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Overview of Home Telehealth for  
Chronic Disease Management



*Supporting Informed Decisions*

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CADTH  
600-865 Carling Avenue  
Ottawa ON Canada K1S 5S8  
Tel.: 613-226-2553  
Fax: 613-226-5392  
E-mail: [pubs@cadth.ca](mailto:pubs@cadth.ca)

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**Canadian Agency for Drugs and Technologies in Health**

**Overview of Home Telehealth for  
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# 1 Introduction

In Canada, the cost of illness, disability, and death due to chronic diseases such as diabetes mellitus, chronic obstructive pulmonary disease (COPD), and congestive heart failure (CHF) exceeds C\$80 billion annually.<sup>1</sup> Chronic illnesses are associated with approximately 21,946 deaths from cardiovascular disease, 3,617 from chronic respiratory disease, and 1,927 from diabetes each year.<sup>2</sup> A systematic approach to improving and maintaining the health of patients with chronic diseases and long-term conditions is known as chronic disease management. Home care is an integral part of chronic disease management, and health care providers can deliver home care services by visiting a patient's home or by using information and communication technologies (home telehealth).

Home telehealth, which includes home telemonitoring and telephone support, brings health care delivery to the patient's home by connecting the patient and a health care professional. Home telemonitoring is remote care delivery or monitoring that occurs between the health care provider and patient and involves the transmission of patient outcome data to the provider from a remote location. The home telemonitoring services can be synchronous (real-time) or asynchronous (not real-time or store-and-forward telemedicine). Synchronous technologies include audio and video conferencing. Asynchronous telemonitoring involves the storage of clinical digital samples and relevant data, which are forwarded to a health care professional at a distant site by email or the Internet using video clips or other forms of data transmission.<sup>3,4</sup> The infrastructure for home telemonitoring consists of client devices (for example, software, hardware, and services to assist in patient monitoring), central systems to manage client information, a communication network, provider devices, and care team activities (for example, software and hardware to facilitate client-to-provider and provider-to-provider information sharing). Telephone support is patient or caregiver support, such as advice, education, or follow-up by a health care provider, that is usually provided through telephone contact.

The Canadian health care system faces challenges in the provision of home care and services for aging patients who often have multiple chronic conditions. These challenges include the maintenance and improvement of patient quality of life (QoL) and health status, avoidance of unnecessary trips to emergency departments, reduction in hospital readmissions, and reduction of costs. As a result, there is a need to systematically evaluate the clinical benefit and cost-effectiveness of home telehealth versus conventional home care for chronic disease management in Canada.

## 2 Objectives

One aim of this assessment was to examine the literature and to perform meta-analyses of the use of health care services and the outcomes of home telehealth compared with those of usual care (follow-up by a primary care physician or specialist after a patient is discharged from hospital) or no care for the management of patients with diabetes, COPD, and CHF. Another objective was to review the literature on cost-effectiveness and to provide a framework for economic evaluations of home telehealth. In addition, the ethical, legal, and psychosocial issues that are associated with home telehealth were examined. The research questions addressed were:

1. What chronic diseases have been managed through real-time and asynchronous home telehealth approaches in Canada and internationally?
2. What criteria and tools have been developed to identify suitable patients for whom home telehealth would be provided?
3. What strategies could be, or are being, used for the integration of home telehealth into delivery models in Canada?
4. What have been the clinical outcomes for chronic medical conditions managed through real-time and asynchronous home telehealth in comparison with regular home care?
5. What technologies have been available in Canada for the provision of home telehealth in the management of chronic medical conditions?
6. What have been the economic impacts of using real-time and asynchronous home telehealth approaches for chronic medical conditions?
  - a. For which disease conditions are real-time and asynchronous home telehealth most advantageous?
  - b. What other factors (clinical and economic) have been shown to influence the efficiency of these approaches?
7. What are the foreseeable health human resource implications of implementing real-time and asynchronous home telehealth programs?
8. What are the foreseeable privacy and ethical concerns associated with the use of real-time and asynchronous home telehealth?
9. What are the known risk management frameworks for operating real-time and asynchronous home telehealth programs?

