The Economic Evaluation of Manitoba Health Lines in the Management of Congestive Heart Failure

by

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Abstract

Introduction: Telehealth is a healthcare innovation that provides new prospects for cost saving and quality of care. This study conducts a cost-benefit analysis of the Manitoba Provincial Health Contact program for congestive heart failure to determine whether the program is cost-saving relative to usual care. It also offers a cost-effectiveness study to determine whether there are additional benefits to the program that would justify an additional cost. Both studies are conducted from the perspective of the healthcare system.

Methods: This economic evaluation is "piggy-backed" on an effectiveness study conducted by Drs Katz and Doupe, and entitled *Testing the Effectiveness of Health Lines in Chronic Disease Management of Congestive Heart failure (2005).* 179 patients were randomized into three study groups: usual care, a health-lines intervention (HL) and a health-lines with monitoring intervention (HLM). I calculated the benefit-cost ratio in terms of the program intervention cost and the cost savings from averted healthcare visits in order to determine whether the program would pay for itself. Then I conducted a cost-effectiveness study in which outcomes were measured in terms of quality-adjusted life years (QALYs) derived from the SF-36. Bootstrap-resampled incremental cost-effectiveness ratios were computed to allow us to take into account the uncertainty related to small sample size.

Results: The two study groups in this study generated a net saving of $28,307, however, cost savings between the study groups were not statistically significant. Therefore, the cost-benefit study cannot conclude that the program paid for itself. The cost-effectiveness analysis suggests that the HL intervention can generate an additional QALY for $26,486 and HLM for $70,266. Sensitivity analysis, which takes into account program costs, cost savings from reduced utilization, improvements in health and the uncertainty surrounding each of these estimates, suggests that there is a probability of 60% that HL is cost-effective, and 63% that HLM is cost-effective relative to usual care. Moreover, which of the two programs is optimal depends on how a decision-maker values health system savings relative to subjective health. HLM offers greater system savings than HL, but HL generates superior subjective health scores.

Conclusion: The findings demonstrate that the Health Lines strategy for congestive heart failure holds great promise. While small sample size limits the strength of our conclusions, it is probable that both HL and HLM offer better outcomes at reduced cost.

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Chapter 1

Introduction

1.1 Introduction

Chronic diseases are the major cause of death and disability worldwide. They may cause premature deaths, functional disability, decrease quality of life and have a negative economic impact on patients, families and society. According to the World Health Organization, thirty-five million people were estimated to have died from chronic diseases, which accounted for 60% of all deaths globally in 2005 (World Health Organization, 2011). Many studies have shown that chronic diseases account for a significant portion of morbidity and mortality among Canadians (Health Canada, 2002; Heart and Stroke Foundation of Canada, 2003; Canadian Cancer Society, 2010). In Canada in 2005, it was estimated that 207,000 people died from chronic diseases, which accounted for 89% of all deaths. Most prevalent were deaths from cardiovascular diseases (34%), following by cancer (29%), chronic respiratory disease (6%), diabetes (3%), and other chronic disease (17%) (World Health Organization, 2005). Chronic diseases also create increasing health and long-term care costs. In Canada, 50% of the population suffers from a chronic disease such as cancer, congestive heart failure, diabetes, arthritis or a mental health disorder (Manuel, Schultz, & Kopec, 2002).

There is a growing interest in shifting healthcare service from costly hospitals to community settings. Healthcare innovation such as telehealth and virtual clinics provide new prospects for cost saving and quality of care in a community setting. Telehealth uses information and communication technologies, such as telephone, and videoconferencing, to examine, monitor and treat patients over long or short distances. Telehealth services can assist both chronically ill patients and caregivers to effectively prevent and manage chronic disease in a timely manner in patient homes. Telehealth, the provision of care at a distance, is a key component of integrated care between primary care and patient self-management. It functions as a chronic disease management system. Although telehealth is not a replacement for human service, it is growing into an increasingly sophisticated and operable technology (Priyan, 2009). The main features of telehealth for patients with chronic disease are:

- using telephone or internet applications to provide healthcare services;
- monitoring of patients' vital signs and symptoms in their home environment;
- helping patients manage their chronic conditions;

As healthcare costs increased dramatically in recent years, cost-containment has become increasingly important to healthcare planners and decision makers. Interest in the potential cost savings of telehealth has correspondingly grown. Evidence related to cost-effectiveness, however, is mixed. A few international studies have demonstrated that telehealth for congestive heart failure and Chronic Obstructive Pulmonary Disease (COPD) has better outcomes than traditional care and lower costs (Schmidt, Schuchert, Krieg, & Oeff, 2010; Vontetsianos et al., 2005; Whitten, & Mickus, 2007; Wooden et al, 2008) Other studies, however, show telehealth to be associated with unchanged or increased costs. Analyses of cost-effectiveness of telephonic disease management in heart failure by Smith et al. found that direct medical and intervention costs showed no cost savings associated with the intervention. This randomized control trial was based on 1,069 community-dwelling patients with systolic heart failure and diastolic heart failure between 1999 and 2003 (Smith, Hughes-Cromwick, Forkner, & Galbreath, 2008). Another cost-effectiveness study of telephonic disease management in heart failure also found that the intervention was effective but costly to implement and did not reduce healthcare utilization (Pyne et al., 2010).

This study will offer an economic evaluation of the Manitoba Provincial Health Contact program for congestive heart failure interventions. Cost-benefit analysis will determine whether the program will generate more saving than the investment. That is, will the program pay for itself? Cost-effectiveness analysis will allow us to estimate the costs associated with improving patient's health and well-being, in order to determine whether the investment is reasonable. That is, even if a program does not pay for itself in cost saving, it might generate better outcomes that justify a higher cost. Economic evaluation is an important tool for decision making on priority-setting, because economic evaluation includes a set of formal analytical techniques that provide systematic information about costs and benefits of alternatives.

1.2 Study purpose and objectives

This study is "piggy-backed" on to a previous effectiveness study conducted by Alan Katz and Malcolm Doupe. The previous study is entitled: *Testing the Effectiveness of Health Lines in Chronic Disease Management of Congestive Heart Failure (2005)* (hereafter Health Lines study). 179 patients were randomized into three groups. Group one received the standard care. Group two received standard care plus Health Lines (HL): that is, nurses were available on the telephone to provide suggestions about the patient's daily management of the disease. Group three received standard care plus Health Lines plus in-house monitoring (HLM): that is, they were provided with monitoring devices and instructions on how to use them. I used the intervention outcomes and healthcare utilization data that were already collected for the Health Line study to conduct an economic evaluation of the intervention. In addition, I was provided with the program cost data for the HL and HLM study groups. No additional data were collected for this study.

The specific objectives for this thesis are described below to:

1) compare standard care with two Health Lines interventions provided by the Provincial Health Contact Centre in terms of their total costs as they relate to patient outcomes; and,
2) conduct the cost-effectiveness and cost-benefit analyses of the Health Lines interventions versus standard treatment for congestive heart failure patients from the Winnipeg and Central Health Regions in Manitoba.

The results yielded from this study are intended to help policy and program planners make efficient use of healthcare resources. This study will provide evidence to determine whether the Provincial Health Contact Centre is a good option as a heart failure intervention strategy compared to usual care.

1.3 Research questions

This study proposes to answer the following questions:

1) what are the total and mean program costs for the congestive health failure intervention program at the Provincial Health Contact Centre?

2) can the Health Lines strategy be shown to pay for itself in terms of averted healthcare utilization costs using a cost-benefit analysis? That is, are estimated net benefits positive?

3) is the Health Lines strategy a cost-effective intervention for congestive heart failure patients compared to the usual standard of care? That is, even if the Health Lines strategy costs more than standard care, are the outcomes (including patient satisfaction and scores on the SF-36) sufficient to justify the increased costs?

In light of these research questions, the following hypotheses will be tested:

1) total healthcare costs, including program costs and system utilization costs, will be lower for the intervention groups compared to the usual standard of care group.

2) Health Lines will reduce the healthcare utilization costs as measured by primary care, specialist physician visits and hospitalization compared to the control group (usual standard of care group).

3) Health Lines will improve patient satisfaction and patient outcomes measured on the Client Satisfaction Questionnaire and SF-36.

Chapter 2

Background

This chapter consists of a broad literature review on the effectiveness and cost-effectiveness of telehealth programs for chronic disease management. A summary of the previous Health Lines study, conducted by Katz and Doupe, in terms of its purpose, methods and results will be provided in the second part of this chapter.

2.1 Literature review

2.1.1 The economic burden of chronic disease

There is compelling evidence to show that the economic burden of chronic disease is high, and costs are particularly high among those with co-morbid chronic illness (Health Canada, 2004).The economic costs of chronic disease include: 1) direct costs related to physician services, diagnostic testing, hospitalization, drug expenses and additional direct health expenditures (including other professionals, capital, public health, insurance administration, and other costs); 2) indirect costs related to loss of productivity, and premature mortality due to the disease; 3) intangible costs such as pain, grief and other associated quality of life issues. Chronic diseases result in a significant drain on Canada's economy in terms of both direct impact on healthcare, and indirect impact on productivity as a result of premature death and illness. Researchers have estimated that as much as 80% of all health care expenditures can be attributed to the treatment of chronic illness (Health Canada, 2004). A US study stated that in 2003 the total treatment costs of chronic diseases were $277 billion US dollars, (Polisena, D. Coyle, K. Coyle, & McGill, 2009).

It is estimated that there are 400,000 Canadians living with congestive heart failure (Heart & Stroke Foundation of Manitoba., 2010). In addition, heart failure is the most frequent indication for hospital readmission and the most frequent discharge diagnosis in Canada. The number of patients with congestive heart failure increases with age. In 2005, there were 54,333 hospitalizations for congestive heart failure in the country, and the hospitalization rates increased by more than three times for those aged 65 and over. Many people had more than one hospitalization during the year (Public Health Agency of Canada, 2009). In Canada, cardiovascular disease is one of the most costly chronic diseases (Patra et al, 2007). In 2000, a conservative cost estimate of cardiovascular disease was $22.2 billion, including $7.6 billion for healthcare costs and $14.6 billion for indirect costs due to loss of economic activity (Public Health Agency of Canada, 2009).

With the predicted increase of older adults in the Canadian population over the next decade, the demand for healthcare services is also anticipated to increase. The economic burden of caring for patients with heart failure is enormous. As both direct and indirect costs of chronic disease are significantly high, effective strategies for controlling, preventing and reducing the cost of chronic disease interventions are imperative. Therefore, health services planners are exploring effective strategies to reduce healthcare spending and improve the patient outcomes.

2.1.2 Effectiveness of telehealth intervention for patients with chronic disease

Heart failure is a chronic disease and a leading cause of death in North America. The prevalence and incidence of heart failure are expected to increase in industrialized countries due to the aging population (Seto, 2008). Congestive heart failure, the inability of the heart to maintain an adequate pumping function throughout the body, is a major public health problem associated with high morbidity and mortality in Canada. Patients with congestive heart failure face a number of daily self-management tasks, including using medication, monitoring symptoms, managing acute episodes, as well as dealing with exercise, stress reduction and appropriate use of resources (Burke, Dunbar-Jacob, & Hill, 1997). Chronic disease management is a systematic approach to improving and maintaining the health of patients with chronic disease conditions. Telehealth programs have been implemented and increased dramatically in the past years. As defined by the American Telemedicine Association, home telehealth is remote care delivery or monitoring in that the healthcare providers deliver the services to patients at home by using information and communication technology (American Telemedicine Association, 2011). The patients take greater responsibility for their own care. Telehealth can be tailored to meet an individual patient's specific needs; this allows healthcare providers to provide more appropriate surveillance and advice and prevent deterioration in a patient's condition. The purpose of telehealth is to assist patients' self management of their long-term chronic conditions and minimize the effects of disability and illness. Telehealth is an innovative model in self-management support and provides an alternative for some aspects of traditional care in chronic disease such as diabetes, congestive heart failure, COPD, hypertension etc.

The infrastructure of home telehealth consists of:

- client devices: software, hardware, and services to assist in patient monitoring and managing condition;
- central systems: client management system that collects and displays the client's condition of vital signs and stores clinical and assessment documents;
- communication network: software, hardware, network, and communication infrastructure required for service delivery and operational support to maintain the integrity of the home telehealth system;
- care team activities: clinical staff and the professional services that are necessary for consultative support to clients using home telehealth. (Tran et al., 2008):

Home telehealth technology can establish a link between patients and healthcare professionals, and motivate patient participation in becoming more active in managing their conditions. Over the past decade, several studies have been undertaken to assess the effectiveness of telehealth and/or to examine issues related to healthcare service utilization and quality of life for patients with chronic heart disease.

Studies have shown that telehealth improves patient-healthcare professional communication and this can increase patient satisfaction and use of preventive services. For example, Paget et al. using home telehealth to empower patients to monitor and manage their long term conditions of heart failure and COPD found the patients felt more involved in their care and more able to manage their care at home; most patients found the service helpful and comfortable (Paget, Jones, Davies, Evered, & Lewis, 2010).

Wakefield et al. demonstrated a home telehealth intervention significantly delayed time to hospital readmission relative to control group patients. In this study a total of 148 patients with heart failure were randomly assigned in the three groups: 49 were randomly to usual care, 52 to videophone intervention and 47 to telephone intervention. Nurses contacted the intervention patients each week for 90 days after hospital discharge. After the 90 day intervention period, the intervention group patients were more likely to show increased knowledge about their medications (Wakefield et al., 2009).

A systematic review of 13 worldwide randomized controlled studies about home telemonitoring for congestive heart failure patients found that five studies reported significant reductions in mortality, and six studies reported some reduction in congestive heart failure hospital admission, although none of them reported a significant reduction in all-cause hospital admission. Four studies found no significant difference in emergency department visits among the patients in the treatment and control group (p=0.43). However, three studies found either lower emergency contacts or an increase in emergency department visits (Clarke, Shah, & Sharma, 2011).

Polisena et al. also conducted a systematic review of 21 original studies (including one Canadian study) which included 3,082 patients with congestive heart failure to identify the average effects of home telemonitoring compared with usual care. The evidence suggested home telemonitoring may provide better clinical outcomes. Home telemonitoring was associated with reduced mortality rates (risk ratio =0.64; 95% CI: 0.48-0.85), but also with increased primary care visits, specialist visits and home care visits. This study also found that home telemonitoring helped reduce hospital admission, emergency department visits and bed-days of care for all-cause or congestive heart failure related cause. Thirteen studies reported quality of life or patient satisfaction using various instruments, such as the Minnesota Living with Heart Failure Questionnaire, SF-12

Health Survey, or the Barnason Efficiency Expectation Scale-Heart Failure. Overall, patient quality of life and satisfaction with home monitoring were similar or better than with usual care (Polisena et al., 2010).

However, not many Canadian studies examined the effectiveness of the telehealth for congestive heart failure. Only one Canadian study was included in the Clarke and Polisena's review studies. Woodend et al. in Canada conducted a randomized controlled trial and tested the impact of a three-month telehome monitoring intervention on hospital admission, quality of life, and functional status in patients with heart failure or angina. A total of 249 patients (121 with heart failure and 128 with angina) were enrolled and randomized to receive either 3 months of telehome care after discharge or usual post-discharge care. The intervention consisted of video conferencing and phone-line transmission of weight, blood pressure, and electrocardiograms. After the three-month intervention, the results showed home telemonitoring significantly reduced the number of hospital readmissions, hospital days for patients with angina and improved quality of life and functional status in patients with heart failure or angina. The study used the SF-36 survey to measure the quality of life between groups and found higher quality of life in the telemonitoring group than usual care patients. Patients also found the technology easy to use and expressed high levels of satisfaction (Wooden et al., 2008)

2.1.3 Studies of telehealth for chronic disease management

A number of researchers have found that telehealth can be an effective method to reduce healthcare use rates and costs as well as improve quality of life (Clark, Inglis, McAlister, Cleland, & Stewart, 2007; Noel, Vogel, Erdos, Cornwall, & Levin, 2004; Scalvini, et al., 2005; Inglis et al., 2010).

1) Clinical outcome

For example, studies have shown that telehealth can better control HbA1c and blood pressure for diabetes and hypertension patients (Izquierdo et al., 2003; Shea, 2007). Many studies have also found that telehealth program improve self-management behavior, such as the proper use of medication and self-monitoring (Piette, 2005; Po, 2000; P. Suter, W. Suter, & Johnston, 2011).

A system review by Barlow et al. concluded that the most effective telehealth interventions were related to automated vital signs monitoring and telephone follow-up by nurses, which reduced health service use and improved clinical indicators (Barlow, Singh, Bayer, & Curry, 2007). Six other randomized controlled trial studies in the US and Europe of the application of telehealth to individuals with congestive heart failure reported a reduction of between 27% and 40% in overall hospital admissions, and a significant reduction in the hospital length of stay and healthcare services used (K. A. Stroetmann, Robinson, K.C. Stroetmann, McDaid, 2010). The following table 1 summarizes the main telehealth intervention clinical outcomes for the chronic diseases of diabetes, congestive heart failure, hypertension, asthma, COPD and mixed chronic conditions.

Table 1: Summary of clinical outcome comparisons of the usual care and home telehealth in the management of chronic disease from the literature

Chronic Disease	Home telehealth outcomes
Diabetes	-improved HbA1c levels relative to usual care; -reduced hospitalization readmissions and hospital bed days; -higher numbers of primary care visits, specialist visits and home care visits; -Health related quality of life and patient's satisfaction was increased or better than usual care; -reduced total healthcare costs
Congestive heart failure	-reduced rates of hospitalization readmissions, emergency visits, hospital bed days; -reduced mortality; -increased primary care visits, specialist visits and home care visits; -health-related quality of life and patient's satisfaction were better than usual care. -reduced healthcare costs.
COPD	-reduced rates of rehospitalizations and emergency room visits; -mortality rate was higher in home telemonitoring and telephone support compared to usual care; -limited evidence with respect to primary care visits, specialist visits and home care visits; -health related quality of life and patient's satisfaction among intervention groups was mixed.
Asthma	- peak expiratory flow (PEF) variability was significantly smaller; - forced expiratory flow in 1 second significantly increased; -Improved quality of life; -improved lung function and airway responsiveness.
Hypertension	-reduced Diastolic Blood Pressure, Systolic Blood Pressure and Mean Arterial Pressure; -patient's satisfaction was increased; -cost-effective.
Other long-term condition (Mixed)	-reduced healthcare utilization; -reduced mortality; -no substantial difference in health related quality of life and patient satisfaction among intervention groups; -reduced costs in hospitalization.

