Original Research

Telehealth Remote Monitoring for Community-Dwelling Older Adults with Chronic Obstructive Pulmonary Disease

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Abstract

Objective: *To determine if self-monitoring via home-based telehealth equipment could, when combined with ongoing remote monitoring by a nurse, reduce the incidence of hospitalizations and emergency department (ED) presentations for people with chronic obstructive pulmonary disease (COPD).* ***Subjects and Methods:*** *A randomized controlled trial was used to compare the outcomes for participants receiving the telehealth equipment and monitoring with those for participants in an information-only control group, over a period of 6 months. Participants receiving the telehealth intervention were taught to measure and record their vital signs (blood pressure, weight, temperature, pulse, and oxygen saturation levels) on a daily basis. These were then transmitted automatically via telephone to a secure Web site where they were monitored each day by the telehealth nurse.* ***Results:*** *The telehealth group had fewer ED presentations and hospital admissions and a reduced length of stay in comparison with the control group. These results were not statistically significant. However, the reduction in health service use was large enough to result in significant cost savings, with the annual cost savings of the telehealth group compared with the control group being $2,931 per person.* ***Conclusions:*** *Telehealth monitoring of patient vital signs reduced health service utilization for individuals with COPD and resulted in significant cost savings. In terms of individual health benefits, improvements in participants' self-management behaviors and control over their condition was evident.*

Key words: *telehealth, remote monitoring, respiratory disease*

Introduction

Telehomecare is fast becoming a viable solution to the problems faced by many community care agencies as the population ages and we consider how we can assist people living with chronic illness to manage their disease more effectively to improve their quality of life and reduce the demand on health services. One of the growing areas of telehomecare is the remote monitoring of patients' vital signs by a clinician using equipment installed in the patient's own home. Remote monitoring has gained momentum in recent years because it is seen not only as a way of providing prompt medical intervention before deterioration in the patient's condition that can prevent unnecessary hospital admissions,[1] but also as a way of managing staffing shortages, reducing costs,[2] and improving patients' knowledge and self-efficacy.[3]

One particular chronic condition that requires ongoing self-management to minimize morbidity and has begun to show positive outcomes using remote monitoring is chronic obstructive pulmonary disease (COPD).[4] COPD is a progressive and disabling disease that causes restrictions in lung airflow. People with COPD can often suffer from acute exacerbations, which are characterized by severe shortness of breath, coughing fits, and sputum production.[4] Not only are these exacerbations costly in terms of increased healthcare utilization and hospitalizations, but they can also significantly reduce the quality of life for the person living with COPD.[5]

Although there is a growing body of research on the benefits of telehomecare for chronic conditions such as heart failure,[6] diabetes,[7] and wounds,[8] there is still limited methodologically sound evidence in relation to the benefits and financial viability of telehealth monitoring for people with COPD.[1] A recent systematic review of the literature available on home telemonitoring for pulmonary conditions found only two studies that conducted a detailed cost analysis of this approach.[9] They concluded that more evaluative research, using larger samples sizes and more robust study designs, particularly randomized controlled trials, was required in order to confirm the economic viability of this kind of telehomecare program.[9] Another review by Polisena et al.[10] also reported that although home telehealth was generally clinically effective, the current evidence regarding the effect on health service utilization was limited and that once again more robust research was required.

This study therefore aimed to address this gap in current knowledge on health service utilization, cost-effectiveness, and any associated benefits of telehealth monitoring for people living with COPD.

Subjects and Methods

STUDY DESIGN AND POPULATION

A randomized controlled trial was used to compare the outcomes for participants receiving the telehealth monitoring with participants receiving information only. The study was conducted by Silver Chain, a large health and community care organization based in Western Australia. The study population consisted of Silver Chain clients who had a diagnosis of COPD, were receiving domiciliary oxygen, spoke English, and lived in the metropolitan area. Clients were excluded if they had dementia, were receiving palliative care, did not have a telephone landline, or were unable to use the telehealth

equipment because of cognitive or physical impairment. Ethics approval for this project was granted by the Silver Chain Human Research Ethics Committee.