### **3 Clinical Review**

#### ***Methods***

Published literature was obtained by searching MEDLINE, MEDLINE Daily Update, MEDLINE In-Process & Other Non-Indexed Citations, BIOSIS Previews, and EMBASE. For the clinical component, CINAHL and PsycINFO were also searched. Parallel searches were run in PubMed, The Cochrane Library, CRD Health Technology Assessment (HTA), plus the Health Economic Evaluations Database (HEED) and the CRD NHS Economic Evaluation Database (NHS EED) for the economic component. All searches were limited to articles published from 1998 to 2008, with no language restrictions. For research questions 8 and 9, the time frame was limited to 1993 to 2008 so that work based on international conferences on informatics and medicine in the early 1990s could be captured. The main search concept was home telehealth and results that were specific to chronic diseases (diabetes, COPD, and CHF) were flagged in a focused search. For the economic component, filters were applied to the initial search to limit retrieval to cost analyses and other economic studies. These searches were supplemented with a focused literature search that was designed to address the health services impact of home telehealth (research questions 7, 8, and 9). Monthly updates and searches were set up to capture any new literature. Grey literature was identified by searching the websites of HTA and related agencies, professional associations, and other specialized databases. Commercially available search

engines were used to search for web-based information. Conference proceedings, hand searches of the bibliographies of key papers, and appropriate expert and agency contacts supplemented the search.

Two reviewers independently selected potentially eligible studies involving clinical and health-related QoL outcomes (Question 4) if the study was of any design, included patients with any of or all three chronic diseases (diabetes, CHF, and COPD), investigated home telehealth (use of audio, video, or other technologies to provide care at home and monitor patient status at a distance), compared usual care or no care, and reported primary outcomes [e.g., hospitalizations, readmissions, bed days of care (BDOC), emergency department visits, outpatient visits at primary care or specialist clinics, and home visits by physicians or nurses] and secondary outcomes [e.g., disease-related health outcomes or death, functional status (anxiety, depression, self-efficacy, compliance, satisfaction, and QoL)]. One reviewer selected potentially eligible studies on relevant ethical and legal issues (Questions 8 and 9) or on general issues with implications for e-Health. Priority was given to literature that was published from 2003 to 2008.

Reviewers independently extracted data from included studies using a structured form. The quality of studies that were selected for the clinical review was independently evaluated by two reviewers using a rating scale that is described in the full report.<sup>5</sup> The ratings were A (high quality), B (good quality), C (fair to good quality), D (poor to fair quality), and E (poor quality). Articles on ethical, legal, or psychosocial issues were not assessed for quality. All disagreements about study selection or data extraction were resolved by consensus.

All statistical analyses in the clinical review were conducted using STATA 8.2. If the quantitative pooling of results was appropriate, the random effects model was used to compute treatment efficacy and summary estimates. Data reporting counts (for example, number of hospitalizations) were summarized as rate ratios [ratio of the rate in the experimental intervention group (such as home telemonitoring or telephone support) to the rate in the control group (such as usual care)] to measure the number of events that occurred per patient and to account for varying lengths of follow-up. The natural logarithm of the rate ratio was used.<sup>6</sup> For studies that reported the mean number of events, the mean outcome was multiplied by the number of patients at the end of the follow-up period to obtain the number of events per group. The relative risk (or risk ratio) was used to summarize dichotomous data (for example, number of patients who were re-hospitalized or visited the emergency department and the number of deaths). Continuous data with variances (standard deviation or standard error) were combined using the weighted mean difference. Missing data were imputed for randomized controlled trials (RCTs) that measured glycosylated hemoglobin (HbA1c), but not for observational studies. Heterogeneity between studies was measured using the  $I^2$  statistic.<sup>7</sup> Meta-analyses were conducted on RCTs and prospective cohort studies with a quality score of “C” or higher.