Source: compiled by the author from cited sources

In summary, telehealth applications showed an improvement in clinical outcomes, such as reductions in hospital readmission, emergency visits, and mortality. Most patients were satisfied with the services. In addition, telehealth used in congestive heart failure interventions provided better outcomes in terms of reduction of reduced hospitalization, emergency visits, and mortality.

2) Economic Evaluations

The economic evaluation of telehealth in the literature includes interventions for cardiology, diabetes, COPD, dermatology and psychiatry, and these studies analyzed interventions in primary care, secondary care and home care settings using telephone, videoconferencing and monitoring. The results indicated that investment in technology enhanced the healthcare services. Some of these studies showed that telehealth substantially lowered hospitalization and emergency visits during the intervention and resulted in a saving of costs in healthcare utilization. For example, Noel et al. found when home telehealth was integrated with the health facility's electronic medical record system, the intervention for complex heart failure, chronic lung disease, and diabetes showed a significant reduction in healthcare costs for elderly high- resource users with complex co-morbidities. The bed-days-of-care ($p < 0.0001$) and urgent clinic/emergency room visits were significantly decreased at 6 months intervention ($p = 0.023$). Although functional levels and patient-rated health status did not show a significant difference between groups, the intervention improved cognitive status, treatment compliance and stability of chronic disease (Noel, Vogel, Erdos, Cornwall, & Levin, 2004).

Seto et al. reviewed ten economic analyses including nine US studies and one Italian study in order to compare the costs between telemonitoring and usual care for heart failure. They found that all of these reviewed studies found cost reductions from telemonitoring relative to usual care, which ranged between 1.6% and 68.3%. Cost reductions were mainly attributed to reduced hospitalization expenditures. Travel cost for patients using telemonitoring was 3.5% lower than the usual care group (Seto, 2008).

A US multidisplinary team of nurses, physicians, pharmacists, and dieticians developed a disease management program for patients with chronic heart failure after discharge from the hospital. A nurse-administered 24-hour health information line was used as a patient education tool to reinforce education received in hospital, such as early warning signs of heart failure exacerbation. The findings indicated that the telephone intervention not only reduced hospital readmissions of patients, cost of care for heart failure, but also reduced the length of stay for patients who were readmitted. Additionally, 375 emergency department visits were avoided. However, this study does not examine patient satisfaction with the program (Slater, Phillips, & Woodard, 2008).

Jennett et al. in Canada conducted a literature search on cost-effectiveness of telehealth for a variety of chronic conditions. This study reported that telehealth increased access to health services, cost-savings, cost-effectiveness, enhanced educational opportunities, improved health outcomes, better quality of life, better quality of care and enhanced social support (Jennett et al., 2003). Clark et al. in Australia suggested that telehealth services were cost-effective in treating patients with chronic heart failure (Clark et al., 2007). Another review suggested that teleconsultation was a cost-effective method of delivering healthcare services to diabetics (Verhoeven et al., 2007).

Evidence shows telehealth intervention may increase the efficiency and reduce costs and disparities for rural, remote, and underserved populations. An economic evaluation of a telehealth network in British Columbia showed that clinical support for maternal/child care for remote areas by a videoconferencing network was not only cost saving, but also cost-effective. The estimated annual travel costs of $724,457 for administrative meetings were avoided. This study suggests that the cost-effectiveness of telehealth to remote areas will increase over time as the cost of equipment continues to fall, the network connections become cheaper, and utilization rates rise (Schaafsma, Pantazi, Moehr, Arglin, & Grimm, 2007). A study from Finland investigated whether internet-based remote monitoring offered a safe, time saving, feasible and cost-effective alternative to implantable cardioverter defibrillator (ICD) follow up. Forty-one patients aged from 41 to 76 with previously implanted ICDs were followed for 9 months. Both physicians and patients reported the system easy to use. Compared to in-office visits, remote monitoring required less time from patients (6.9 ± 5.0 v.s. 182 ± 148min, $p<.001$) and physicians (8.4 ± 4.5 v.s. 25.8 ± 17.0 min, $p<.001$) to complete the follow-up. Remote telemonitoring reduced the overall cost of routine ICD follow-up by €525 per patient (Raatikainen, Uusimaa, van Ginneken, Janssen, & Linnaluoto, 2008).

An economic analysis of the EHAS telemedicine system in Alto Amazonas found that telemedicine programs were cost-effective ways to improve rural health in developing countries (Martínez, Villarroel, Puig-Junoy, Seoane, & del Pozo, 2007). Telemedicine systems providing voice communication were set up at seven health centers and 32 health posts in the Alto Amazonas province of Peru during 2001. A cost analysis in this study estimated that the program had an annual net savings of US$ 320,126. Also, after the implementation of the program, patients' urgent referrals significantly decreased ($p<.03$).

A few studies examined cost-effectiveness by calculating the cost of an intervention relative to quality of life. Barnett et al. in the US conducted a retrospective, pre-post study which compared a cohort of 370 veterans with diabetes before and after the introduction of a care coordination/home telehealth program for two periods of 12 months. The SF-36 questionnaire at baseline and at 12 months was used to convert outcomes into quality-adjusted-life-years (QALYs). Overall, the mean cost per QALY generated by the telehealth intervention was $60,941 (Barnett et al., 2007).

Another cost-effectiveness analysis investigated the clinical and economic impact of teleophthalmology evaluated diabetic retinopathy in prison inmates with type 2 diabetes in the US. This study found that teleophthalmology generated more QALYs at a lower cost than the alternatives. (Aoki et al., 2004).

A randomized controlled trial compared a nurse-led telemonitoring program to usual care in a population of asthmatic outpatients. The measurement was performed at baseline, 4, 8 and 12 months. The study also not only assessed the direct costs such as one year cost of healthcare costs, patient and family costs, but also estimated indirect costs due to productivity loss. This study revealed that from a societal perspective, the intervention was cost effective (€15,366/QALY from the healthcare perspective v.s. €31,035/QALY from the societal perspective) (Willems, Joore, Hendriks, Wouters, & Severens, 2007).

However, some telehealth interventions were found costly to implement and did not reduce utilization. The evidence suggests that telehealth may be cost-effective for certain services and area. For instance, Kennedy and Yollowless showed that videoconferencing was important for enhancing psychiatry services in rural areas in Australia, but it was not necessarily cost-effective for all consumers, or for public mental health services (Kennedy & Yollowless, 2000). This is also confirmed in the broader review of telehealth by Wade et al., in which it was noted that telehealth services were cost-effective for home care and access to on-call hospital specialists, but showed mixed results for rural service delivery, and were not cost-effectiveness for local delivery of services between hospital and primary care, depending upon the particular circumstances. Moreover, telehealth might not be cost-effective from the health services perspective (Wade, Karnon, Elshaug, & Hiller, 2010).

Therefore, there are inconsistent findings in the literature and it is not clear whether telehealth interventions are cost-effective. It has been reported in a few studies that economic evaluation of telehealth adheres less closely to methodological standards than economic evaluation in other fields. These studies showed that economic evaluation in telehealth are highly diverse in terms of the study context and the methods applied (Bergmo, 2009; Bergmo, 2010; Dávalos, French, Burdick, & Simmons, 2009; Reardon, 2005). In a review study of economic evaluation in telemedicine, Bergmo (Bergmo, 2009) found that eight studies had addressed all the key evaluation criteria, such as a clear study objective, adequate comparison, reporting of study design, transparent measurements and valuation costs and outcomes, reporting data source and addressing uncertainty; but the majority of the studies lacked information on perspective and costing method, few used general statistics and sensitivity analysis to assess validity, and even fewer used marginal analysis. Dávalos et al. (Dávalos, et al., 2009) identified some of the main gaps within the economic evaluation of telemedicine programs based on a comprehensive review of the literature:

1. limited generalizability: because of the heterogeneity of telemedicine programs, most of the results cannot be generalized.
2. disparate estimation methods: no uniform methodology or guidelines to conduct standardized economic evaluation in telemedicine.
3. few completed benefit-cost analyses: most economic evaluation focus on program costs, and have not examined a broad range of economic benefits from a variety of perspectives.
4. lack of randomized control trials (RCTs): the use of RCTs in telemedicine is scant.
5. lack of long-term evaluation studies: long-term studies in telemedicine are rare so that sustainability of these initiatives cannot be studied.
6. absence of quality data and appropriate measures: shortage of appropriate data undermines the quality and reliability of economic evaluation.
7. small sample sizes: telemedicine programs usually involve small samples, thus posing important statistical limitations.

Based on the gaps identified, some researchers offer specific recommendations to improve the economic evaluation of telemedicine which are summarized below.

2.1.4 Framework for economic analysis

According to Mclntosh & Cairns, any economic evaluation of telemedicine should include an explicit statement of the research question posed, to allow readers to identify the perspective of the study and the relevance of the results to healthcare decision making

(Mclntosh & Cairns, 1997). Polisena et al. summarized a list of criteria for quality assessment of economic evaluation in telemedicine:

1. is a well-defined question posed in answerable form?
2. is the study perspective appropriate? The study can be conducted from societal, healthcare system, and third-party payer perspectives.
3. is the methodology of high quality? The estimates of incremental costs and effects must come from a valid and reliable source. Estimates of the incremental costs and effects for telehealth programs must come from a suitable research design which minimizes potential bias, such as randomized controlled trials.
4. is the methodology appropriate? The study requires an estimate of the incremental costs of a program as well as the incremental effects on outcomes such as quality of life.
5. is the comparator appropriate? The study must assess the incremental costs and effects of the program compared with usual care.
6. is the quality of the clinical evidence appropriate? To allow assessment of whether the incremental costs of telehealth are worthwhile, the study must compare outcomes with and without telehealth.
7. are appropriate costs considered? All resources associated with the implementation of the telehealth program must be identified and measured, and a unit cost for each item must be obtained.
8. is discounting conducted? If the telehealth studies are done over a short time horizon, discounting would normally be precluded. However, studies must

incorporate the costs of equipment which should be allocated over their useful life.

9. is marginal analysis conducted? The study must address the volume of patients to determine what level of enrollment is required for the program to be worthwhile.
10. is sensitivity analysis performed? The robustness of the study to variations in assumptions should be examined through formal sensitivity analyses (Polisena, et al., 2009).

2.1.5 Telehealth program in Canada and Manitoba

In Canada, telehealth services have become an important component in the delivery of health services. Home telehealth has been employed in a wide range of chronic conditions including congestive heart failure, diabetes, stroke and chronic obstructive pulmonary disease (COPD). Telehealth programs are available in many jurisdictions and regional health authorities. The report Home Telehealth for Chronic Disease Management claimed that most provinces in Canada have telehealth programs or have a call centre. These home telehealth programs in Canada target populations with chronic diseases, such as diabetes, COPD, asthma, depression, and cardiovascular diseases, or palliative care (Tran et al., 2008). The Interior Health Authority in British Columbia has a pilot project for patients with wounds (Canadian Agency for Drugs and Technologies in Health, 2008). In British Columbia, the telehealth program was initiated in June 2001 through federal and provincial funding. It helps to reduce the barriers of geography, transportation, infrastructure and social-economic disparity. In particular, BC Telehealth enhances access to services and supports remote and isolated communities, such as First Nations (Moehr, 2003). The Telehealth Ontario provides residents in Ontario 24 hour access health advice or general health information from a Registered Nurse about managing symptoms of chronic illness, injuries and lifestyle issues (Ontario Ministry of Health and Long-term Care, 2008).

In Manitoba, the TeleCARE program was based on the Manitoba provincial call centre, known as the Provincial Health Contact Centre (PHCC). Applying information technology, PHCC-Info Santé in Manitoba is intended to help patients with chronic disease such as congestive heart failure or Type 2 diabetes manage their condition through combining nursing call center with a home monitoring strategy. The service is province-wide and available to all Manitobans. Nurses and other health care providers who are specialists in chronic disease self-management provide care and assessment via the telephone according to an established patient call schedule. During the phone calls, an assessment of the patient's health is made and the health care provider monitors symptoms and gives professional advice about the disease in a timely manner. In addition, the health care provider offers education and self-monitoring tools for patients to better manage their health.

The program leverages existing infrastructure and human resources, e.g., telephone, technology, clinical and advanced call centre business processes, and health care providers by incorporating a software enhancement--the McKesson Care Enhanced platform for the management of congestive heart failure or Type 2 diabetes patients-- in order to improve access to care and improve clinical outcomes. Provincial Health Contact is an ideal intervention strategy to help monitor risk factors believed to have a correlation with the illness, such as patient diet, BMI, blood pressure, stress levels and physical activity.

Congestive heart failure was selected as the innovative model for chronic disease management in Manitoba because of the growing prevalence of cardiovascular disease in Canada, with more than 50,000 new cases of congestive heart failure diagnosed every year (Kostuk, 2001).

2.2 Summary of Testing the Effectiveness of Health Lines in Chronic Disease Management of Congestive Heart Failure

A research study of *Testing the Effectiveness of Health Lines in Chronic Disease Management of Congestive Heart Failure*, funded by Canadian Institute for Health Research (CIHR) and Canadian InfoWay, was conducted by Drs. Alan Katz, Malcolm Doupe, et al. This study examined whether congestive heart failure patients who used telehealth were healthier compared to those who did not use telehealth. In this section, I will briefly describe the purpose, study design, methodology, and findings of the Health Lines study. This information was derived from a *Preliminary Report of Research Findings from the Chronic Disease Management of Congestive Heart Failure through Health Lines Initiative (2009)* (Katz & Doupe, 2009).

2.2.1 Purpose

The main purpose of the Health Lines Study was to test the effectiveness of telehealth interventions as a model of chronic disease management for people diagnosed with congestive heart failure in the Winnipeg and Central Health Regions of Manitoba.

2.2.2 Study Participants

Patients were recruited in two phases. In the first phase, primary care physicians from Winnipeg and Central Manitoba helped identify eligible patients from their health region through their practice administrative data. Criteria for patients enrolling included:

- Adults aged 40+ years old
- Residents in Winnipeg or Central Health Regions
- New York Heart Association levels II, III and IV of congestive heart failure [severity], excluding level I.
- English speaking
- No significant cognitive, physical or visual impairment
- No rotary phone [or "touch-tone phone only"] land-line (no cell phones)
- Not terminally ill

In the second phase, physicians sent letters of invitation to eligible patients in their practices. Patients who decided to participate in the research would be mailed a consent form. In total, 179 patients were eligible for the study.

2.2.3 Instrumentation

The study was designed as an experimental study. Patients were randomly assigned into one of three groups (a control group and two Health Lines intervention groups). The most important advantage of this study design was the elimination of selection bias, balancing both known and unknown prognostic factors. These groups were divided as follows:

- *Active control or usual care group.* This group of patients continued to receive the regular treatment. The amount and type of this treatment was decided by healthcare providers (e.g. family physicians, other healthcare professionals).
- *Health Lines (HL) group.* This group of patients continued to receive care from their healthcare providers, but also nurses were available on the telephone for assessment and consultation. Upon enrolment into the program, the health line nurses would do an individual assessment over the phone with participants, based on heart failure severity, co-morbidity and current medications, etc. Nurses were able to stratify patients and developed a customized management plan for each patient. Patients received a call schedule tailored by the disease conditions. During the phone calls, in some instances, nurses provided suggestions about the patient's daily management of the disease. The nurses had contact with these patients at least every six weeks.
- *Health Lines plus Monitoring (HLM) group*. This group of patients continued the care of "Health Lines", plus they received nursing care and the provision of in-home monitoring devices such as electronic blood pressure machines and weight scales. Health lines nurses trained the patients to use them in their homes. An automated monitoring system dialed the patient's home phone three times a week requesting blood pressure and weight readings, symptom assessment, and monthly to assess depression and coping skills. Once patients had warning signs or symptoms, the health lines nurses would follow-up contact the patient's family doctor and advise the patient on where and how to seek care if necessary.

Patients in these three study groups had a 12 month active phase. At the end of twelve months, a follow-up phase started allowing for the collection of outcome measure data. Patient health outcome status surveys were conducted by mail with follow-up over the phone to participants at baseline and at 3, 6, 12 months of the active intervention. The following survey instruments were used to assess general and CHF-specific quality of life and self-care behaviors:

- Minnesota Living with Heart Failure Questionnaire (Rector & Cohn, 1992);
- SF-36 (to assess quality of life);
- Revised Self-care Behavior Scale (ARTINIAN);
- Client Satisfaction Questionnaire (CSQ-8) [only on completion].

2.2.4 Summary of Methods

A multivariate mixed model design was used to assess the effects of study groups (Usual Care, Health Lines, Health Lines plus monitoring) on patient outcomes over time. The following table 2 indicates the dependent, independent and control variables for the multivariate analysis.

Table 2: Description of dependent, independent and control variables used in the Health Lines study

Variable type	Name	Data type	Categories	Reference group
Dependent	Primary care physician visits	Continuous		
	Specialist visits	Continuous		
	Hospital separations	Continuous		
	Hospital Length of stay	Continuous		
	Costs	Continuous		
Independent	Study or intervention group	Categorical	Standard care Standard care plus Health Lines Standard care plus Health Lines plus in-house monitoring	Standard care
Control	Gender	Categorical	Female Male	Female
	Age	Continuous		
	Geography	Categorical	Winnipeg Regional Health Authority Central Regional Health Authority	Winnipeg Regional Health Authority
	Congestive Heart Failure severity	Categorical	Level 2 Level 3 Level 4	Level 2
	Health care utilization	Continuous		

2.2.5 Summary of Results

The following highlights the findings of the multivariate analyses on a range of healthcare use outcomes, including primary care and specialist physician visits, hospital separations and lengths of stay.

- As compared to the control group, age and sex adjusted rates of healthcare use were significantly lower for patients in one or both of the intervention groups, for outcomes such as all-cause primary care physician visits (i.e., all visits to a primary care physician, irrespective of the physician's diagnosis), CHF-specific primary care physician visits, as well as all-cause visits to cardiac specialists. Conversely, adjusted rates of use were similar across study groups, for hospital separations and lengths of stay.
- analyses of costing data (combined for all-cause primary care and specialist physician visits, and all-cause hospital separations), demonstrate lower costs associated with healthcare use for each study group as compared to the control group.
- While not directly related to the health lines interventions, additional findings help to define patterns of healthcare use for patients with CHF, summarized as follows:
    - Irrespective of the health lines interventions, similar rates of GP visits were reported for patients in each of the Winnipeg and Central RHAs. However, rates of cardiac and internal specialist visits were higher for patients in Winnipeg, while rates of hospital separations were higher for

patients in the Central RHA. These data help to describe differences in patterns of health use in urban versus more rural geographies.