SAMPLE SIZE

Earlier analysis of Silver Chain client hospital admission data had found an annual admission rate of 1.7 times for clients with COPD. Previous research examining the impact of telehealth monitoring on individuals with chronic disease has found a reduction in hospital admissions of up to 68% can be achieved.[11] Anticipating a 45% reduction in hospital admissions, it was calculated that 40 participants in each group were required in order to detect this difference with 80% power and alpha = 0.05.

RECRUITMENT

Clients meeting the selection criteria were identified using Silver Chain's client information management system (ComCare) and were then invited to participate by letter. The letter included an information statement and explained that a research assistant would telephone them in the next few days to discuss the research trial. If during this phone call clients expressed an interest in participating, a time was arranged to visit them at home. During this visit the research assistant obtained informed consent (which included permission to contact their general practitioner [GP]/specialist), collected baseline data, and randomly assigned the participant to the intervention or control group.

Prior to recruitment, the random number generator in STATA version 9 (StataCorp., College Station, TX) was used to randomly allocate 80 study numbers to the intervention or control group (40 in each). Envelopes were then made up with the study number written on the outside and the group assignment inside.

After a participant had been recruited, their GP/specialist was sent a fax that included an information statement and a consent form. The fax explained that their patient had consented to take part and requested that they accept clinical governance for the participant during the research. If their patient was allocated to the telehealth group, the fax also included a threshold document for the doctor to define the normal parameters for their patient in terms of blood pressure, temperature, pulse, oxygen flow rate, and oxygen saturation levels.

INTERVENTION

This study used the HealthHUB™ (Docobo Ltd., Bookham, Surrey, United Kingdom), a small portable unit that has an integrated display and large functional keys. Participants were visited at home by the telehealth nurse, who installed the telehealth equipment and trained participants in its use. Participants were also provided with an educational book about COPD and a telehealth instruction manual.

Participants measured their vital signs (blood pressure, weight, temperature, pulse, and oxygen saturation levels) and answered questions relating to their general state of health, on a daily basis. These were transmitted automatically via telephone to a secure Web site where they were monitored daily by the telehealth nurse. Any deviations outside the participant's normal parameters, specified by their GP or specialist, triggered an alert. The telehealth nurse would then phone the participant to discuss his or her measurements and provide advice/support or recommend he or she make an appointment to visit the GP. The outcome of the phone call and any recommendations/actions taken were then recorded on the telehealth Web site. The participants' GPs/specialists were also provided with a secure log-in so they could access the telehealth Web site and view their patient's readings.

The control group were also visited by the telehealth nurse, who provided them with the same COPD book. There was no other contact with this group apart from data collection.

DATA COLLECTION

Participants were provided with a calendar to record every time they used any health service. This information was then collected by phone each month, for the 6-month study period. Participant demographics and the number and duration of telehealth nurse visits, telephone calls, and monitoring were extracted from Silver Chain's ComCare. Quality of life was measured during the initial interview and again at 6 months using the Chronic Respiratory Questionnaire Self-Administered Standardized Version (CRQ-SAS).[12] Client satisfaction was evaluated via face-to-face interviews at the completion of the trial.

DATA ANALYSIS

Paired and independent-samples *t* tests and chi-squared tests were used to compare the demographics, quality of life, and health service use of the two groups. STATA version 11 was used for all analyses.