More information about the technologies that are available in Canada for chronic disease management was obtained from the grey literature. A search of Health Canada’s Medical Devices Active License Listing database provided information on Class II, III, and IV telehealth devices and manufacturers. An environmental scan of Canadian home telehealth programs was conducted by email to appropriate contacts in a regional health authority or provincial or territorial ministry of health and other sources.<sup>8,9</sup>

## **Results**

A total of 6,236 clinical citations were identified in the original search. From these, 820 potentially relevant reports were retrieved for scrutiny, and 79 reports (describing 78 unique studies) were selected for inclusion. Study designs, sizes, and quality varied. The details about study identity, characteristics, and quality assessment appear in the full report.<sup>5</sup> Of the included studies, 26 pertained to diabetes, 35 to CHF, nine to COPD, and eight to mixed chronic diseases. The comparator “no care” was not identified in any of the included studies, so usual care was used as the comparator throughout the clinical review. The clinical outcomes (varying with type of chronic disease) were mortality, number of patients hospitalized and re-hospitalized, number of patients visiting emergency departments, primary care clinics or specialist clinics, BDOC, number of primary care visits and office visits, HbA1c, QoL, and patient satisfaction. Meta-analyses were conducted for studies with low heterogeneity ( $I^2 \leq 50$ ).

### **a) Diabetes**

Of the 26 studies, 12 RCTs and eight observational studies compared home telemonitoring, and five RCTs and one observational study compared telephone support with usual care. The number of study participants ranged from 28 to 1,665, and follow-up varied from three months to three years. Seventeen studies were rated “A,” 10 were conducted in the US, and 15 were funded by government alone. Most studies included patients who were medically stable, able to perform blood glucose testing, and willing to use a computer or telephone to transmit data.

A meta-analysis of 12 RCTs that measured HbA1c was conducted. Home telemonitoring was found to provide better glycemic control (lower HbA1c) in patients with diabetes than usual care. The results of all other studies are reported qualitatively. Based on these findings, home telemonitoring seems to reduce re-hospitalization and BDOC but results in a higher use of primary care and specialist clinics compared with usual care. The evidence for health services use associated with telephone support was limited. Health-related QoL and patient satisfaction with home telehealth seems to be similar or better compared with usual care. Management strategies did not differ between type 1 or type 2 diabetes.

### **b) Congestive heart failure**

Of the 35 CHF studies, 11 RCTs and nine observational studies compared home telemonitoring, and 13 RCTs and five observational studies compared telephone support and usual care. Three studies had three comparative arms (home telemonitoring, telephone support, and usual care). The number of study participants ranged from 22 to 1,518, and follow-up varied from two to 16 months. Ten studies were rated “A,” 27 were conducted in the US, and 14 were funded by government alone. Most study participants were older than 55 years of age and had a mean NYHA functional classification of 3 to 4.

The meta-analyses of RCTs found that home telemonitoring and telephone support were associated with reduced rates of re-hospitalizations. All-cause mortality was reduced with home telemonitoring, but neither all-cause or CHF-related mortality was reduced with telephone support. The number of CHF-related hospitalizations but not all-cause hospitalizations was reduced with telephone support versus usual care. Because of the heterogeneity among studies, meta-analyses could not be conducted for other outcomes, but studies showed that emergency department visits and BDOC were reduced with home telemonitoring and telephone support. The

numbers of non-hospitalized health care visits (primary care, specialist and home care) were increased with home telemonitoring and telephone support. Health-related QoL and patient satisfaction were comparable or better than with usual care.

**c) Chronic obstructive pulmonary disease**

Of the nine COPD studies, one RCT and three observational studies compared home telemonitoring, and five RCTs compared telephone support with usual care. The number of study participants ranged from 36 to 191, and follow-up varied from three months to one year. Two studies were rated “A,” various countries were represented, and five studies were funded by government. Most study participants were older than 65 years of age and had a mean forced expiratory volume in 1 second (FEV<sub>1</sub>) of 27% to 43%.