- Patient age was directly related to primary care visits, with older patients having higher rates of these visits. Conversely, older patients had lower rates of visits to cardiac and internal specialist physicians.
- The findings also demonstrated a relationship between patient heart failure severity and subsequent health care use. Patients with more severe heart failure (measured at study baseline) subsequently had more visits to primary care physicians during the study period, but fewer visits to cardiac and specialist physicians.
- Irrespective of the health lines interventions, patients with higher rates of healthcare use at baseline generally had higher rates of health care use during the study period. This result was found for all-cause visits to primary care and internal specialist physicians, as well as hospital lengths of stay.

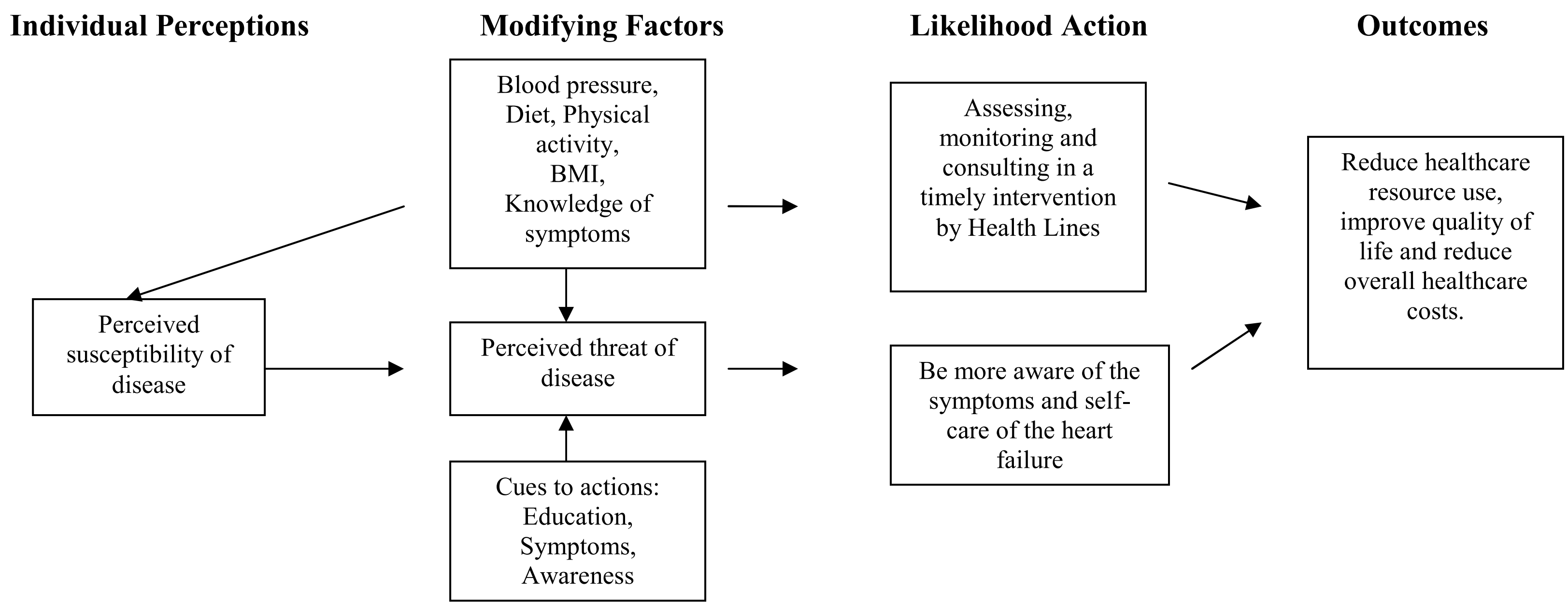
No economics evaluation was concluded as part of this study. While the costs of healthcare utilization were collected for each patient, direct costs of offering the program were not included. Moreover, utilization costs were treated as dependent variables to be predicted by a variety of patient-specific characteristics. Aggregate costs were not compiled by study group, nor were costs compared with evidence of program effectiveness.

2.3 Conceptual framework

The conceptual framework of this study is outlined in Figure 1 based on the Health Belief Model (HBM) (Glanz, Rimer, & Viswanath, 2002). The HBM is a psychological model commonly used in health education and promotion. The components of HBM mainly address perceived seriousness, perceived susceptibility, perceived benefits, perceived barriers, modifying variables, cues to actions and self-efficacy. The underlying concept of HBM is that health behavior is determined by personal beliefs or perceptions about a disease and the strategies available to decrease its occurrence (Hochbaum, 1958). A person who perceives a disease threat will change his or her behavior, if health professionals make them believe that once they give up the health risk behaviors and take the appropriate actions, health outcomes will improve.

According to HBM, educating patients about heart failure prevention and monitoring the signs and symptoms of the disease state provide a model of chronic disease management for congestive heart failure patients through a timely health contact intervention.

Figure 1: Conceptual framework of this study



Source: Health Belief Model (Glanz et al., 2002)

Chapter 3

Economic Evaluation: Methodology

This economic evaluation uses the qualitative and quantitative data collected for the Health Lines study, and combines it with cost data for the intervention. Specifically, it makes use of costing data of healthcare services utilization, cost data for the intervention program, and outcomes from the Revised Self-care Behavior Scale, SF-36, and client satisfaction questionnaires. The program operating costs and development costs of running the Health Lines program were obtained from the Manitoba Provincial Health Contact Centre.

3.1 Study design

This study is an extension of the Health Lines research project. It is a secondary analysis designed to conduct a cost-benefit and cost-effectiveness analysis of the intervention. As such, the design decisions of the original research team constrain the way this study is conducted.

3.2 Study sample selection

The data were elicited from a total of 179 patients who participated in the Health Lines study. Data cleaning was done based on the following criteria: 1) patients under 40 years old were deleted; 2) two observations did not have a clear enrollment date and were missing values in all variable fields; and 3) two observations' completion dates were earlier than their enrollment dates. This study filtered five invalid records and a total of 174 patients' records were used for the analysis.

3.3 Study instruments

3.3.1 Costs measurement

The economic costs of the telehealth program interventions depend upon the perspective adopted. Since we are conducting this analysis from the perspective of the healthcare system, only direct costs are included. Patient costs, such as time away from work or travel costs, are excluded. No capital costs were incurred during the study period because the PHCC used the existing fixed asset at Misericordia Health Centre to deliver the services. The direct costs include all expenses from the healthcare sector associated with the program. Specific cost items included equipment and technology cost, personnel wages, technician assistance, travel expenses, administrative supports and supplies. The following intervention cost data represents one year expenditure during the Health Lines study period (table 3).

Table 3: Cost categories of Health Lines intervention program

Staffing salaries	**-** physician, project manager, nurses etc;
Setting up and operating costs	-Nurse travel (Telemonitoring management) -Meeting and events -Telephone, long distance charges -Technician assistance -Travel, conference fees -Programming & software enhancement -Telemonitoring device -Software acquisition

Source: Manitoba Provincial Health Contact Centre, 2010

Healthcare utilization data were obtained between the enrollment to the intervention completion. Two main types of healthcare utilization data were included in the data collection: healthcare utilization for all causes and healthcare utilization specifically for congestive heart failure. The costs for healthcare incorporated all utilization data, such as family physician visits, physician specialist visits, cardiac physicians visit, internist specialists, and hospital in-patient days. The congestive heart failure specific utilization data were categorized if there was a diagnosis of congestive heart failure (*International Classification of Disease (ICD), Ninth Revision code 428 and Tenth Revision code 150*). (Note that whether a physician visit carries this diagnosis may depend on the peculiarities of the practice, and therefore the congestive heart failure specific data will underestimate total costs for congestive heart failure specific visits. Therefore, we conducted the analyses in terms of both congestive heart failure specific costs and total healthcare costs.) These healthcare service costs are used to determine whether Health Lines reduced overall healthcare utilization costs compared with the standard treatment. Table 4 presents detailed comparisons for healthcare service cost items from the Health Lines study.

Table 4: Healthcare utilization costs

Service Category	Healthcare Cost
Primary care physicians	- Family physicians visits for all reasons at baseline, 3 months, 6 months, 9 months, 12 months ;
Primary care physicians_CHF	- Family physicians visits for CHF at baseline, 3 months, 6 months, 9 months, 12 months ;
Specialists	- Physician specialist visits for all reasons at baseline, 3 months, 6 months, 9 months, 12 months ;
Specialists_CHF	- Physician specialist visits for CHF at baseline, 3 months, 6 months, 9 months, 12 months ;
Cardiac physicians	-Cardiac physician visits for all reasons at baseline, 3 months, 6 months, 9 months, 12 months ;
Cardiac physicians_CHF	- Cardiac physician visits for CHF at baseline, 3 months, 6 months, 9 months, 12 months ;
Internist specialists	- Internist specialist visits for all reasons at baseline, 3 months, 6 months, 9 months, 12 months ;
Internist specialists _CHF	- Internist specialist visits for CHF at baseline, 3 months, 6 months, 9 months, 12 months ;
Hospital in-patient days	-Hospital in-patient days for all reasons at baseline, 3 months, 6 months, 9 months, 12 months ;
Hospital in-patient days_CHF	--Hospital in-patient days for CHF at baseline, 3 months, 6 months, 9 months, 12 months ;

3.3.2 Effectiveness measurement

The effectiveness data for the Health Lines interventions are crucial to the cost-effectiveness analysis. The effectiveness data assess the health consequences of interventions in terms of their impact on health-related quality of life. The measures of effectiveness in the recent literature used multiple outcome measures to evaluate the intervention effectiveness, ranging from impact on process to final outcomes. These measures varied from diagnostic accuracy, blood glucose levels, body mass index, mental health, physical capability and quality-adjusted life-years gained (Bergmo, 2009).

The main effectiveness measures for this study are based on a series of survey questionnaires which were collected by the Health Lines study. These survey instruments measured the intervention outcomes from different point of views:

1. *The Short Form-36 (to assess quality of life)*

The Short Form-36 (SF-36) is a standardized health questionnaire designed to measure functional health and well-being from the patient's point of view. It consists of 36 items that assess eight dimensions of health status (Ware & Sherbourne, 1992). The eight dimensions are:

- physical functioning (PF, 10 items): limitations in physical activities due to health problems;
- role limitation-physical (RP, 4 items): limitations in usual role activities due to physical problems;
- role limitation-emotional (RE, 3 items): limitations in usual role activities due to emotional problems;
- social functioning (SF, 2 items): limitations in social activities due to physical or emotional problems;
- general mental health (MH, 5 items);

- energy and vitality (EV, 4 items),
- bodily pain (BP, 2 items), and
- general health perception (GH, 5 items).

Scores on each scale range from 0–100, with a score of 100 indicating the highest rating of health. In addition, a Mental Component Summary scale (MCS) and a Physical Component Summary (PCS) scale can be derived from these eight scales by factor analysis.

2. Revised Self-Care Behavior Scale

Self-Care behavior was assessed using the Revised Heart Failure Self-care Behavior Scale (ARTINIAN), a modified version of the Heart Failure Self-care Behavior Scale (Jaarsma et al, 1999). This 29 item scale is based on Orem's Theory of Self-care (Orem, 1991) and has been used previously by researchers in combination with the Minnesota Living with Heart Failure Questionnaire (MLWHFQ), to assess interventions for patients with CHF. This scale outlines activities that patients with CHF must perform to some extent so that they can continue to function in their daily life. As examples, patients are asked if they take their medications daily, if they contact their doctor when they are short of breath, and if they spread their activities out over the whole day so that they do not get too tired (Arinian et al, 2003; Artinian, Magnan, Sloan, & Lange, 2002). The content validity of this scale has been determined by a panel of experts; Chronbach's α test-retest reliability is reported at 0.84 & 0.81 (Artinian, et al., 2003).

3. Client Satisfaction Questionnaire (CSQ-8) (only on completion)

A Client Satisfaction Questionnaire is an eight-item questionnaire used to measure client general satisfaction with services on completion of the project. The CQS-8 was developed to provide a brief, standard assessment for the interventions. Each question has four response choices, where one indicates the lowest rating of degree of satisfaction and four indicates the highest degree of satisfaction with the services. According to Larsen DL, Attkisson et al. (1979), client satisfaction ratings may be elicited by telephone, mail, or interview. Attkisson and Zwick (1982) report excellent performance related to the CSQ-8 for internal consistency ($\alpha = .93$) and validity (Attkisson & Zwick, 1982).

As mentioned in Chapter 2, the first two survey instruments were used at baseline, 3, 6, 12 months of the interventions, while the last survey instrument of the CQS-8 was used only on project completion. The results from the above survey instruments were used to assess the intervention effectiveness. The mean scores will be calculated for survey instruments 2 and 3 and survey instrument 1 will be used to calculate quality adjusted life years (QALYs), which combine increased life expectancy and improvements in health status.

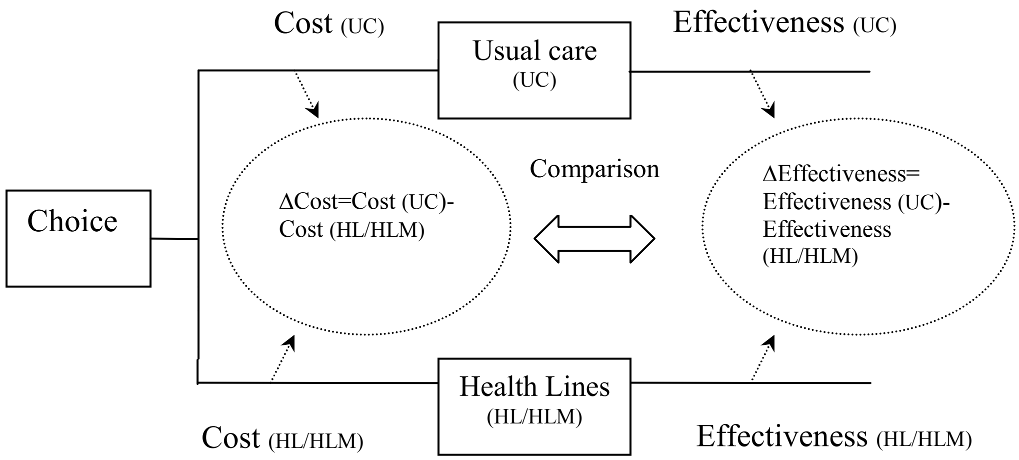
3.4 Cost-effectiveness analysis

Cost-effectiveness is one form of full economic evaluation where both cost and health consequences of interventions in terms of their impact on quality of life and healthcare utilization averted are examined. This method is to help determine which health intervention provides the most effective care within a budget constraint. Cost effectiveness analysis can provide useful information to inform healthcare decision making.

In this study, I will make a comparison of costs and consequences between the usual care and Health Lines interventions based on: (i) when costs are equal, the more effective the better; (ii) when effectiveness is equal, lower costs are better; (iii) if both effectiveness and costs are not equal, I will assess the ratio of incremental cost (ΔC) and incremental effectiveness (ΔE) or the incremental cost-effectiveness ratio of each strategy. The incremental cost-effectiveness ratio (ICER) - the cost per unit of effect- is the most used measure of program cost-effectiveness, with lower ICERs more cost-effective than higher. The incremental effectiveness associated with Health Lines relative to usual care is the change of health benefits measured in terms of quality adjusted life years (QALYs) gained from the intervention. The incremental cost is the difference between the program intervention costs for Health Lines and standard care. ICER is the ratio of additional costs to additional benefits; it will be calculated to compare Health Lines intervention strategy to the standard care for congestive heart failure patients and will be expressed as the difference in cost incurred per additional QALY.

Figure 2 below shows that the incremental cost-effectiveness model for this study which is formulated in terms of a choice between usual care and either Health Lines intervention for congestive heart failure patients.

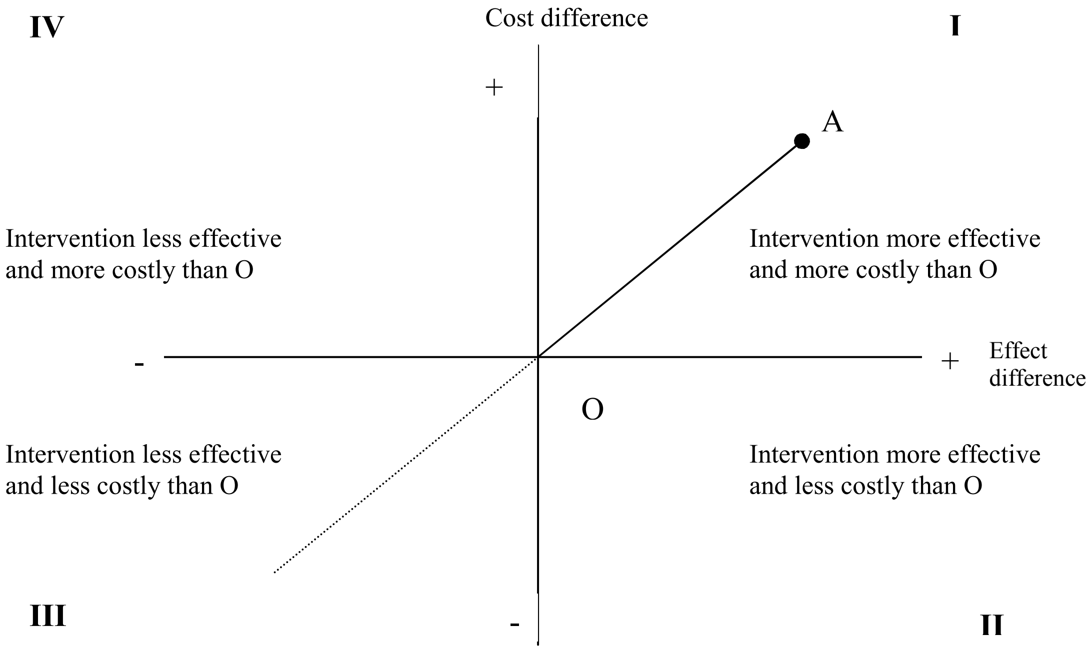
Figure 2: Diagram of the incremental cost-effectiveness analysis



Source: Drummond, Sculpher, Torrance, O'Brien, & Stoddart (2005)

Black (1990) created a framework for conceptualizing the results of a cost-effectiveness analysis called the cost-effectiveness plane shown in figure 3 (Black, 1990). The cost-effectiveness plane explains the costs and effects of an intervention compared to some alternatives. In this diagram, point A is the intervention and the origin O represents the comparison intervention. If point A is in quadrants II or IV, the choice is clear. In quadrant II, costs are lower and effects are greater, so the intervention dominates its alternatives and should be taken. In quadrant IV, costs are higher and effects lower; therefore the intervention is dominated by the alternative. If point A is in quadrants I or III, it implies that greater effectiveness is gained at a higher cost, while a reduction in costs is achieved only with poorer outcomes. In these two quadrants, whether or not the intervention should be undertaken depends on the trade-off a decision-maker is prepared to make between costs and effects.