The cost evaluation examined the extra costs of providing the telehealth intervention and determined whether there was a net benefit in health system usage and any annualized cost savings for those in the telehealth group compared with the control group. Two types of costs were included: actual equipment costs and labor costs, which included telehealth nurse visits, daily monitoring calls, and any associated travel expenses to participants' homes, calculated as a weekly cost. Net benefits were derived by comparing the health system usage of both groups. Unit costs for GP, specialist, and emergency department (ED) visits were taken from the 2005/06 unit costs in *Table 7.2* of Flatau et al.,[13] adjusted by 6.51% per annum increase[14] in the Australian Bureau of Statistics health services price index. Hospital visit costs were based on length of stay rather than number of hospitalizations. Length of stay cost was calculated using the average cost per bed-day in public hospitals[15] adjusted by a 6.51% per annum increase.[14]

Results

Eighty clients (40 telehealth and 40 control) were recruited into the study, with 71 clients (36 telehealth and 35 control) completing the trial. Nine participants were lost to follow-up (seven died, two withdrew). Of the two participants who withdrew, one was unable to manage the equipment, and one was no longer interested in taking part.

DEMOGRAPHIC CHARACTERISTICS

Table 1 shows the gender, age, living arrangement, and carer availability for both groups; none of these differences was statistically significant.

HEALTH SERVICE USAGE

Table 2 shows the number of GP and specialist visits, ED presentations, number of hospital admissions, and length of stay in hospital for each group. These health contacts are shown for COPD-related contacts, non–COPD-related contacts, and the combined totals.

There are substantial differences between the two groups in their health service usage. The telehealth group were hospitalized less than half as many times as the control group and spent a total of 77 fewer days in the hospital over the 6-month period. The telehealth group had nearly 25% more GP visits than the control group, but the majority of these visits were non–COPD-related. None of these differences reached statistical significance.

ANNUAL COST SAVINGS

Costs and net benefits of the telehealth group compared with the control group were calculated for the 6-month period and then annualized. Two types of costs were included: equipment costs and labor costs. Equipment costs are shown in *Table 3*. They include the cost of the equipment depreciated over 3 years using the straight line method plus the weekly cost of monitoring. *Table 4* applies unit costs to the difference in all health system contacts.

As can be seen in *Table 5*, the annualized net savings in the telehealth group was $2,931 per person.

QUALITY OF LIFE

The questions in the CRQ-SAS are divided into four domains: dyspnea, fatigue, emotional function, and mastery (ability in self-managing their disease). Each is scored separately. There were no statistically significant differences between the telehealth and control group for any of the domains at baseline or at 6 months. There was, however, a clinically significant change found within the telehealth group for the mastery domain between baseline and 6 months. The minimum amount of change that has been found to be clinically significant or important in a respondent's day-to-day life is an

Table 1. Demographics

	TELEHEALTH GROUP ($N=36$)	INFORMATION-ONLY GROUP ($N=35$)	P VALUE
Age range (years)	54–88	57–87	
Mean age (years)	71	74	0.201
Female (%)	61.1% ($n=22$)	42.9% ($n=15$)	0.124
Living alone (%)	25.0% ($n=9$)	37.1% ($n=13$)	0.292
Has a carer (%)	52.8% ($n=19$)	57.1% ($n=20$)	0.712

Table 2. Health System Usage

ITEM	NUMBER OF OCCASIONS; MEAN (SD)		DIFFERENCE
	CONTROL GROUP	TELEHEALTH GROUP	
COPD-related health system usage			
GP visits	33; 0.94 (1.3)	35; 0.97 (1.3)	+2
Specialist visits	55; 1.6 (1.7)	60; 1.7 (1.7)	+5
ED presentations	11; 0.31 (0.63)	6; 0.17 (0.51)	−5
Hospital admissions	17; 0.49 (0.85)	8; 0.22 (0.48)	−9
Hospital LOS (days)	162; 4.6 (9.1)	85; 2.4 (7.1)	−77
Non–COPD-related health system usage			
GP visits	175; 5 (4.3)	216; 6 (4.4)	+41
Specialist visits	41; 1.2 (1.5)	35; 0.97 (1.5)	−6
ED visits	10; 0.29 (0.62)	12; 0.33 (0.68)	+2
Hospital visits	9; 0.26 (0.89)	8; 0.22 (0.59)	−1
Hospital LOS (days)	21; 0.6 (2.3)	21; 0.58 (1.7)	0
All related health system usage			
GP visits	208; 5.9 (4.4)	251; 7 (5.1)	+43
Specialist visits	96; 2.7 (2.1)	95; 2.6 (2.2)	−1
ED visits	21; 0.6 (0.95)	18; 0.5 (0.77)	−3
Hospital visits	26; 0.74 (1.2)	16; 0.44 (0.73)	−10
Hospital LOS (days)	183; 5.2 (9.3)	106; 2.9 (7.3)	−77

COPD, chronic obstructive pulmonary disease; ED, emergency department; GP, general practitioner; LOS, length of stay; SD, standard deviation.