Data could be pooled for all-cause mortality with telephone support and for the number of hospitalizations with home telemonitoring. Mortality was higher for telephone support than usual care. The number of hospitalizations for home telemonitoring versus usual care did not differ when the results of one RCT and two observational studies were pooled but were less with home telemonitoring for the RCT alone. Home telemonitoring and telephone support were found to reduce the rates of re-hospitalization and emergency department visits. The results for BDOC and non-hospital health care visits were limited and varied. No differences between groups were reported for health-related QoL and patient satisfaction.

**d) Mixed chronic diseases**

Of the eight studies with a mixed chronic disease population, four RCTs and three observational studies compared home telemonitoring, and one RCT compared telephone support with usual care. No meta-analyses were conducted because of study heterogeneity. Home telemonitoring seemed to reduce health services use relative to usual care. One RCT each reported lower mortality with home telemonitoring or telephone support compared with usual care. No differences between groups were reported for health-related QoL and patient satisfaction.

The 17 systematic reviews and one meta-analysis of home telehealth that were identified in the literature search are summarized in the full report.<sup>5</sup>

## **4 Economic Review**

### ***Methods***

The literature search strategy that was used for the clinical review was used for the economic review. Two reviewers independently selected potential studies for inclusion if the intervention was telehealth, if the study included patients with any of or all three chronic diseases (diabetes, CHF, and COPD), and if the design was an economic evaluation comparing home telehealth with an alternative care strategy that did not include home telehealth. Economic evaluations included cost-minimization analyses, cost-effectiveness analyses, cost-utility analyses, cost-benefit analyses, or a comparison of the costs of a strategy comparing home telehealth with an alternative care strategy that did not include home telehealth, with the assumption that the strategies that included home telehealth were no less effective than the alternatives.

One reviewer extracted data, which was verified by another reviewer, for each included study. Extracted data included study author, reference, country, disease, patient population, current care strategy and strategy incorporating home telehealth, type of analysis, types of health care resources, perspective (societal or health care system), design (RCT, before and after, and case study), time horizon, results, design and reporting of economic evaluation, and assessment of quality. One reviewer assessed study quality using a 10-point checklist that specified the requirements for studies in home telehealth and that is described in the full report.<sup>5</sup> Questions in the checklist were phrased for “yes” or “no” answers, and the number of questions with a “yes” response for each study was recorded. This number should not be interpreted as a quality score, because each question is not of equal weight.

## **Results**

A total of 1,597 economic citations were identified in the original search. From these, 134 potentially relevant reports were retrieved for scrutiny, and 22 reports were selected for inclusion. Three non-peer reviewed reports<sup>1,8,10</sup> of Canadian evaluations of home telehealth were examined using a narrative approach. Details appear in the full report.<sup>5</sup>

One included report was a full cost-utility study.<sup>11</sup> The others were cost analyses or cost-minimization analyses. Seventeen studies came from the US and 12 studies focused on CHF. The study characteristics (for example, patient population, comparators, included resources) appear in the full report.<sup>5</sup> Fourteen studies were based on RCT data, four on case studies, and four on before-and-after studies. The time horizon of studies ranged from two months to 18 months. Most of the studies were of poor quality and included only comparisons of costs. Therefore, they were not full economic evaluations. Given these limitations, most studies found that home telehealth was cost saving from the health care system perspective.

## **Framework for Economic Evaluations**

We suggest a framework for future evaluations of home telehealth programs that is consistent with the study quality checklist that was used for the economic review and with the CADTH economic guidelines.<sup>12</sup> The focus should be on the incremental costs that are associated with the application of the program to a patient population, as opposed to an individual patient, including costs for both. This would permit analysis of costs based on different sizes of patient populations, as required for marginal analysis. The costs to be included are telehealth program costs (administration, delivery, and capital costs), home health care costs (nursing and homecare visit costs), health care costs (physician visit, emergency department visit, and hospitalization costs), and patient-borne costs. Studies should have clinical (including surrogate markers of disease) or patient QoL outcomes. Evaluations of home telehealth should include a formal assessment of patients’ QoL, preferably using established utility questionnaires that would facilitate the assessment of quality-adjusted life years gained or the estimation of short-term effects on utility due to the intervention. In terms of effectiveness, there should be consideration of clinical outcomes, such as event rates and death, if possible, and surrogate outcomes (for example, HbA1c, FEV<sub>1</sub>) given the usual short-term horizon of evaluations of home telehealth. An example of how the framework can be applied appears in the full report.<sup>5</sup>