Figure 3: Diagram of the cost-effectiveness plane



Source: Adapted from Black (1990)

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3.4.1 Measuring quality adjusted life years (QALYs)

QALYs measure morbidity and mortality on the same scale. The Panel on Cost-Effectiveness in Health and Medicine (1996) recommended the use of QALYS in cost-effectiveness studies so that comparisons between different interventions can be made (Siegel, Weinstein, Russell, & Gold, 1996). Since 1996, their use has grown in cost-effectiveness analysis.

To obtain QALYs, a conversion formula developed by Brazier et al. will be used. This method is chosen because it is based on the well-validated and commonly used SF-36 (Brazier, Roberts, & Deverill, 2002). The SF-6D is a classification for describing health derived from a selection of SF-36 items. It is composed of six multi-level dimensions. Any patient who completes the SF-36 can be uniquely classified according to the SF-6D. The SF-6D scoring algorithm computer program (non-commercial application) is provided by the University of Sheffield, UK. This scoring algorithm will be used to calculate QALYs in this study.

3.5 Cost-benefit analysis

Unlike the cost-effectiveness analysis, cost-benefit analysis compares the total of benefits to the total costs of an intervention, all measured in dollar units. Cost-benefit analysis is used to determine allocative efficiency. It addresses the question: “Does this program pay for itself?” Cost-benefit analysis will determine if the Health Lines benefit exceeds its cost. The higher the benefit-cost ratio (BCR), the better the intervention strategy is. If BCR is greater than 1, then there is a positive net benefit from this investment. If the BCR is lower than 1, then it has a negative net benefit, and does not pay for itself.

3.6 Statistical analyses

The healthcare utilization cost was non-normally distributed due to skewness from several high-cost outliers. Therefore, non-parametric tests were used to test if there is a statistically significant difference in costs across three study groups at 5% significance level. The mixed effects repeated measures models were used to test if there are statistically significant differences in effectiveness in terms of SF-6D utility and SF-36 domain scores over time and between groups.

A non-parametric bootstrap with replacement method and 1,000 replications was used to estimate the confidence interval for cost and effect differences (Drummond et al., 2005).

Data manipulation programming and all statistical analyses were performed using SAS (version 9.2, SAS Institute, Inc., Cary, N.C.).

3.7 Ethics

Prior to conducting this research project, application for ethics approval was made to the University of Manitoba, Bannatyne Campus, Research Ethics Board in April 2010. The Health Research Ethics Board (HREB) approved it on May 19, 2010 (Ethics reference number: H2010:164). Since the data contain personal health information, Health Information Privacy Committee (HIPC) approval was sought and granted from Manitoba Health in July 2010 (File number: 2010/2011-09). A research agreement was made with the Manitoba Centre for Health Policy in November 2010 because this study used data from the Population Health Research Data Repository. An agreement for access to personal health information for research purpose from Misericordia Health Centre (MHC) has also been approved.

Chapter 4

Results & Analysis

This chapter provides an in-depth description of the findings from the statistical analyses, cost-effectiveness analysis and cost-benefit analysis conducted for this study. The results are described in the following sections.

4.1 Sample characteristics

Data were analyzed for a total of 174 patients who enrolled in the Health Lines study between April 25, 2005 and April 12, 2006. The last day of the Health Lines study was September 25, 2006, therefore, the intervention period ranged from 166 to 518 days, which means that some of the later enrollees have fewer outcome measures. The description of the sample population is presented in table 5. Approximately 1/3 was randomly allocated to each study group. The average age of all patients was 75 (SD 12) years. The average age of patients in the three groups were 75 (SD 12) years in the control group, 76 (SD 11) in the HL group and 74 (SD 12) in the HLM group. The participants include 90 (52%) females and 84 (48%) males. Seventy-three (42%) of all patients were 80 years and older. Sixty percent (104) of patients resided in the Winnipeg Health Region, while 70 (40%) patients were from the Central health region. More than 1/3 patients (82) had moderate stage of heart failure and 31% (54) of all study patients had an advanced stage of heart failure.

Table 5: Demographic characteristics across three study groups

Variable	Overall	Control	HL	HLM
		Gender		
Female	90 (52%)	24 (44%)	32 (52%)	34 (59%)
Male	84(48%)	31 (56%)	29 (48%)	24 (41%)
		Age group		
40-59	23 (13%)	8 (15%)	7 (12%)	8 (14%)
60-69	33 (19%)	17 (27%)	10 (17%)	16 (27%)
70-79	44 (25%)	15 (23%)	17 (28%)	12 (21%)
80 and older	73 (42%)	25 (45%)	26 (43%)	22 (38%)
		Geography		
WRHA	104 (60%)	34 (62%)	36 (59%)	34 (59%)
Central RHA	70 (40%)	21 (38%)	25 (41%)	24 (41%)
		CHF severity*		
NYHA class II	38 (22%)	11 (20%)	14 (23%)	13 (22%)
NYHA class III	82 (47%)	27 (49%)	30 (49%)	25 (43%)
NYHA class IV	54 (31%)	17 (31%)	17 (28%)	20 (35%)

*New York Heart Association functional status

As compared to the control group, healthcare service utilization for all causes was lower in both intervention groups although this is not significantly different between groups (p=0.3893). Winnipeg patients in the intervention groups had fewer emergency department visits, but there are no statistically significant differences between the three study groups. The number of CHF healthcare visits was apparently higher in the intervention groups, but it was not significantly different from the control group[1] (p=0.1147). CHF specific primary care visits accounts for roughly 10% of all cause primary care visits of each group (table 6). This finding indicates that the patients might have co-morbidity conditions. The number of deaths during the intervention period was small in each group. There were 3 deaths in the control group, 3 deaths in the HL group; and 5 deaths in the HLM group respectively. Differences between groups are not statistically significant.

Hospital in-patient days during the intervention are summarized in table 7. Patients in the control group had more all-reasons hospital inpatient days than both intervention groups, but the differences were not significant. However, hospital inpatient days for CHF were significantly higher for the intervention groups relative to the control group ($p<.05$).

Tables 20 to 22 in Appendix A show the counts of healthcare contacts for all causes and for CHF in each 90-day intervention period. These tables detail the primary care visits and hospitalizations, including family physician visits, physician specialist visits, cardiac specialist visit, and internist visits as well as in-patient days. In each study group, patients had more healthcare visits at the baseline and the first 90-day intervention period

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[1] Recall that not all CHF related contacts will be flagged as CHF-related by the data. Identification, particularly for physician visits, depends on the practice of the physician.

than in subsequent periods. This is probably because the study was stopped early before all patients had been followed for a year.

Table 6: Counts of primary care and emergency contacts by groups[2]

Study group	Overall	Baseline	0-3 months	4-6 months	7-9 months	10-12 months
Visits for all reasons						
Control	2,110	596	594	362	282	276
HL	1,908	513	579	348	258	210
HLM	1,584	566	377	303	182	156
Visits related to CHF						
Control	224	67	70	41	25	21
HL	257	98	80	31	26	22
HLM	219	87	42	46	24	20
Emergency department visits*						
Control	45	24	12	NA	4	5
HL	37	11	14	NA	7	5
HLM	30	12	11	NA	7	0

*Only include patients in Winnipeg Health Region

[2] No significant difference in healthcare utilization between groups.

Table 7: Counts of hospital in-patient days by groups[3]

Study group	Overall	Baseline	0-3 months	4-6 months	7-9 months	10-12 months
For all reasons						
Control	626	121	141	197	111	56
HL	326	57	104	62	46	57
HLM	269	50	107	72	24	16
Related to CHF						
Control	0	0	0	0	0	0
HL	7	0	7	0	0	0
HLM	106	18	64	20	0	4

[3] No significant difference between groups.

4.2 Annual experimental cost for the Health Lines intervention program

The cost of the program intervention was estimated from a healthcare provider's perspective using an accounting approach. The direct costs of providing the service consisted of staff salaries, telemonitoring devices for the HLM group, software acquisition, travel, technician assistance, programming and software enhancement and telephone cost. All direct costs were allocated to each patient in the intervention groups over a one year period. The expected life of telemonitoring device was estimated at 5 years and the cost of purchasing the telemonitoring items has been depreciated over this time period using a straight line method. Thus, the yearly estimated telemonitoring cost was $14,732.

Table 8 lists the total expenditure of the health line services provided by the Provincial Health Contact centre during the intervention period. The total expenditure for delivering the telehealth intervention program for the congestive heart failure patients was $235,397, of which the total staff salaries accounted for $210,183 (89%), and total set-up and operating cost for $25,214 (11%). Thus, the per capita cost of the intervention program for HL and HLM study group subjects was:

A) Annual cost per capita of HL group = $\dfrac{\text{Grand total cost-telemonitoring device}}{\text{Number of HL patients + Number of HLM patients}}$

$$= \frac{\$220{,}665}{119}$$
$$= \$1{,}854$$

B) Annual cost per capita of HLM group=A + $\dfrac{\text{telemonitoring device}}{\text{Number of HLM patients}}$

$$= \$1{,}854 + \$254$$
$$= \$2{,}108$$

Table 8: Annual costs of CHF intervention program

	Cost
Staffing cost salary	
-physician, project manager, nurses	$210,183
Setting up and operating cost	
-Telemonitoring devices	$14,732*
- Software acquisition	$0
-Nurse travel (Telemonitoring management)	$0
-Meeting and events	$2,399
-Telephone, long distance charges	$568
-Technician assistance	$4,247
-Travel, conference fees	$3,268
-Programming & software enhancement	$0
Grand Total	$235,397

*Telemonitoring devices were depreciated over a 5-year expected lifetime.
Source: Manitoba Provincial Health Contact Centre, 2010

4.3 Healthcare utilization cost

Two types of healthcare utilization cost data were analyzed: 1) healthcare utilization cost for all reasons and 2) healthcare utilization cost with a diagnosis of congestive heart failure. The cost data for healthcare services in this study are skewed, because costs are naturally bounded by zero and there are a small proportion of patients with very high costs. Therefore, this small number of patients has a much bigger effect on mean cost. Faced with skewed data, Drummond et al. suggested presenting as much detail about the cost distribution as possible. Therefore, both mean and median costs of the healthcare service were reported by this study (Drummond et al., 2005).

Table 9 presents the mean (SD) and the total cost[4] for all-reason visits to primary care providers and hospitalizations for three study groups. Compared to the control group, both HL and HLM intervention groups had lower healthcare utilization costs, including both inpatient and outpatient costs. The one-year mean cost of healthcare utilization for all causes was $7,151 for the usual care group, $4,576 for the HL group and $4,203 for the HLM group respectively. Overall the healthcare costs per patient were higher in the control group, but the difference is not statistically significant (p=0.7765). Figure 4 compares the total inpatient and outpatient costs for the three study groups. Inpatient costs were found to account for a big proportion (more than 70%) of the total cost of healthcare utilization in each study group.

Table 23 in Appendix A compares the mean (SD) cost of healthcare utilization of each study group for all cause visits and for a diagnosis of congestive heart failure visits for each 90-day period of the study period. Differences in the total cost were not

[4] Not including ER visit cost of Winnipeg patients.

statistically significant between groups, but there was a decrease of mean cost during the last 90-day study period compared to the baseline for each group.

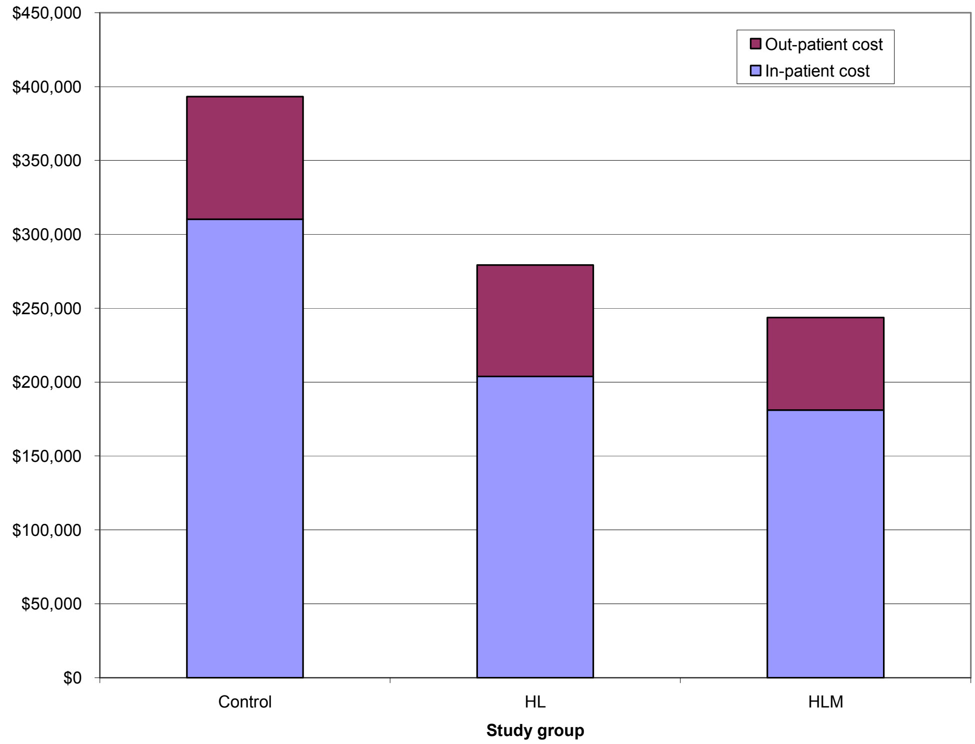
The mean cost for all-cause visits was also not significantly different by gender, geographical location, age groups and New York Heart Association functional status between groups (Appendix A). Females and males in the control group had the highest mean cost of healthcare utilization for all reasons compared to the two telehealth intervention groups. Patients with an advanced stage of heart failure had relatively higher mean cost. However, in most cases there was no statistically significant difference between groups.

Table 9: Healthcare utilization costs for the three study groups

	Control	HL	HLM	*p**
		For all reasons		
Mean (SD) cost	$7,151 (18106)	$4,576 (9,996)	$4,203 (8,651)	
Median cost	$1,054	$788	$1,025	
Total cost	$ 393,316	$279,158	$243,770	0.7583
Minimum cost	$98	$47	$178	
Maximum cost	$118,407	$65,894	$42,775	
		With a diagnosis of CHF		
Mean (SD) cost	$180 (376)	$198 (474)	$1,212 (4504)	
Median cost	$33	$92	$66	
Total cost	$9,915	$12,050	$70,283	0.2804
Minimum cost	$0	$0	$0	
Maximum cost	$2,435	$3,592	$24,818	

*Non-parametric Kruskal-Wallis test

Figure 4: Comparison of total inpatient and outpatient costs for the three study groups



Emergency department costs for the Winnipeg patients were also estimated in this study. Dawson and Zinck determined the ED spending in Canada in 2005-2006 based on CIHI's Canadian Management Information Systems Database. They found that the average cost per ED visit in Manitoba was $103 (Dawson & Zinck, 2009). Using this estimated ED cost per visit, the total cost of ED visits in each 90-day intervention period was quantified as shown in table 10. All study groups had higher ED costs at baseline and the first 90 days. Both intervention groups had a decreasing trend of ED spending over time. However, the costs of ED visits for the intervention groups were not significantly different from the control group.

Table 10: Estimated total cost for Emergency Department visits for all reasons for patients in Winnipeg Health Region

	Control	HL	HLM	*p*
Baseline	$2,892	$1,326	$1,446	0.1807
0-3 months	$1,446	$1,687	$1,326	0.9852
4-9 months	$482	$844	$844	0.8783
10-12 month	$603	$603	$0	0.1094

*Non-parametric Kruskal-Wallis test

4.4 Survey outcomes

Study participants were asked to complete surveys during the study period at baseline, 3 months, 6 months and 12 months. The following filters were used to remove invalid surveys for three reasons: 1) surveys occurring after September 25, 2006 (when WRHA started providing the intervention to the control group); 2) surveys completed one month or more after people indicated they were formally out of the study; 3) people with only one survey.

A total of 410 surveys were used to analyze the effectiveness of the intervention, including 131 patients who completed baseline and the first follow-up surveys, 92 patients who completed the second follow-up survey and 56 patients who completed the last survey. The follow-up surveys were completed, on average, at 100 days (follow-up survey one), 191 days (follow-up survey two) and 365 days (follow-up survey three) after study enrollment. Patient demographics were similar comparing this sub-sample to the overall study group. For example, 51.1% of the survey sample was female with an average patient age of 75.1 years. Fifty-five percent of patients resided in the WRHA and 31.8% of all patients had an advanced stage of heart failure.

Table 11: Survey sample distribution by study group

Study group	Baseline	First follow-up survey	Second follow-up survey	Third follow-up survey
Control	44 (33.59%)	44 (33.59%)	31 (33.70%)	19 (33.93%)
HL	47 (35.88%)	47 (35.88%)	32 (34.78%)	18 (32.14%)
HLM	40 (30.53%)	40 (30.53%)	29 (31.52%)	19 (33.93%)
Total	131	131	92	56

4.4.1 Outcome of SF-36

Health status can be measured by using the SF-36 questionnaire. The mean scores (SD) of the eight SF-36 health domains and health utility are presented in table 13. Each domain is scored from 0-100, with higher scores representing better health. Mixed effects repeated measures models were used to test the statistical significance of each health domain score for four surveys over time between groups. Significance level was set at $p<.05$.

Overall, the domain scores of SF-36 physical functioning and role limitation (physical) were significantly different over time among groups. In particular, physical functioning was observed to be significantly different between groups over time ($p=0.0011$). The domain scores of bodily pain and role limitation (emotional) were significantly different between groups. None of other health domains were observed significantly different over time or between groups.

In order to use this information in a cost-effectiveness analysis, SF-36 scores in the eight domains were converted to a single 'preference based' utility score indicating the value that would be placed on a health state. The SF-6D algorithm was used to convert SF-36 responses and generate a utility score for each subject. The SF-6D is based on 6 of the 8 dimensions of SF-36 –'General Health' is omitted and 'role limitation (physical)' and 'role limitation (emotional)' are combined. Each dimension has a number of levels such as 'limited a lot' and 'limited a little' and the combination of levels over dimensions describes 18,000 ($=6\times4\times5\times6\times5\times5$) unique health states. Using a fractional factorial design, 249 health states were valued by a representative sample of the UK general population. The standard gamble technique was used to elicit utility values (Brazier et al., 2002). In this way, a utility score was generated for the different health states based on patients' responses to the SF-36 questions.

