of life (COPD Assessment), showing slight improvement in scores.
Access	Ability of Patients/ Providers to Access Services	Increased access to health services compared to usual care	All studies identified the ability to increase the number of patients monitored and managed by deploying their solutions. However, this increase to accessibility was not quantified and compared to the current state.
	Patient and Caregiver Participation	Decreased caregiver and patient burden	None of the studies had evidence to assess this metric.

	Benefit Sub-Area	Hypotheses – Use of RPM would result in…	Summary
Productivity	Health system efficiency and sustainability	Decreased health system utilization	Compelling evidence for the decrease in health system utilization, focusing on reductions in ED visits and hospitalization across all studies. JRHC also calculated the reduction in necessary nursing home visits.

Appendix H – Key Informant Interviews

The following individuals were interviewed throughout the development of this study, to provide insight on RPM, provide evidence of benefits based on established programs and to illustrate the critical success factors necessary for program success.

Name	Role	Organization
Allison Boothe	Project Manager, iCON Aboriginal and mDAWN, eHealth Strategy Office, Faculty of Medicine	University of British Columbia
Barry Billings	Vice President, CellTrak Canada	CellTrak
Joseph Cafazzo*	Lead, Centre for Global eHealth Innovation	University Health Network Toronto General Hospital
Cheryl Connors	Executive Director	Canadian Network for Respiratory Care
Malcolm Fisk	Senior Research Fellow, Health Design and Technology Institute	Coventry University
Cheryl Forchuk	Professor, School of Nursing	Western University
Grant Gillis*	Executive Director, Forums & Practices	COACH: Canada's Health Informatics Association
Cheryl Hansen*	Executive Director Innovation, e-Health, The Office of Sustainability	Government of New Brunswick
Nadine Henningsen	Executive Director	Canadian Home Care Association
Kendall Ho*	Director, eHealth Strategy Office, Faculty of Medicine	University of British Columbia
Sally Inglis	Senior Research Fellow	University of Technology, Sydney
Scott Lear*	Professor, Faculty of Health Sciences	Simon Fraser University, Healthy Heart Program, St. Paul's Hospital

Nancy Lefebre*	Co-Chair, OHCA-OCSA Nursing Practice Council; Chief Clinical Executive, SVP, Knowledge & Practice	St. Elizabeth Healthcare
Richard Lester	Medical Head, Division of STI/HIV Control	BC Centre for Disease Control
Susan May	Director, Home Healthcare Services	GE Healthcare
Kasra Moore	Vice President, Health Delivery Solutions	Telus Health
Deb Mulholland	Vice President, Global Services	CellTrak
Neil Olynick	Program Lead, Telehealth	eHealth Saskatchewan
Krisan Palmer	Regional Telehealth Coordinator	Horizon Health Network New Brunswick
Guy Pare*	Canada Research Chair, Information Technology in Health Care	HEC Montréal
Laurie Poole*	Vice President, Telemedicine Solutions	Ontario Telemedicine Network
Richard Scott	Associate Professor, Centre for Innovation in Health Technology	University of Calgary
Heather Sherrard*	Vice President of Clinical Services	University of Ottawa Heart Institute
Sue VanderBent	Executive Director	Ontario Home Care Association

*Member of Expert Advisory Panel