## ***Home Telehealth in Canada and Abroad***

Telehealth devices and the accompanying software that are available in Canada vary in complexity. Most devices are telephone- or computer-based, with current or future video and peripherals capabilities (for example, devices to measure blood pressure, pulse, respiration, blood glucose, and body temperature). The environmental scan found that six of 10 provinces have established telehealth programs or pilot projects underway. Most programs target chronic disease populations such as those with diabetes, COPD, asthma, depression, cardiovascular diseases, or palliative care. Manitoba, Newfoundland and Labrador, the Northwest Territories, Nunavut, and Yukon do not have home telehealth programs but may be moving in this direction. A list of chronic diseases that are managed using telehealth worldwide appears in the full report.<sup>5</sup>

### ***Limitations***

There are several limitations to our research. Comparisons of synchronous versus asynchronous technologies were not part of the primary objectives and were not explored. The pooling of outcomes in our meta-analyses resulted in high study heterogeneity ( $I^2 > 50$ ). To explore this, several subgroup analyses by study design (RCTs and observational studies versus RCTs alone) or intervention (home telemonitoring versus telephone support) were conducted, but statistical heterogeneity remained unexplained in some cases. Given the limited number of studies in the subgroup analyses, a meta-regression was not done. As a result, clinical and health services outcomes were reviewed qualitatively for many studies. A qualitative economic review was also done because of differences in patient populations, study designs, and interventions. The number of studies in the subgroup analyses was insufficient to measure the publication bias that was related to clinical and health services use. Nonetheless, the literature search was comprehensive and included published and grey literature, thereby reducing the risk of report bias.

## **5 Health Services Impact**

With the transfer of electric telemetry, data gathering, and communication technologies and techniques from industry to health care, ethical and legal issues must be considered.<sup>13</sup> Discussions about the patient and human resource implications; risk management; legal issues; and ethical, equity, and psychosocial issues associated with home telehealth appear in the full report.<sup>5</sup>

With respect to the patient, home telehealth must satisfy the same ethical principles that govern the overall delivery of health care. These principles are autonomy, equality, beneficence, non-maleficence, and integrity.<sup>14-16</sup> Patient-centred issues include privacy, confidentiality, informed consent, patient selection, and psychosocial implications as a result of the medicalization of the home environment. Professional issues include the fiduciary nature of the health care professional-patient relationship as it applies to the offer of home telehealth to patients without access to appropriate care and dealing with patients' feelings of immediacy or abandonment as they become co-participants in health care delivery. Other considerations are a lack of a comprehensive code of ethics or standards to guide home telehealth, limited opportunities for employee training, liability, malpractice, and uncertain reimbursement for provision of home telehealth services. There are risk management and legal issues to consider with home telehealth

such as the appropriateness, safety, and reliability of the technology; confidentiality; security; and the need for a standard unique patient identifier that conforms to applicable privacy legislation and that is transferable at the national level. The role of the *Canada Health Act* and the implications for home telehealth service delivery is complex, with comprehensiveness, universality, and accessibility being particularly relevant.

## Conclusions

Home care is an instrumental part of the chronic disease management model, and home telehealth is an extension of health care delivery in a patient's home. Our clinical review showed that home telehealth is generally clinically effective, and no patient adverse events were reported in the included studies. Evidence on the impact of health services utilization is more limited but shows potential in some studies. Our economic review reported home telehealth to be cost-saving, although the overall quality of the original research was low.

It is evident from the responses to our pan-Canadian survey of home telehealth programs that home telehealth interventions are becoming an integral part of health care delivery to improve access to health services. The survey also showed that there exists a viable industry that can support implementation of home telehealth. More research, such as multicentre RCTs, is warranted to accurately measure the clinical and economic impact of home telehealth for chronic disease management to support Canadian policy makers in making informed decisions.

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