In order to generate the QALY, I used an algorithm developed by Brazier et al. to calculate the SF-6D utility scores from baseline, 3-, 6-, and 12-month SF-36 data (Brazier, Deverill, Green, Harper, & Booth, 1999). Table 12 illustrates that the SF-6D utility scores from the control group ranged from 0.59 to 0.63; the HL group ranged from 0.64 to 0.70; the HLM group ranged from 0.61 to 0.65. There are significant differences in QALYs between groups for the first survey. Mixed effects repeated measures models test the significant difference in the SF-36 utility scores between groups and over time for all four survey points and show that the SF-6D health utility for the intervention groups was significantly higher than the control group; the differences were also statistically significant between groups and over time.

Table 12: Mean (SD) QALY for intervention groups relative to the control group

	Control	HL	HLM	*p*
Baseline survey	0.60 (0.13)	0.65 (0.11)	0.61 (0.10)	0.1968
Follow-up survey 1	0.60 (0.11)	0.67 (0.12)	0.63 (0.11)	**0.0314***
Follow-up survey 2	0.59 (0.12)	0.64 (0.12)	0.62 (0.10)	0.2230
Follow-up survey 3	0.63 (0.12)	0.70 (0.10)	0.65 (0.11)	0.2408

*ANOVA test and the significance level was set at P<.05

Table 13: SF-36 mean (SD) domain scores and SF-6D mean (SD) utility score by group

SF36	Baseline			Follow-up survey 1			Follow-up survey 2			Follow-up survey 3			Time	Group	Time*study group
	Control (N=44)	HL (N=47)	HLM (N=40)	Control (N=44)	HL (N=47)	HLM (N=40)	Control (N=31)	HL (N=32)	HLM (N=29)	Control (N=19)	HL (N=18)	HLM (N=19)	*p*	*p*	*p*
Physical functioning	40.18 (27.61)	37.66 (28.85)	40.93 (27.62)	35.83 (23.79)	45.22 (29.84)	41.88 (28.77)	35.67 (26.90)	32.50 (26.09)	41.72 (29.80)	41.58 (29.30)	53.44 (23.36)	42.50 (29.67)	**0.0113**	0.5200	**0.0011**
Role Physical	28.29 (36.19)	37.41 (28.85)	33.13 (38.56)	25.61 (34.68)	42.02 (40.41)	33.13 (38.56)	19.17 (29.86)	30.47 (35.77)	26.72 (35.31)	38.16 (45.16)	39.06 (38.70)	38.89 (43.91)	**0.0317**	0.2537	0.8337
Bodily pain	53.30 (30.75)	64.28 (24.95)	56.00 (28.38)	50.93 (27.48)	66.04 (25.65)	54.56 (27.31)	54.27 (26.64)	61.78 (29.44)	49.14 (27.86)	53.05 (26.82)	80.67 (28.38)	60.33 (32.62)	0.1107	**0.0017**	0.2323
General health	44.61 (23.30)	45.93 (19.47)	44.73 (17.79)	46.10 (21.61)	49.13 (18.28)	45.85 (21.29)	47.43 (21.25)	46.13 (17.68)	42.52 (23.26)	49.05 (19.59)	55.63 (27.51)	40.17 (23.38)	0.2087	0.5341	0.5300
Vitality	39.20 (20.88)	42.17 (23.28)	42.50 (20.29)	39.64 (23.44)	44.36 (22.71)	41.67 (24.50)	38.17 (22.22)	39.69 (25.71)	41.72 (21.85)	41.84 (22.68)	45.67 (23.74)	36.11 (23.49)	0.9763	0.9205	0.4495
Social Functioning	61.08 (30.29)	73.91 (26.06)	73.13 (25.72)	62.80 (29.54)	75.00 (27.21)	71.88 (23.64)	62.08 (31.74)	69.53 (28.56)	66.38 (30.45)	63.82 (34.33)	77.50 (26.81)	73.61 (27.75)	0.5313	0.0598	0.9811
Role Emotional	49.61 (41.39)	62.77 (40.71)	57.50 (43.35)	55.69 (46.19)	72.34 (38.90)	61.67 (40.33)	53.33 (46.81)	69.79 (43.47)	60.92 (44.60)	59.65 (47.89)	77.78 (34.88)	75.93 (35.80)	0.0994	**0.0396**	0.9563
Mental health	68.64 (21.81)	75.48 (19.63)	71.25 (16.30)	71.19 (21.07)	78.38 (20.49)	73.85 (20.86)	70.67 (21.10)	79.25 (23.82)	75.17 (19.67)	73.82 (17.98)	78.93 (21.51)	81.78 (12.96)	0.1005	0.2882	0.4743
SF-6D utility	0.60 (0.13)	0.65 (0.11)	0.61 (0.10)	0.60 (0.11)	0.67 (0.12)	0.63 (0.11)	0.59 (0.12)	0.64 (0.12)	0.62 (0.10)	0.63 (0.12)	0.70 (0.10)	0.65 (0.11)	**0.0247**	**0.0452**	0.8993

*Domain scores range 0-100
**Mixed effects repeated measures models, p value was set <.05 for overall follow-up over time and follow-up difference between groups

4.4.2 Outcome of Self-Care Behavior Scale survey

The Revised Heart Failure Self-Care Behavioral Scale outlines activities that patients with CHF must perform to some extent so that they can continue to function in their daily life. As examples, patients are asked if they take their medications daily, if they contact their doctor when they are short of breath, and if they spread their activities out over the whole day so that they do not get too tired. Patients in this study were asked 29 questions about how often they demonstrated each behavior with a choice of 'none of the time' which scores a zero to 'all of the time' which scores a five on the Likert scale (Appendix B). Individual items are summed to provide scores from 0-145, with higher scores ranking better.

There is some evidence to suggest that health lines is an effective intervention for helping patients with CHF improve self-maintenance so that they can continue to function in their daily life. Based on the results (table 14), overall the control group had lower mean score than the study groups. The results also revealed a significant improvement in Self-Care Behavior in the intervention groups over time ($p<.05$).

Table 14: Mean (SD) score for Self-Care Behavior Scale Survey

	Control	HL	HLM	*P**
Baseline	98.48 (19.19)	105.90 (17.80)	101.90 (19.65)	0.1153
Follow-up survey 1	101.00 (15.43)	108.59 (20.70)	104.60 (19.29)	0.1219
Follow-up survey 2	103.31 (17.70)	106.06 (16.75)	102.61 (19.72)	0.6917
Follow-up survey 3	105.18 (19.00)	120.77 (17.80)	110.57 (17.52)	**0.0067**

* ANOVA test at 5% significance level

4.4.3 Outcome of client satisfaction survey

Patient satisfaction with the telehealth intervention was estimated using the Client Satisfaction Questionnaire administered when the study was completed. The questionnaire has an 8-item, 4-point Likert scale that asked a patient's general satisfaction with the telehealth intervention services that they were receiving. Examples of the questions included in this questionnaire are: "How would you rate the quality of the service you received?", "Did you get the kind of service you wanted?", "How satisfied are you with the amount of help you received?", "Have the services you received helped you deal more effectively with your problems?"

A total of 74 patients including 30 patients from the control group, 36 patients from HL study group and 8 from HLM study group completed the questionnaire. Most patients who responded to the survey (76%) were 70 years and older; 60% were female and 40% were male.

As a general measure of satisfaction, the mean total (SD) score results were: Control group patient 27.07 (4.38); HL patients 26.69 (4.35); HLM patients 28.88 (2.47) ($p = 0.4211$). Given that the maximum possible score in the CSQ-8 is 32, the patients' scores were high and similar within and across groups. Patients in the HLM intervention group gave the highest satisfaction scores for all questions.

Table 15 demonstrates the mean score for client responses to specific questions. These indicated that patients generally felt good about the quality of the services and thought it helped them deal more effectively with problems, even though no statistically significant differences were found between groups.

Table 15: Mean scores (SD) for the Client Satisfaction Questionnaire[5]

Client Satisfaction Question	Control (N=30) Mean (S.D.)	HL (N=36) Mean (S.D.)	HLM (N=8) Mean (S.D.)
How would you rate the quality of service your received? 1. Poor 2. Fair 3. Good 4. Excellent	3.50 (0.73)	3.36 (0.72)	3.63 (0.52)
Did you get the kind of service you wanted? 1. No, definitely not 2. No, not really 3. Yes, generally 4. Yes, definitely	3.40 (0.67)	3.22 (0.72)	3.50 (0.53)
To what extent has our program met your needs? 1. None of my needs have been met 2. Only a few of my needs have been met 3. Most of my needs have been met 4. Almost all of my needs have been met	3.07 (0.74)	2.86 (0.83)	3.13 (0.83)
If a friend were in need of similar help, would you recommend our program to him/her? 1. No, definitely not 2. No, not really 3. Yes, I think so 4. Yes, definitely	3.67 (0.55)	3.72 (0.51)	4.00 (0.00)
How satisfied are you with the amount of help you received? 1. Quite dissatisfied 2. Indifferent, or mild dissatisfied 3. Mostly satisfied 4. Very satisfied	3.33 (0.66)	3.28 (0.70)	3.63 (0.52)
Have the service you received helped you to deal more effectively with your problems? 1. No, they seemed to make things worse 2.No, they really did not help 3. Yes, they helped somewhat 4. Yes, they helped a great deal	3.20 (0.61)	3.19 (0.71)	3.25 (0.46)
In an overall, general sense, how satisfied are you with the service you received? 1. Quite dissatisfied 2. Indifferent, or mild dissatisfied 3. Mostly satisfied 4. Very satisfied	3.40 (0.67)	3.36 (0.72)	3.88 (0.35)
If you were to seek help again, would you come back to our program? 1. No, definitely not 2. No, I don't think so 3. Yes, I think so 4. Yes, definitely	3.50 (0.78)	3.69 (0.62)	3.88 (0.35)

[5] ANOVA test shows that there is no significant difference between groups at 5% significance level.

4.5 Does the intervention program pay for itself?

4.5.1 Cost-benefit analysis

The goal of the cost-benefit analysis is to determine whether the benefit of the Health Lines intervention exceeds its cost; a positive net benefit indicates the program will pay for itself. The benefits from the healthcare provider's perspectives are the immediate savings in terms of the utilization averted. The costs for this analysis include the costs of delivering the program. In the cost-benefit analysis, costs and benefits of the program were compared over the study period of one year and the consequences are expressed in monetary terms in order to see which is larger. The benefit-cost ratio is the healthcare system savings caused by reduced system utilization divided by the total costs of offering the telehealth program intervention. The higher the ratio, the better the intervention strategy is. If the ratio is greater than 1, then the intervention cost less to offer than it saves the provider in terms of reduced utilization. If the ratio is less than 1, the intervention costs more to offer than it saves.

As mentioned in section 4.2, the total program cost covered equipment, staff salaries and wages of physicians and nurses, etc. at \$113,114 (HL group) and \$122,283 (HLM group) respectively[6]. Compared to the control group, the total benefits from the averted healthcare utilization costs through the Health Lines intervention were \$114,158 and through the Health Lines plus Monitoring were \$149,546. Consequently, the Health Lines interventions generated a net savings for the healthcare system of about \$28,307.

Table 16 shows the benefit-cost ratio is 1.01 between the control group and HL intervention group, indicating approximately \$1.01 in savings was gained for every dollar spent on the HL intervention, for a total of was approximately \$1,044. Similarly, Table 17

[6] Program costs were calculated based on the cost items listed by table 8.

shows the benefit-cost ratio between usual care and HLM intervention is 1.22, which implies 1.22 in savings are gained for every dollar spent on the HLM intervention, for a total net saving of $27,263. Therefore, we conclude that the Health Lines intervention program is a valuable one that pays for itself. Health Line and Health Lines plus Monitoring intervention strategies for congestive heart failure intervention proved less expensive than usual care and should be implemented.

However, it must be noted that we could not demonstrate that the total costs of either intervention group were significantly different from the costs for the control group. Therefore, the “benefit” used to calculate the above ratio is a notional one and requires validation through ongoing monitoring after the program is introduced.

Table 16: Benefit-cost ratio between control and HL intervention group

Benefit (averted healthcare utilization costs)	Total program cost of HL intervention group	Net benefit (cost-saving) ($)	Benefit-cost ratio
$114,158	$113,114	$1,044	1.01

Table 17: Benefit-cost ratio between control and HLM intervention group

Benefit (averted healthcare utilization costs)	Total program cost of HLM intervention group	Net benefit (cost-saving) ($)	Benefit-cost ratio
$149,546	$122,283	$27,263	1.22

4.6 Cost-effectiveness analysis

Benefit-cost analysis suggested that telehealth was potentially cost saving, however we were unable to draw a strong conclusion because cost differences between groups were not statistically significant. Cost-effectiveness analysis can be used to evaluate an intervention even if it is not cost saving. Many health interventions cost more than usual care, but are justified because they yield additional benefits to the patient that more than make up for additional cost.

Cost-effectiveness analysis is complex because both differences in costs and differences in effects are taken into account in the analysis. The incremental cost-effectiveness ratio (ICER) measures the value of the Health Lines interventions. The ICER is the additional cost per additional unit of output or effect. To evaluate the ICER, the program costs of the interventions were divided by the additional QALYs generated by the intervention in order to generate a cost-effectiveness ratio for each intervention group. The incremental cost-effectiveness ratio tells us how much it costs to generate an additional QALY through each intervention.

The ICERs were calculated based on the first follow-up survey because there is a statistically significant difference in the health effects between groups. Table 18 shows the ICERs of the two interventions-HL and HLM. The ICERs in this table compared the intervention options by simply dividing an intervention's cost by its additional effectiveness. The ICER relative to HL intervention was $26,486/QALY; the ICER relative to HLM intervention was $70,266/QALY. The HLM intervention group had a higher ICER, indicating the cost of generating additional QALYs through HLM services was higher than generating additional QALYs through the HL intervention.

However, the above analysis is based purely on a point estimate of observed cost and effect. In order to allow for sampling variation, the sensitivity analysis below allows us to visualize uncertainty by employing a bootstrapping technique.

Table 18: Incremental cost-effectiveness ratio (ICER) based on the first follow-up survey

Study group	Increment cost	Incremental effectiveness	Incremental cost-effectiveness ratio
HL vs Usual care	$1,854	0.07	$26,486/QALY
HLM vs Usual care	$2,108	0.03	$70,266/QALY

4.7 Sensitivity analysis

The ICERs provide estimates of the mean cost per QALY gained by providing the program intervention. However, the ICERs may not have a normal distribution and the calculation in section 4.6 takes into account only the first survey point which is statistically significant. Moreover it only includes program cost. This section considers all four survey points and takes into account both the program costs and the health system savings generated by the program.

It is necessary to estimate the sampling distribution around the point estimate non-parametrically. The most appropriate technique is to use the "bootstrap" (Brigg, Wonderling, & Mooney, 1997). A non-parametric bootstrap with replacement method was used to create 1,000 resamples of the cost and effectiveness data from all four survey points for replacement. By using this method, 1,000 further hypothetical incremental costs and incremental effects were modeled.

Table 19 below shows that the mean increase in QALYs for each intervention over all four survey points, and the incremental cost of each intervention, taking into account health system savings as well as program costs. The simulation shows that the mean incremental costs of the interventions relative to the usual care were negative once we take into account savings from healthcare utilization averted: HL versus the usual care was -$1,789 (95% CI -$18,433, $12,282); HLM versus the usual care was -$7,410 (95% CI -22,952, $1,540). The mean incremental effects of the interventions were positive compared to the usual care: HL versus the usual care was 0.066 (95% CI -0.01, 0.130); HLM versus the usual care was 0.01 (95% CI -0.063, 0.088). Note, however, that neither incremental costs nor incremental effects were significantly different from zero.

The negative ICER indicates that by adopting Health Lines strategies rather than the usual care, there is improvement in life-years gained and lower expected costs. This finding suggests that both Health Lines strategies are cost-effective alternatives to usual care. However, since both mean incremental cost and mean incremental QALY intervals include zero, the interventions cannot be shown to be cost-effective at the conventional 5% significance level.

Table 19: Summery of mean incremental costs and effects from 1,000 bootstrap re-samples

	Mean incremental cost (2.5th-97.5th percentile)	Mean Incremental QALY (2.5th-97.5th percentile)	Mean ICER
HL vs Usual care	-$1,789 (-$18,433,$12,282)	0.066 (-0.01, 0.130)	-$27,523
HLM vs Usual care	-$7,410 (-22,952,$1,540)	0.01 (-0.063, 0.088)	-$741,000

Using the above data from the bootstrap sample, the cost-effective plane diagrams resulting from 1,000 bootstrap replications of the incremental cost and effectiveness were plotted in figures 5 and 6. The scatter diagrams depict the mean difference in costs and effects from a bootstrap sample (N=1,000) with replacement from this study. Incremental cost and effect data are combined on a two dimensional cost effectiveness plane. It models the cost difference in one dimension and the effect difference in the other.
The bootstrap replications in each quadrant have different implications. If the bootstrap replications fall in the southeast quadrant (quadrant II) (negative costs and positive effects), the decision on the intervention is clear and considered cost-effective because the intervention costs less and generates better outcomes. By contrast, if the bootstrap replications fall in the northwest quadrant (quadrant IV) with positive cost and negative effect, the intervention is not considered cost-effective because it costs more and generates poorer outcomes. If the bootstrap replications fall in the southwest (quadrant III) and northeast (quadrant I), the decision making will be complex, because better outcomes come with a higher cost. The intervention may be cost-effective, depending on whether the bootstrap replications fall below the amount that decision makers are prepared to pay for better outcomes. The threshold is the amount of money which a decision maker is willing to pay for a quality-adjusted year of life. It is an administrative decision because the decision makers are responsible for the health service budgets.

Figures 5 and 6 illustrate the scatters of simulated bootstrap replications across the four quadrants of the planes. In figure 5, 56.9% of simulated bootstrap replications appear in the southeast quadrant, indicating that the Health Lines intervention will generate QALYs while at the same time reducing the overall cost of patient care. Approximately

39.6% simulated bootstrap replications fall in the northeast quadrant, indicating that QALYs are gained at increased cost (more costly, more effective). Few of these simulations show a reduction of QALYs.

Similarly, in figure 6, around 55.9% of simulated bootstrap replications fall in the southeast quadrant, illustrating that the HLM intervention produced beneficial effects and reduced costs for the healthcare system compared to usual care. Only 3.1% bootstrap replications fall in the northeast quadrant. In addition, about thirty-four percent of the bootstrap replications fall in southwest quadrant indicating no QALY gain but cost saving (less costly and less effective).