Table 3. Labor and Equipment Costs (Over 6 Months)

LABOR	NUMBER OF MINUTES	NUMBER OF HOURS	TOTAL COSTS
RN home visits	8,156	136	$11,704
Monitoring (18 min/week)	16,848	280.8	$23,587
Total RN			$35,291
EQUIPMENT	**PER PATIENT UNIT COSTS**	**DEPRECIATED PER PATIENT UNIT COSTS**	
All equipment	$1,880	$626.66	$22,560
Monitoring system	$14 per week	NA	$26,208
Total equipment			$48,768
Grand total			$84,059

NA, not applicable; RN, registered nurse.

Table 4. Net Benefits of Telehealth (Over 6 Months)

ITEM	UNIT COSTS	DIFFERENCE (TELEHEALTH MINUS CONTROL)	TOTAL COST SAVINGS
GP visits	$48	+43	−$2,064
Specialist visits	$72	−1	$72
ED visits	$465	−3	$1,395
Hospital LOS	$1,468	−77	$113,036
All			$112,439

ED, emergency department; GP, general practitioner; LOS, length of stay.

improvement of 0.5 per question per dimension.[12] There are four questions in mastery domain, and therefore to achieve clinical significance a change of 2 is required. The telehealth group improved by 2.3, achieving clinical significance, whereas the information group changed by only 1.3.

PARTICIPANT SATISFACTION

Overall, participants found the equipment easy to use, and entering their daily measurements took an average of 5 min. Approximately half felt that the telehealth intervention had reduced the number of times they had been to the hospital. Participants commented that in the past they may have gone to the hospital because they were worried or anxious about breathing difficulties, but being able to take their own measurements reassured them that their measures were within normal limits:

> There is no doubt that it has probably saved a couple of trips to hospital or has made me go to the doctor where previously I would have hung on and ended up going to hospital by ambulance.

Table 5. Summary of Annual Cost Savings of Chronic Obstructive Pulmonary Disease Telehealth ($n = 36$)

ITEM	COSTS/COST SAVINGS
COSTS	
Equipment	$48,768
Labor	$70,582
Total	$119,350
Cost savings	
Health system usage	$224,878
Annual	$105,528
Per person	$2,931

Participants also described the telehealth monitoring as beneficial because it helped them to identify if they were getting sick earlier, which ultimately impacted on them seeking treatment before their condition deteriorated and required hospitalization:

> I know if my blood pressure was up the day before they will ring me…so then I'd go to the doctors and if there was a problem, he would find it before it blew into something huge.

Those who felt that the service had not had an impact on their hospitalization rate generally described this as due to the fact that they had been living with their condition for several years so had already learned to recognize the early signs of an acute exacerbation. This group commented that they thought this type of service would be extremely beneficial for people who had been newly diagnosed with COPD:

> I can see it being absolutely marvellous for people who are just starting to be crook because they don't know what the heck is going on, they don't know what the body can handle so it is all a bit scary…panic is a hard thing to control, it happens, you know it's happening and try as you might you can't stop it, and if you can't control the panic you'll end up in hospital whether you want to or not.

Participants generally agreed that receiving telehealth monitoring had provided reassurance and peace of mind knowing that a nurse was monitoring their results daily. Participants described having more control over their condition and being more confident in self-managing their condition as they were now more conscious of what their body was doing.

Some participants also recorded their readings to take to their GP. This prompted more communication with their GP, and in 2 cases participants used their monitoring results to justify/open discussion with their GP about reviewing their medications.