Figure 5: Cost-effectiveness plane from bootstrap sampling of Control and Health Line group patients

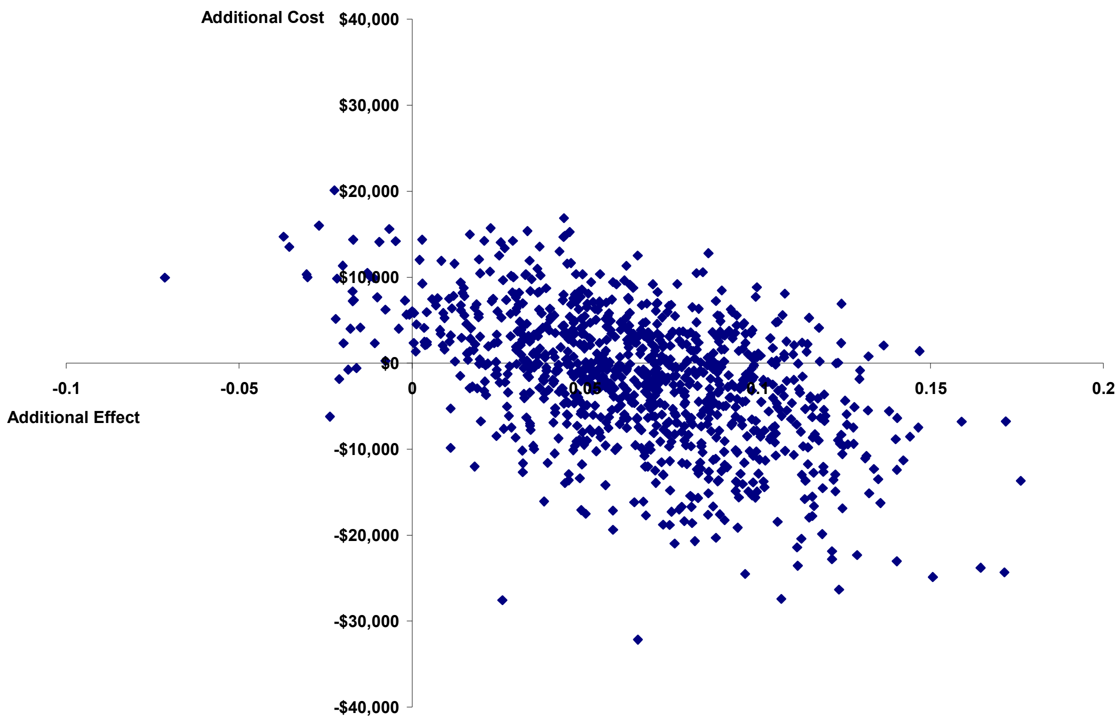
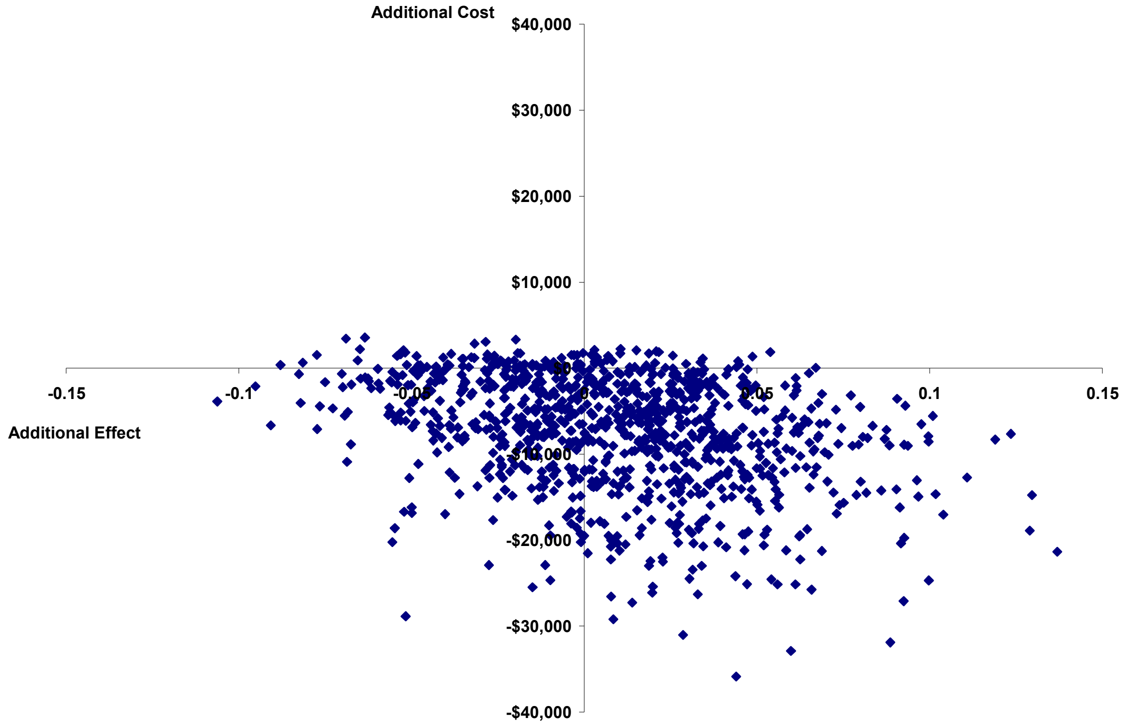


Figure 6: Cost-effectiveness plane from bootstrap sampling of Control and Health Lines plus Monitoring group patients



4.7.1 Cost-effectiveness acceptability curve

The cost-effectiveness acceptability curve (CEAC) is a method for summarizing the uncertainty in estimates of cost-effectiveness. The CEAC shows the probability that the intervention is cost-effective compared with the alternative in a range that the decision makers might be willing to pay for a unit change in outcome. The CEAC is derived from the joint distribution for incremental costs and incremental effects from the bootstrapping result and shows the probability that the decision evaluated is cost-effective (the y-axis), given joint uncertainty in model parameters for different values of the decision maker's willingness to pay for health benefit (the x-axis).

There is no explicit standard about an appropriate threshold [5.] This is an administrative and ultimately political decision. In this study, different thresholds between $0 and $100,000 were used to estimate the probability that the intervention will generate additional QALYs for less than the decision-maker is prepared to spend.

The corresponding cost-effectiveness acceptability curves are presented in Figure 7 which indicates a probability of 60% that the Health Lines intervention is cost-effective relative to usual care if the decision-maker is not prepared to spend anything to gain better outcomes for patients. That is, the potential cost-saving alone may be sufficient to justify the introduction of the intervention. Similarly, there is a probability of 63.1% that a Health Lines plus Monitoring intervention is cost-effective compared to usual care, even when the decision-maker will spend nothing to generate additional QALYs. If better outcomes for patients are taken into account, the probability that the intervention is

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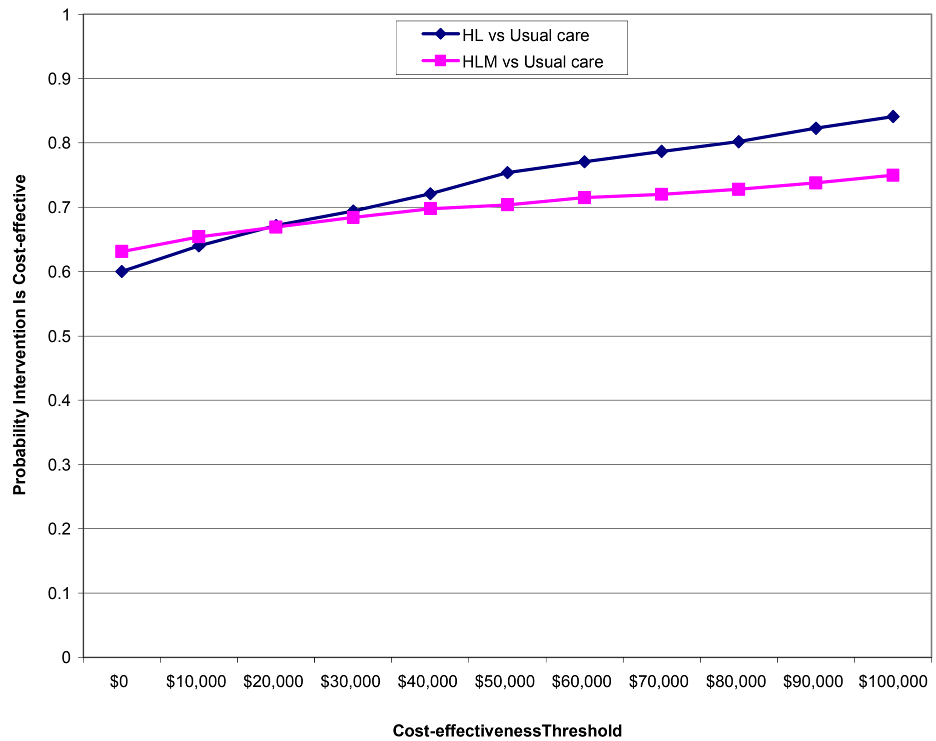
[7] The most popular arbitrary thresholds in the literature include from $20,000, $50,000 to $100,000. Among more than 500 published papers (Grosse, 2008)about cost-utility studies in 2003, half of al studies used a single value of $50,000 as the threshold, therefore, cost-effective studies often refer to use this amount as 'generally accepted'. The second most popular threshold is $100,000.

cost-effective increases. The most often used threshold in the literature is $50,000/QALY in the literature; at this point, a decision to adopt the HL intervention over usual care has a 75.4% probability of being cost-effective. A decision to adopt HLM over the usual care has a 70.4% probability of being cost-effective at that point. When the cost-effectiveness threshold exceeds $30,000, the HL intervention becomes more cost-effective than HLM. The curves cross as decision makers are prepared to pay more for an additional QALY. If they are not prepared to pay anything for an additional QALY, then HLM (the cheapest alternative when you take into account health system savings alone) dominates. As willingness to pay for additional QALYs increases, HL begins to dominate. These curves just represent another way of looking at the data in figures 5 and 6.

Figure 7: Cost-effectiveness acceptability curves



Chapter 5

Discussion

5.1 Summary of Findings

The purpose of this study was to determine whether Health Lines interventions are cost-effective interventions relative to the standard treatment for congestive heart failure patients from the Winnipeg and Central Health Regions in Manitoba. The first goal was to use a cost-benefit analysis to determine whether introducing HL and/or HLM would pay for itself in terms of health system savings.

Although there were program costs in providing HL and HLM, both interventions generated net health system savings through reduced utilization. Differences in total costs were not significant among groups, largely because the sample size was too small. If either program were to be introduced for all eligible patients, the larger sample size would likely demonstrate statistically significant cost reductions. Moreover, the per capita costs of offering the program would fall if the overhead could be spread over a greater number of patients. (There is no evidence that the program was operating at capacity.)

There are, however, sometimes reasons to offer a program even if it does not pay for itself. If patient health and satisfaction are improved, decision-makers might decide to pay an additional cost for a new program. Cost-effectiveness analysis allows us to compare the benefits patients derive from a program with the costs of offering the program.

Our cost-effectiveness analysis was also limited by sample size. We measured patient satisfaction with the Client Satisfaction Questionnaire, and found that patients in all three groups were very satisfied with their treatment. There were no statistically significant differences among groups. We used the SF-36, a generic Health-Related Quality of Life survey, to measure subjective health. Patients receiving either of the two interventions reported significantly better scores in physical functioning, physical pain, emotional health and overall health utility compared to the control group. Using an algorithm supplied by the University of Sheffield, we converted the SF-36 scores into Quality-Adjusted Life Years (QALYs) and found that there were statistically significant differences in QALYs generated by the three programs at the time of the first survey. A standard cost-effectiveness calculation, taking into account only the program costs and the significant QALY outcomes, demonstrated that the HL intervention could generate an additional QALY for $26,486 and HLM could generate an additional QALY for $70,266. The HL intervention falls well within the usual threshold of $50,000 that decision-makers sometimes adopt.

Finally, I conducted a sensitivity analysis to take into account the uncertainty associated with small samples sizes, and to try to generate advice helpful to decision-makers. Sensitivity analysis does not add any additional information to the statistical analysis already reported. It does, however, allow us to simulate outcomes to better estimate the probability that an intervention will be cost-effective.

When we took into account the increased QALYs generated by both interventions at all four survey points using mixed effects repeated measures models, and combined apparent health system savings with program costs to generate a net cost, the analysis suggests that both HL and HLM generate better outcomes at a lower cost than usual treatment. These results are associated with a great deal of uncertainty because most of the results we used in this part of the analysis were not statistically significant. That is, we report the results of a modeling exercise based on our best information.

Assuming that a decision-maker would be interested in implementing only one of the two interventions, our sensitivity analysis suggests that the best program to implement depends on how much the decision-maker values reduced healthcare system costs relative to improvements in subjective quality of life. Even though it costs more on a per capita basis to offer HLM, health system savings more than offset this cost. The more important a patient's subjective quality of life becomes to the decision-maker, the more cost-effective the HL strategy becomes.

This may seem odd. One would expect that reduced health system utilization would be associated with better health outcomes, and all the evidence suggests that HLM patients are receiving more appropriate care with lower overall costs. Yet, HL patients report better subjective health outcomes. It may be that HLM focuses attention of patients on their health to a greater extent than HL, which leads them to worry more about their health. It might be possible to find out more about why patients react the way they do through a qualitative study.

In any case, the decision about which program to implement belongs to the decision-makers responsible for allocating the healthcare budget. Our evidence suggests that either HL or HLM is better than usual care.

5.2 Study limitations and strengths

Like other studies, this study has its strengths and weaknesses. This study has four main strengths:

- a key strength is that both cost and effects were compared. Patient quality of life as the intervention effect was included to determine whether the patients benefit from the intervention compared to the standard treatment. The QALYs used in the cost-effective analysis are derived from a generic instrument, SF-36.
- secondly, this study was designed as an RCT, and results based on rigorous RCT can provide a 'gold standard' to assess the impact of the Health Line interventions.
- thirdly, this study introduced information on participants' characteristics, study perspective, and detailed medical and intervention costs.
- lastly, this study addressed uncertainty and used sensitivity analysis to assess its validity.

The majority of the economic evaluation studies of telemedicine focused on cost estimates alone; only a few studies investigated cost-effectiveness or cost-benefit, especially for heart failure intervention. In this study, both costs and consequences of the interventions are considered, making it easy for decision makers to compare different programs and to make an evidence-based decision as to which is worth implementing from a healthcare provider's perspective.

There are four limitations in this study that should be taken into consideration when using the findings.

- a small sample size that might not precisely reflect the outcome difference for the target population, thus posing statistical challenges and limiting the scope of the possible analysis;
- the long term outcomes, such as mortality prevention due to the Health Lines intervention and the program sustainability, cannot be examined;
- complete emergency department data were not be included in the study since data for Portage cannot be accurately captured using current administrative data files.
- Indirect costs such as travel cost to healthcare facilities, losses of productivity, leisure time and absenteeism from work and premature death were not estimated; therefore, the total societal cost due to congestive heart failure disease was excluded. However, this might imply that telehealth intervention can generate more economic benefits for both the healthcare system and congestive heart failure patients than this study suggests.

Despite these limitations, this study provided some evidence of cost patterns and short-term intervention outcomes in order to help decision-makers to allocate resources efficiently.

Chapter 6

Conclusions

6.1 Conclusion

This study provides evidence that both Health Lines interventions are preferable to the standard care. The findings add to the growing body of evidence that telehealth for congestive heart failure patients have positive effects on outcomes. Moreover, our study suggests that either both interventions would very probably pay for itself in terms of reduced healthcare costs once patient volume is increased. Even at low patient volume, however, it appears that both HL and HLM hold great promise in terms of saving cost for the healthcare system and improving health outcome for patients with congestive heart failure.

Each of the interventions, however, is unique. HLM has its strongest impact on health system utilization averted. Even at low patient volumes, it comes very close to showing a statistically significant reduction in net costs for the healthcare system. It has, however, little impact on perceived well-being among patients relative to usual care. HL, by contrast, increases health scores for patients. They perceive and report themselves to be healthier than do their counterparts receiving usual care or the HLM intervention. Unfortunately, this perceived improvement in health does not translate into reduced utilization of the healthcare system. HL produces better outcome, but it does not reduce net costs relative to usual care.

This creates a bit of a challenge for healthcare decision-makers. Either intervention would appear to be better than usual care, but which one should be adopted? If the decision-makers want to improve the patient's health outcome, then HL is optimal. If the decision-makers consider only the cost saving for the healthcare system, then HLM is the optimal strategy to be implemented. If a decision has to be made about which of the two interventions should be provided for the patients in question, the CEAC offers useful information about the probability that the intervention is cost-effective, given a decision-maker's willingness to pay for perceived improvements in health. Our results allow us to go beyond standard statistical concerns about significance levels. Taking into account the joint uncertainty surrounding all the parameters in the model, the CEAC allows a decision to be made based on the best available information. It does not yield an automatic conclusion about which intervention is optimal; rather, it recognizes that the decision will be based on administrative and political decisions about the appropriate amount to spend to improve patient well-being. Trade-offs between the desires of patients and the net cost of providing services are an unavoidable part of healthcare decision-making.

While standard statistical concerns might lead us to be cautious about recommending an intervention when our results do not meet a 5% level of significance, this caution seems misplaced in this case. There is very good circumstantial evidence that either intervention is preferable to usual care. Moreover, the total amount of money for the intervention program is not substantial. In the worst case, the program would have little effect on either costs or outcomes; in the best, patient health would benefit at lower net cost to the system. Therefore, it seems reasonable to continue the program, and monitor data on costs and outcomes to see if it is as effective as our study suggests it might be.

On the basis of these findings, this study will guide healthcare providers and policy makers who are responsible for integrating telehealth into chronic disease management, funding telehealth programs, and creating policies that encourage the use of communication technology to support healthcare services and improve the quality of care. This information is critical for moving telehealth from its current limited use for a few chronic disease interventions to become an integral component of the healthcare delivery system in Manitoba.

6.2 Further directions

This study does suggest some considerations that should guide future economic evaluations of telehealth, or indeed other economic evaluation to be "piggy-backed" on clinical trials. Long observation periods are recommended to investigate the long term economic impact on the healthcare system. Such investigations should include measures of overall costs from both the healthcare provider's perspective and patients' perspectives. A societal perspective is optimal. Future prospective research should:

- consider that sample size calculation before the study should be determined not only on the basis of clinical endpoints of the trial, but also on economic endpoints (Briggs & Tambour, 1998) in order to have an appropriate sample size to detect significance from the economic evaluation. Costs are always heavily skewed and outliers common. Sample size calculations must take into account, in addition to all the ordinary factors that govern power calculations, the covariance between cost and outcome. It is likely that sample size for economic evaluation will exceed that for clinical analysis.

- collect long term intervention and healthcare service cost and outcome data to evaluate the long term sustainability of the intervention.
- include costs from the patient's perspectives such as productivity loss, absenteeism from work and extra travel cost to the health facilities due to the disease in order to have a broader economic view of the cost-effectiveness of the new technology.

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Appendix A Tables and charts

Table 20: Counts of healthcare uses by type for each three-month period of the study intervention for CONTROL group

Type	Overall	Baseline	0-3 months	4-6 months	7-9 months	10-12 months
Visits for all reasons						
Family physician	1,030	252	251	199	153	175
Specialist	589	190	176	94	69	60
Cardiac specialist	154	44	50	20	25	15
Internist	337	110	117	49	35	26
Hospital separation	43	10	11	9	7	6
Hospital length of stay	514	118	103	50	21	222
Hospital in-patient days	625	121	141	197	111	56
Emergency department visit	45	24	12	N/A	4	5
Visits related to CHF						
Family physician	122	29	31	25	19	18
Specialist	44	17	17	7	2	1
Cardiac specialist	14	4	5	2	2	1
Internist	44	17	17	7	2	1
Hospital separation	0	0	0	0	0	0
Hospital length of stay	0	0	0	0	0	0
Hospital in-patient days	0	0	0	0	0	0
Emergency department visit	N/A	N/A	N/A	N/A	N/A	N/A

Table 21: Counts of healthcare uses by type for each three-month period of the study intervention for HL group

Type	Overall	Baseline	0-3 months	4-6 months	7-9 months	10-12 months
Visits for all reasons						
Family physician	923	212	265	168	145	133
Specialist	547	166	173	114	69	52
Cardiac specialist	106	37	36	14	13	6
Internist	305	98	105	52	31	19
Hospital separation	44	5	17	8	6	8
Hospital length of stay	326	47	114	45	58	62
Hospital in-patient days	326	57	104	62	46	57
Emergency department visit	37	11	14	N/A	7	5
Visits related to CHF						
Family physician	210	67	66	31	24	22
Specialist	20	13	5	0	2	0
Cardiac specialist	9	5	4	0	0	0
Internist	18	13	5	0	0	0
Hospital separation	1	0	1	0	0	0
Hospital length of stay	7	0	7	0	0	0
Hospital in-patient days	7	0	7	0	0	0
Emergency department visit	N/A	N/A	N/A	N/A	N/A	N/A

Table 22: Counts of healthcare uses by type for each three-month period of the study intervention for HLM group

Type	Overall	Baseline	0-3 months	4-6 months	7-9 months	10-12 months
Visits for all reasons						
Family physician	796	253	216	147	96	84
Specialist	488	177	109	96	59	47
Cardiac specialist	49	26	9	6	5	3
Internist	251	110	43	54	22	22
Hospital separation	23	5	7	5	3	3
Hospital length of stay	187	35	62	50	24	16
Hospital in-patient days	269	50	107	72	24	16
Emergency department visit	40	12	11	N/A	7	0
Visits related to CHF						
Family physician	165	54	39	37	18	17
Specialist	22	14	1	4	2	1
Cardiac specialist	11	5	1	2	2	1
Internist	21	14	1	3	2	1
Hospital separation	4	1	1	1	0	1
Hospital length of stay	34	1	19	10	0	4
Hospital in-patient days	106	18	64	20	0	4
Emergency department visit	N/A	N/A	N/A	N/A	N/A	N/A

Table 23: Mean (SD) cost of healthcare utilization for each 90-day period of the study intervention

	Control	HL	HLM	*p**
		Visits for all reasons		
Baseline	$1,187 (2663)	$776 (2038)	$1,226 (5217)	0.6037
0-3 months	$1,632 (4540)	$1,364 (3125)	$1,140 (4031)	0.2376
4-6 months	$2,110 (7131)	$1,076 (3598)	$1,248 (5398)	0.5879
7-9 months	$1,516 (7498)	$708 (2417)	$333 (1041)	0.6871
10-12 months	$707 (2294)	$651 (2830)	$257 (859)	0.4464
		Visits related to CHF		
Baseline	$63 (176)	$58 (105)	$471 (3255)	0.3332
0-3 months	$61 (136)	$95 (393)	$481 (2651)	0.2046
4-6 months	$30 (74)	$16 (27)	$157 (680)	0.6954
7-9 months	$12 (33)	$16 (37)	$17 (43)	0.7059
10-12 months	$13 (40)	$11 (31)	$86 (574)	0.8422

*Non-parametric Kruskal-Wallis test

Table 24: Healthcare utilization mean cost (SD) of 12-month for by gender, and age groups and New York Heart Association functional status

	Control	HL	HLM	*p**
Visits for all reasons				
Female	$8,417 (13773)	$3,302 (6912)	$3,709 (7154)	0.2996
Male	$6,171 (21032)	$5,981 (12542)	$4,902 (10544)	0.7444
40-59 years old	$5,339 (8994)	$12,623 (24666)	$1,075 (739)	0.8099
60-69 years old	$2,103 (2852)	$2,856 (3391)	$5,148 (10402)	0.6731
70-79 years old	$5,750 (12781)	$6,731 (9215)	$4,914 (11423)	0.3619
80 and older	$9,985 (24465)	$1,820 (2060)	$4,265 (7255)	0.1084
NYHA class II	$2,636 (794)	$1,701 (784)	$1,196 (567)	0.7302
NYHA class III	$6,508 (12294)	$4,405 (7499)	$5,288 (9975)	0.4653
NYHA class IV	$11,094 (28667)	$7,248 (15989)	$4,801 (9452)	0.9808
Visits related to CHF				
Female	$131 (214)	$146 (164)	$251 (761)	0.1724
Male	$218 (464)	$254 (667)	$2,572 (6793)	0.8561
40-59 years old	$101 (195)	$97 (193)	$90 (121)	0.8188
60-69 years old	$208 (305)	$423 (1115)	$1,696 (6171)	0.8853
70-79 years old	$331 (634)	$195 (222)	$112 (170)	0.7136
80 and older	$108 (163)	$147 (150)	$1,867 (5103)	0.2091
NYHA class II	$79 (146)	$174 (231)	$76 (166)	0.2294
NYHA class III	$233 (483)	$267 (650)	$1,666 (4806)	0.3601
NYHA class IV	$165 (268)	$93 (99)	$1,382 (5521)	0.5432

*Non-parametric Kruskal-Wallis test

Table 25: Healthcare utilization mean cost (SD) for all reasons for each 90 days intervention by gender

	Control	HL	HLM	*p**
		Females		
Baseline	$1,376 (3502)	$702 (2359)	$630 (1176)	0.3513
1-3 months	$3,189 (6572)	$802 (2182)	$614 (1422)	0.1544
4-6 months	$2,488 (4792)	$1,171 (3847)	$1,688 (6968)	0.4586
7-9 months	$365 (1044)	$466 (1309)	$398 (1282)	0.5317
10-12 months	$999 (2744)	$162 (445)	$380 (1107)	0.6594
		Males		
Baseline	$1,040 (1820)	$859 (1651)	$2,070 (8012)	0.9041
1-3 months	$426 (737)	$1,984 (3860)	$1,885 (6032)	0.6070
4-6 months	$1,817 (8586)	$972 (3366)	$624 (1360)	0.8150
7-9 months	$2,407 (9923)	$975 (3237)	$242 (559)	0.9829
10-12 months	$481 (1892)	$1,191 (4046)	$82 (132)	0.6988

*Non-parametric Kruskal-Wallis test

Table 26: Healthcare utilization mean cost (SD) for CHF for each 90 days intervention by gender

	Control	HL	HLM	*p**
		Females		
Baseline	$41 (105)	$52 (87)	$38 (67)	0.1935
1-3 months	$52 (100)	$42 (73)	$22 (40)	0.3132
4-6 months	$20 (38)	$20 (30)	$38 (90)	0.7129
7-9 months	$9 (32)	$17 (42)	$12 (39)	0.4065
10-12 months	$8 (25)	$15 (37)	$141 (749)	0.6418
		Males		
Baseline	$79 (215)	$67 (124)	$1083 (5057)	0.8677
1-3 months	$68 (160)	$153 (564)	$1131 (4082)	0.5853
4-6 months	$39 (930)	$11 (22)	$326 (1041)	0.6520
7-9 months	$15 (35)	$16 (31)	$23 (50)	0.8116
10-12 months	$17 (49)	$7 (23)	$8 (21)	0.6459

*Non-parametric Kruskal-Wallis test

Table 27: Healthcare utilization mean cost (SD) for all reasons for each 90 days intervention by age groups

	Control	HL	HLM	*p**
40-59 years old				
Baseline	$2,099 (5368)	$1,121 (1981)	$359 (242)	0.7687
1-3 months	$1,637 (3844)	$1,013 (2297)	$412 (735)	0.5218
4-6 months	$1,011 (2588)	$5,207 (8901)	$43 (41)	0.6877
7-9 months	$205 (340)	$2,354 (6059)	$95 (111)	0.7335
10-12 months	$388 (756)	$2,927 (7725)	$166 (194)	0.5745
60-69 years old				
Baseline	$441 (554)	$872 (1938)	$3,155 (9775)	0.8089
1-3 months	$687 (986)	$966 (1544)	$1,087 (2054)	0.8847
4-6 months	$630 (1378)	$797 (1757)	$423 (931)	0.9511
7-9 months	$215 (353)	$147 (185)	$94 (166)	0.5921
10-12 months	$130 (205)	$74 (146)	$389 (1208)	0.5900
70-79 years old				
Baseline	$1,453 (2672)	$1,347 (3281)	$236 (181)	0.7683
1-3 months	$2,085 (6104)	$2,692 (5250)	$241 (278)	0.1446
4-6 months	$1,576 (4668)	$848 (2800)	$3,916 (11557)	0.6852
7-9 months	$503 (1618)	$1,093 (2383)	$427 (951)	0.3219
10-12 months	$133 (208)	$750 (2070)	$95 (115)	0.3287
80 and older				
Baseline	$944 (1663)	$297 (524)	$678 (1258)	0.3066
1-3 months	$1,623 (4438)	$787 (1407)	$1,933 (6289)	0.2313
4-6 months	$3,196 (9840)	$259 (584)	$830 (1786)	0.2616
7-9 months	$2,908 (11007)	$256 (585)	$543 (1525)	0.5277
10-12 months	$1,315 (3304)	$221 (593)	$282 (954)	**0.0439**

*Non-parametric Kruskal-Wallis test

Table 28: Healthcare utilization mean cost (SD) for CHF for each 90 days intervention by age groups

	Control	HL	HLM	*p**
		40-59 years old		
Baseline	$67 (164)	$71 (157)	$19 (22)	0.7754
1-3 months	$23 (48)	$15 (40)	$17 (33)	0.8973
4-6 months	$7 (19)	$0 (0)	$14 (21)	0.1730
7-9 months	$0 (0)	$11 (29)	$17 (39)	0.3483
10-12 months	$3 (10)	$0 (0)	$22 (36)	0.1386
		60-69 years old		
Baseline	$39 (74)	$96 (166)	$1696 (6171)	0.3980
1-3 months	$86 (127)	$315 (958)	$28 (52)	0.9271
4-6 months	$26 (45)	$0 (0)	$19 (61)	0.2335
7-9 months	$31 (55)	$12 (29)	$18 (51)	0.8108
10-12 months	$25 (43)	$0 (0)	$14 (54)	0.0268
		70-79 years old		
Baseline	$109 (284)	$63 (93)	$26 (65)	0.3059
1-3 months	$130 (227)	$91 (145)	$15 (23)	0.1217
4-6 months	$59 (126)	$8 (14)	$41 (70)	0.4120
7-9 months	$11 (35)	$21 (49)	$22 (58)	0.5632
10-12 months	$22 (61)	$12 (24)	$8 (19)	0.8214
		80 and older		
Baseline	$41 (106)	$41 (65)	$43 (53)	0.3842
1-3 months	$25 (44)	$38 (44)	$1234 (4257)	0.2204
4-6 months	$22 (41)	$32 (33)	$373 (1082)	0.2569
7-9 months	$11 (29)	$17 (34)	$12 (30)	0.8851
10-12 months	$8 (28)	$19 (43)	$206 (931)	0.2494

*Non-parametric Kruskal-Wallis test

Table 29: Healthcare utilization mean cost (SD) for all reasons for each 90 days intervention by New York Heart Association function status

	Control	HL	HLM	*p**
NYHA II				
Baseline	$1,103 (2103)	$399 (540)	$473 (1055)	0.7720
1-3 months	$314 (385)	$692 (983)	$179 (190)	0.1202
4-6 months	$98 (148)	$405 (778)	$374 (832)	0.4776
7-9 months	$1,038 (2930)	$142 (207)	$119 (130)	0.8992
10-12 months	$83 (171)	$63 (120)	$52 (88)	0.8736
NYHA III				
Baseline	$1,675 (3402)	$1,029 (2703)	$455 (866)	0.1567
1-3 months	$2,461 (6009)	$1,780 (4143)	$1,802 (5904)	0.1802
4-6 months	$1,735 (4437)	$660 (2311)	$2,181 (8079)	0.3774
7-9 months	$143 (214)	$643 (1864)	$362 (846)	0.9895
10-12 months	$493 (1726)	$293 (619)	$489 (1277)	0.9499
NYHA IV				
Baseline	$464 (1184)	$641 (1353)	$2,679 (8752)	0.1815
1-3 months	$1,168 (2865)	$1,186 (1995)	$936 (1858)	0.9336
4-6 months	$4,006 (11523)	$2,363 (5991)	$649 (1576)	0.6235
7-9 months	$4,006 (13205)	$1,290 (3863)	$437 (1514)	0.2081
10-12 months	$1,450 (3460)	$1,768 (5240)	$99 (156)	0.3805

*Non-parametric Kruskal-Wallis test

Table 30: Healthcare utilization mean cost (SD) for CHF for each 90 days intervention by New York Heart Association function status

	Control	HL	HLM	*p**
		NYHA II		
Baseline	$51 (149)	$64 (105)	$23 (57)	0.4005
1-3 months	$12 (22)	$71 (137)	$3 (13)	**0.0068**
4-6 months	$7 (16)	$14 (25)	$22 (56)	0.8109
7-9 months	$3 (10)	$12 (32)	$18 (56)	0.8445
10-12 months	$0 (0)	$12 (29)	$10 (19)	0.2464
		NYHA III		
Baseline	$89 (229)	$73 (126)	$33 (44)	0.5794
1-3 months	$89 (175)	$142 (553)	$1,102 (3998)	0.9228
4-6 months	$27 (59)	$13 (25)	$318 (1019)	0.2324
7-9 months	$13 (39)	$23 (44)	$24 (51)	0.2398
10-12 months	$14 (34)	$16 (39)	$189 (873)	0.9812
		NYHA IV		
Baseline	$30 (49)	$30 (48)	$1,382 (5521)	0.6958
1-3 months	$48 (95)	$30 (42)	$16 (26)	0.5209
4-6 months	$52 (109)	$22 (31)	$43 (112)	0.7230
7-9 months	$17 (33)	$9 (24)	$6 (13)	0.4460
10-12 months	$20 (58)	$2 (8)	$8 (24)	0.7817

*Non-parametric Kruskal-Wallis test

Table 31: Healthcare utilization mean cost (SD) for all reasons for each 90 days intervention by location

	Winnipeg RHA	Central RHA	*p**
	Control		
Baseline	$1,649 (3208)	$437 (1104)	0.0032
1-3 months	$1,775 (5358)	$1,399 (2861)	0.2091
4-6 months	$1,317 (3988)	$3,393 (10405)	0.1893
7-9 months	$332 (1089)	$3,433 (11982)	0.1555
10-12 months	$138 (226)	$1,628 (3562)	0.0437
	HL		
Baseline	$992 (2420)	$466 (1295)	0.0048
1-3 months	$1,752 (3864)	$807 (1448)	0.1635
4-6 months	$1,691 (4591)	$191 (487)	0.6464
7-9 months	$767 (2871)	$622 (1603)	0.6730
10-12 months	$651 (3396)	$651 (1789)	0.0630
	HLM		
Baseline	$1,722 (6728)	$466 (1295)	0.0096
1-3 months	$526 (943)	$807 (1448)	0.0092
4-6 months	$1,726 (6969)	$191 (487)	0.5569
7-9 months	$142 (228)	$622 (1603)	0.5776
10-12 months	$119 (243)	$651 (1789)	0.4927

*Non-parametric Kruskal-Wallis test

Table 32: Healthcare utilization mean cost (SD) for CHF for each 90 days intervention by location

	Winnipeg RHA	Central RHA	*p**
	Control		
Baseline	$85 (219)	$27 (49)	0.8139
1-3 months	$71 (160)	$45 (84)	0.6628
4-6 months	$28 (59)	$35 (95)	0.9208
7-9 months	$11 (33)	$15 (34)	0.1555
10-12 months	$14 (46)	$12 (29)	0.5158
	HL		
Baseline	$56 (96)	$63 (119)	0.6482
1-3 months	$48 (108)	$162 (601)	0.0401
4-6 months	$11 (25)	$23 (29)	0.0167
7-9 months	$13 (39)	$22 (34)	0.0613
10-12 months	$5 (16)	$21 (44)	0.0175
	HLM		
Baseline	$785 (4248)	$26 (40)	0.6208
1-3 months	$25 (42)	$1,128 (4083)	0.7886
4-6 months	$43 (96)	$318 (1042)	0.6865
7-9 months	$24 (55)	$6 (14)	0.4483
10-12 months	$16 (42)	$186 (892)	0.0344