Discussion

The results of this research demonstrate that self-monitoring via home-based telehealth equipment can, when combined with remote monitoring of patients' results by a nurse, provide measurable health benefits for people living with COPD. These benefits were found to include a reduction in ED presentations, hospital admissions, and days in the hospital.

Much of the research investigating the use of telehealth technology has reported good outcomes in terms of reduced hospitalizations and ED presentations.[16,17] However, there has been no consistent or definitive evidence in relation to how much this type of technology reduces health service utilization.[9] This research shows that although there was not a statistically significant difference between the groups in terms of health service utilization, the intervention resulted in the telehealth group having almost half the number of COPD-related ED presentations, hospitalizations, and days spent in the hospital compared with the control group.

Prior to this study there was limited evidence as to the economic benefits of telehealth monitoring, particularly in relation to people with COPD.[1] A recent systematic review of the literature available on home telemonitoring for pulmonary conditions[9] found only two studies that conducted a detailed cost analysis of this approach, and only one of these reported actual dollar savings. This study, by Pare et al.,[1] showed a $355 saving per person in the intervention group over 6 months. Although these previous results are consistent with ours insofar as there were savings for those receiving a telehealth intervention, the $2,931 savings per annum found in our study were somewhat more substantial. This research therefore makes an important contribution to building the evidence base regarding the economic viability of such services within the wider health community.

This research has also shown that telehealth monitoring can provide users of the service with more than just reduced health service contacts. Participants reported benefits relating to increased self-confidence, control, and awareness in managing their condition, as well as an improved sense of security and reduced anxiety. Participants' self-reports of improvement in self-management were supported by the increase in a sense of mastery of their disease, as found by the CRQ-SAS quality of life tool over time. These results are similar to previous studies that also found that telemonitoring enhanced confidence in self-management,[18] improved individuals' sense of security,[19] and increased their personal awareness of their health status.[20] As with previous work exploring the acceptability of telehealth technology for older adults,[18] participants in this study reported a high level of satisfaction with the user-friendliness of the equipment.

Daily monitoring was also found for some participants to have prompted more communication about their condition with their GP, and in some cases the monitoring results were used to open discussion with their GP about reviewing their medications, demonstrating that participants were taking a more proactive role in managing their condition.

If telehealth remote monitoring is to become a widely adopted and viable service for homecare agencies in the future, it is important to understand to whom best to target this kind of service. Although our initial findings from participant interviews suggest that there are more benefits for those who have been newly diagnosed with their disease, this is something that needs further exploration. It is also essential that we understand how long the telehealth monitoring service needs to be provided to be most cost-effective. What is the optimal time for people to learn to self-manage more effectively and be able to recognize their own symptoms of exacerbation without relying on the telehealth monitoring or equipment? These are important questions to consider in future research for telehomecare models.

LIMITATIONS

Information about participants' pretrial hospitalizations was not collected, so the research was unable to explore any differences for individual health service use over time, only between-group differences.

In addition, this research relied on retrospective self-report of health system contacts. To assist in participant recall, calendars were given to all participants and were referred to at the monthly data collection phone calls.

A further limitation was the timing of the study. Because of funding constraints, the research was conducted over summer when participants with COPD are least likely to be hospitalized owing to respiratory infections.[21] As a consequence the hospital admission rate was markedly lower than expected, and the study was insufficiently powered for the difference between the two groups in hospital utilization to achieve statistical significance even though the telehealth group's hospital utilization was virtually half that of the control group. Future research needs to be conducted over a longer period that includes all seasons.

Conclusions

This research has shown that remote monitoring of patient vital signs using telehealth equipment resulted in a smaller number of health service contacts for individuals with COPD and resulted in significant cost savings. In terms of individual health benefits, improvements in participants' self-management and control over their condition were evident, and it is importantl that older people were receptive to using this type of technology and enjoyed using it as a tool in managing their COPD.

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Disclosure Statement

No competing financial interests exist.

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