*Non-parametric Kruskal-Wallis test

Figure 8: Survey sample distribution by gender

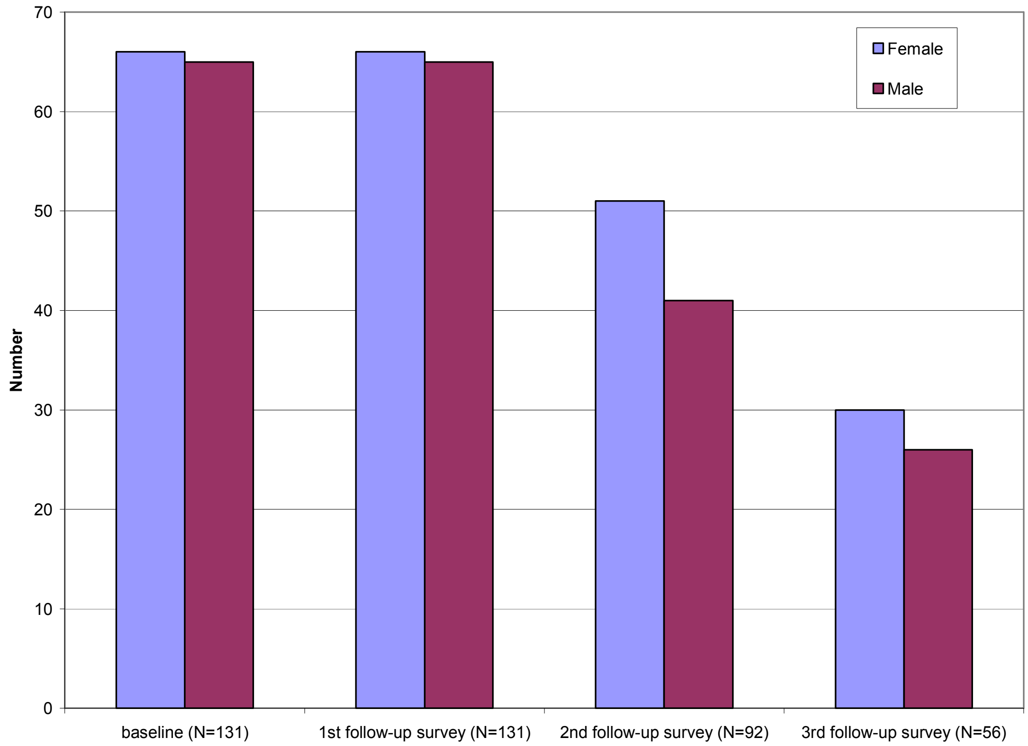


Figure 9: Survey sample distribution by location

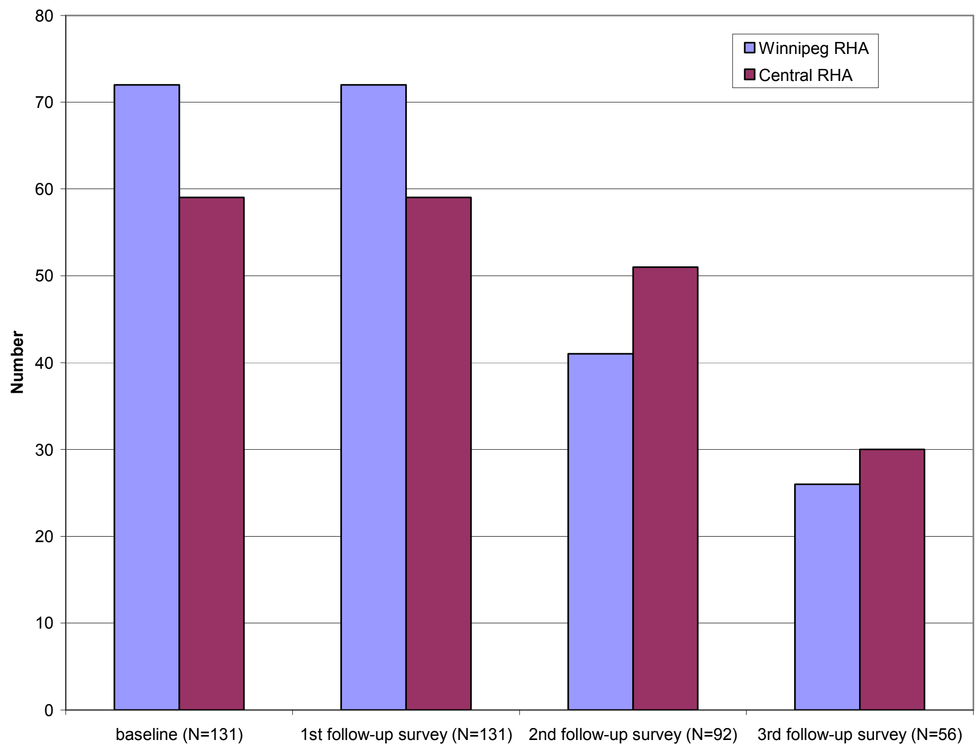


Figure 10: Survey sample distribution by New York Heart Association functional status

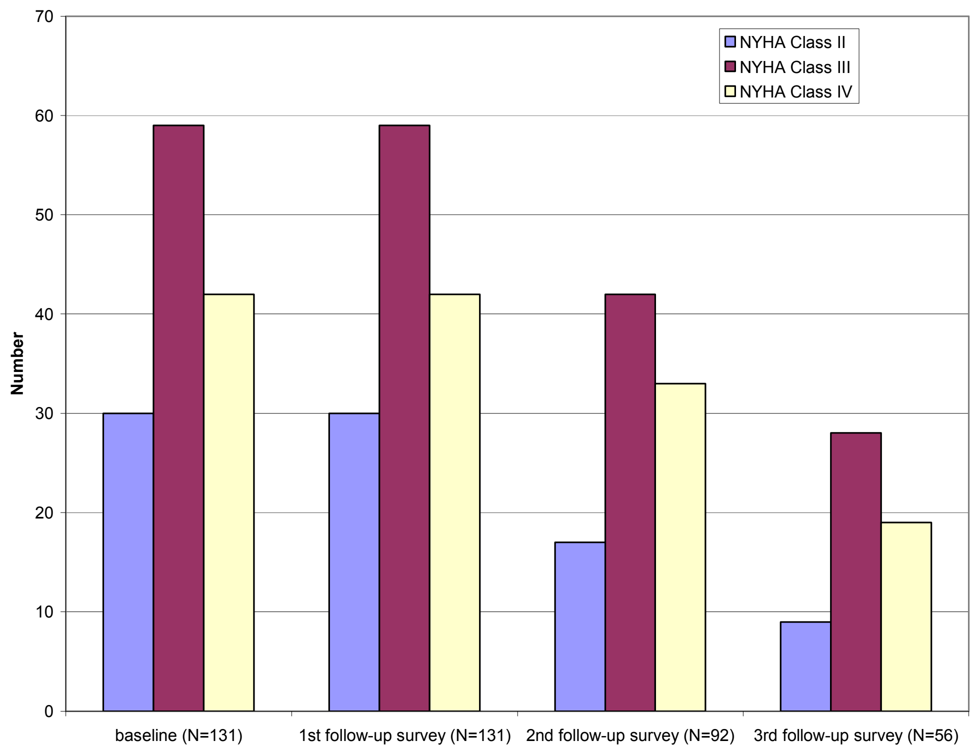
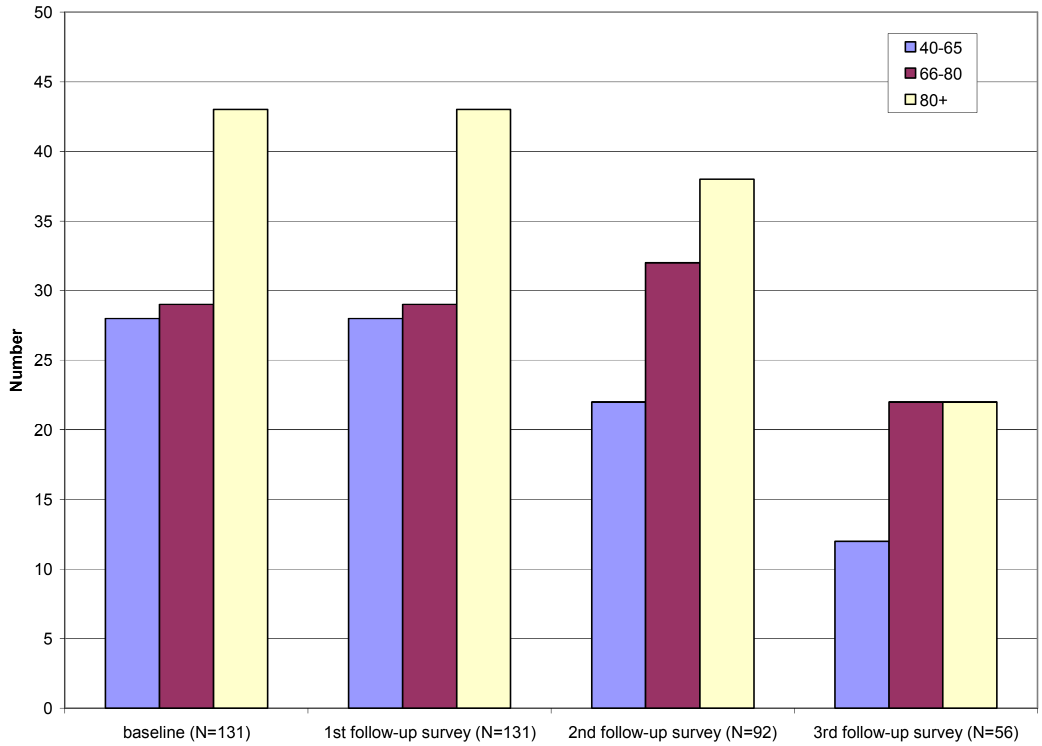


Figure 11: Survey sample distribution by age groups



Appendix B The Revised Heart Failure Self-care Behaviour Scale

THE REVISED HEART FAILURE SELF-CARE BEHAVIOR SCALE[1]

The following questions are concerned with heart failure self-care behaviors. Using the scale, please indicate how often you use each of the following behaviors. *Please answer all of the questions.*

	None of the time					*All of the time*
1. I take my pills every day.	0	1	2	3	4	5
2. I always refill prescriptions for my pills on time	0	1	2	3	4	5
3. I keep my appointments with my doctor.	0	1	2	3	4	5
4. I take my pills as the doctor prescribed- I take all the doses of my pills.	0	1	2	3	4	5
5. I think a person can live a happy and good life, even after having heart failure.	0	1	2	3	4	5
6. I have a system to help me when to take my pills.	0	1	2	3	4	5
7. I believe that having heart failure is a condition to which I can adjust.	0	1	2	3	4	5
8. When I am short of breath, I rest.	0	1	2	3	4	5
9. I get a flu shot once a year.	0	1	2	3	4	5
10. I stay away from people who have a cold or flu.	0	1	2	3	4	5
11. I talk to my doctor and family about my condition to make choices and plans for the future.	0	1	2	3	4	5
12. I spread my activities our over the whole day so I do not get too tired.	0	1	2	3	4	5
13. To help reduce my symptoms, like fatigue or shortness of breath, I limit the activities that are hard for me.	0	1	2	3	4	5
14. I put my feet up when I sit in a chair.	0	1	2	3	4	5
15. I limit my alcohol intake to 1 glass of beer or win or 1 shot a day.	0	1	2	3	4	5
16. I am a nonsmoker.	0	1	2	3	4	5
17. I plan rest times during my day.	0	1	2	3	4	5
18. When I feel anxious about my worsening symptoms of heart failure, I talk with my doctor about it.	0	1	2	3	4	5
19. I contact my doctor when I feel more short of breath	0	1	2	3	4	5
20. When I am short of breath or tired, I ask for help with something I am unable to do.	0	1	2	3	4	5
21. I contact my doctor when I see my feet, ankles, legs, or stomach swell.	0	1	2	3	4	5
22. I watch how much water I pass (urinate) each day.	0	1	2	3	4	5
23. I do not eat canned soups or TV dinners.	0	1	2	3	4	5
24. I am physically active (eg, walk or ride a bike) 3 to 4 days per week.	0	1	2	3	4	5
25. I am careful not to drink 'too many fluids'	0	1	2	3	4	5
26. I weigh myself every day of the week	0	1	2	3	4	5
27. I contact my doctor when I realize I am feeling tired all the time	0	1	2	3	4	5
28. I contact my doctor when I have nausea or do not feel like eating	0	1	2	3	4	5
29. I contact my doctor when I have gained 2 pounds or more in a day or 3 pounds or more since my last visit to the doctor	0	1	2	3	4	5

[1] Artinian et al, 2002.

Appendix C Client Satisfaction Questionnaire

CLIENT SATISFACTION QUESTIONNAIRE[1]

Please help us improve our program by answering some questions about the services you received at the ________________________________. We are interested in your honest opinions, whether they are positive or negative. *Please answer all of the questions.* We also welcome your comments and suggestions. Thank-you very much, we appreciate your help.

CIRCLE YOUR ANSWER

1. How would you rate the quality of service you received?

4	3	2	1
Excellent	Good	Fair	Poor

2. Did you get the kind of service you wanted?

1	2	3	4
No, definitely not	No, not really	yes, generally	Yes, definitely

3. To what extent has our program met your needs?

4	3	2	1
Almost all of my needs have been met	Most of my needs Have been met	Only a few of my Needs have been met	None of my needs Have been met

4. If a friend were in need of similar help, would you recommend our program to him/her?

1	2	3	4
No, definitely not	No, I don't think so	Yes, I think so	Yes, definitely

5. How satisfied are you with the amount of help you received?

1	2	3	4
Quite dissatisfied	Indifferent, or mildly dissatisfied	Mostly satisfied	Very satisfied

6. Have the services you received helped you to deal more effectively with your problems?

4	3	2	1
Yes, they helped a great deal	Yes, they helped somewhat	No, they really didn't help	No, they seemed to make things worse

7. In an overall, general sense, how satisfied are you with the service you received?

4	3	2	1
Very satisfied	Mostly satisfied	Indifferent or mildly dissatisfied	Quite dissatisfied

8. If you were to seek help again, would you come back to our program?

1	2	3	4
No, definitely not	No, I don't think so	Yes, I think so	Yes, Definitely

WRITE COMMENTS BELOW:

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[1]Hargreaves & Attkisson, 1978

Appendix D The SF-36 Questionnaire

THE SF-36 QUESTIONNAIRE

INSTRUCTIONS: THIS SURVEY ASKS FOR YOUR VIEWS ABOUT YOUR HEALTH. THIS INFORMATION WILL HELP KEEP TRACK OF HOW YOU FEEL AND HOW WELL YOU ARE ABLE TO DO YOUR USUAL ACTIVITIES.

ANSWER EVERY QUESTION BY MARKING THE ANSWER AS INDICATED. IF YOU ARE UNSURE ABOUT HOW TO ANSWER A QUESTION, PLEASE GIVE THE BEST ANSWER YOU CAN.

1. In general, how would you say your health is now?

Check one (✓)

Poor . . . . 1( )
Fair . . . . 2( )
Good . . . . 3( )
Excellent . . . . 4( )

2. *Compared to one year ago,* how would you rate your health in general now?

Check one (✓)

Much better now than one year ago . . . . 1( )
Somewhat better now than one year ago . . . . 2( )
About the same now than one year ago . . . . 3( )
Somewhat worse now than one year ago . . . . 4( )
Much worse now than one year ago . . . . 5( )

3. The following items are about activities you might do during a typical day. Does *your health* now limit you in these activities? If so, how much?

(Circle one number on each line)

Activities	Yes, limited a lot	Yes, limited a little	No, not limited at all
a. **Vigorous activities**, such as running, lifting heavy objects, *participating in strenuous sports*	1	2	3
b. **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	1	2	3
c. Lifting or carrying groceries	1	2	3
d. Climbing **several** flights of stairs	1	2	3
e. Climbing **one** flight of stairs	1	2	3
f. Bending, kneeling, or stooping	1	2	3
g. Walking **more than a mile**	1	2	3
h. Walking **several blocks**	1	2	3
i. Walking **one** block	1	2	3
j. Bathing or dressing yourself	1	2	3

- 1 -

4. During the *past 4 weeks* have you had any of the following problems with your work, or other regular daily activities *as a result of your physical health?*

(Circle one number on each line)

	Yes	No
a. Cut down on the **amount of time** you spent on work and other activities	1	2
b. **Accomplished** less than you would like	1	2
c. Were limited in the **kind** of work or other activities	1	2
d. Had **difficulty** performing the work or other activities (for example, it took extra effort)	1	2

5. During the *past 4 weeks,* have you had any of the following problems with your work or other regular activities *as a result of any emotional problems* (such as feeling depressed or anxious)?

(Circle one number on each line)

	Yes	No
a. Cut down on the **amount of time** you spent on work or other activities	1	2
b. **Accomplished less** than you would like	1	2
c. Didn't do work or other activities as **carefully** as usual	1	2

6. During the *past 4 weeks*, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

Check one (✓)

Not at all . . . . 1(   )
Slightly . . . . 2(   )
Moderately . . . . 3(   )
Quite a bit . . . . 4(   )
Extremely . . . . 5(   )

7. How much *bodily* pain have you had during the *past 4 weeks?*

Check one (✓)

None . . . . 1(   )
Very mild . . . . 2(   )
Mild . . . . 3(   )
Moderate . . . . 4(   )
Severe . . . . 5(   )
Very severe . . . . 6(   )

8. During the *past 4 weeks*, how much did *pain* interfere with your normal work (including both work outside the home and housework?

Check one (✓)

Not at all . . . . 1( )
A little bit . . . . 2( )
Moderately . . . . 3( )
Quite a bit . . . . 4( )
Extremely . . . . 5( )

9. These questions are about how you feel and how things have been with you *during the past 4 weeks.* For each question, please give one answer that comes the closest to the way you have been feeling. How much time during the *past 4 weeks* -

(Circle one number on each line)

	All of the time	Most of the time	A good bit of the time	Some of the time	A little of the time	None of the time
a. Did you feel full of pep?	1	2	3	4	5	6
b. Have you been a very nervous person?	1	2	3	4	5	6
c. Have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5	6
d. Have you felt calm and peaceful?	1	2	3	4	5	6
e. Did you have a lot of energy?	1	2	3	4	5	6
f. Have you felt downhearted and blue?	1	2	3	4	5	6
g. Did you feel worn out?	1	2	3	4	5	6
h. Have you been a happy person?	1	2	3	4	5	6
i. Did you feel tired?	1	2	3	4	5	6

10. During the *past 4 weeks*, how much of the time has your *physical health* or *emotional problems* interfered with your social activities (like visiting with friends, relatives, etc.)?

Check one (✓)

All of the time . . . . 1( )
Most of the time . . . . 2( )
Some of the time . . . . 3( )
A little of the time . . . . 4( )
None of the time . . . . 5( )

11. How TRUE or FALSE is *each of the following statements for you?*

(Circle one number on each line)

	Definitely True	Mostly True	Don't Know	Mostly False	Definitely False
a. I seem to get sick a little easier than other people	1	2	3	4	5
b. I am as healthy as anybody I know	1	2	3	4	5
c. I expect my health to get worse	1	2	3	4	5
d. My health is excellent	1	2	3	4	5