Research Department
Strategic Research Series - Number 024

Telehealth Monitoring of People with Chronic Obstructive Pulmonary Disease: Are The Benefits Sustained?

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20 December 2011

Contents

EXECUTIVE SUMMARY

Telehealth remote monitoring is fast becoming an innovative option for community care providers as they seek alternative ways to assist people to effectively self-manage their chronic illness in the community. As the population ages the number of people living with complex chronic illnesses continues to rise, placing a significant burden on the Australian healthcare system. Chronic illness is associated with high use of health care services and increased hospital admissions that often, through effective self-management, could have been prevented. Using telehealth technology to remotely monitor patients in their own homes presents an opportunity to reduce the incidence of hospitalisations and emergency department presentations through the early detection of exacerbations in the person's condition.

In recognition of this, in 2009 Silver Chain applied and received funding from the Commonwealth Department of Health and Ageing to conduct a randomised controlled trial (RCT) of telehealth monitoring with Silver Chain clients who had a diagnosis of Chronic Obstructive Pulmonary Disease (COPD). The initial trial recruited eighty clients who had a diagnosis of COPD and were receiving a domiciliary oxygen service from Silver Chain. The results of this trial were very positive with reductions in health service use for the telehealth group resulting in substantial cost savings over the six month period.

This current study, as an extension of the initial RCT, aimed to build on the positive findings of the original research by addressing some of the limitations in the initial study and some gaps that still exist in telehealth research. Specifically this study aimed to firstly, determine whether the reduction in health service usage and associated costs found in summer in the initial COPD trial are still evident in winter when people are more likely to experience exacerbations of their disease due to colds and flu and secondly determine whether there are any changes in quality of life and disease management behaviours associated with the removal of the telehealth monitoring equipment.

In order to be able to investigate both the sustainability of the positive effect of the telehealth monitoring over winter and the sustainability of this effect when the equipment was withdrawn, this study utilised a cross-over design for half of the subjects whilst retaining a parallel group design for the other half. Specifically, at the completion of the previous trial, half of the participants in the intervention group retained the equipment for another six months while the other half had the equipment withdrawn. Conversely, half of the control group participants were given the telehealth intervention while the other half remained in the 'Information Only' control group.

The findings of this trial included that:

- All of the groups showed an increase in COPD related health service use in the winter period compared to the summer.

- The group who received no telehealth intervention (Info-Info) at all during the twelve month trial period had the largest percentage increases in non-COPD related GP visits, emergency department presentations, hospital admissions and days in hospital, in the winter period compared to the summer period.

- The Info-Tele group, while having the highest health service utilisation of all of the groups both in summer and winter, benefited most from the telehealth intervention in winter showing percentage decreases for non-COPD related GP visits, ED presentations, hospital admissions and days in hospital in the winter period compared to the summer period.

- Having the telehealth equipment and remote monitoring for the entire twelve month period did not provide any increased benefit in relation to health service usage or added cost savings particularly in comparison to those participants who had the equipment removed after six months.

- In terms of cost savings between the summer and winter period, the largest cost saving ($1,448 per person) was seen in the group from whom the telehealth equipment was removed after six months; and a modest cost saving ($46 per person) was achieved for the group having the telehealth intervention in winter only.

- The group having had no telehealth intervention at any point in the twelve month period, showed the largest increase in health service costs of $7,466 per person in winter compared to summer.

- Over a third of participants who had the telehealth equipment removed purchased either an oximeter or blood pressure monitor so that they could continue to monitor their own health after the telehealth equipment had been removed.

- Two thirds of participants in the group whose telehealth monitoring was discontinued agreed that there had been some form of lasting benefit six months after the equipment was removed. The main benefits being described were that they were more aware of their symptoms, had an increased understanding of the fluctuations in their condition and were now in a habit of monitoring their condition more closely.

- Participants reported a high level of satisfaction with the user friendliness of the equipment and the overall telehealth service as a whole. A large percentage (81.5%) agreed that they would be receptive to using such a service in the future.

The results of this study indicate that the maximum cost effectiveness of remote monitoring using telehealth equipment may be achieved by short term interventions rather than remote monitoring for extended periods of times no evidence of added benefit from twelve month rather than six month monitoring for was found. Further research is required to establish whether shorter periods of telehealth monitoring might be sufficient to achieve the sorts of outcomes demonstrated in this study and to determine whether the effects are long lasting.

Apart from the obvious health service utilisation and cost benefits, this research showed that the telehealth technology was readily accepted by the older people who participated in the trial and they expressed an interest in wanting to use such a service in the future if it were possible.

This research clearly shows that the use of telehealth remote monitoring can provide significant cost savings in terms of reduced health service use for people with COPD over both winter and summer periods and that there are ongoing health benefits even after the telehealth monitoring equipment has been removed.

BACKGROUND

Telehealth remote monitoring is fast becoming an innovative option for community care providers as they seek alternative ways to assist people to effectively self-manage chronic illness. As the population ages the number of people living with complex chronic illnesses continues to rise, placing a significant burden on the Australian healthcare system.[1] Chronic illness is associated with high use of health care services and increased hospital admissions that often, through effective self-management, could have been prevented. Using telehealth technology to remotely monitor patients in their own homes presents an opportunity to reduce the incidence of hospitalisations and emergency department presentations through the early detection of exacerbations in the person's condition.

Whilst there is a growing body of research on the benefits of telehealth for chronic conditions such as heart failure[2], diabetes[3] and wounds[4], the evidence base in relation to the clinical outcomes and financial viability of telehealth monitoring for people with Chronic Obstructive Pulmonary Disease (COPD) is still somewhat limited.[5] A recent systematic review of the literature on home telemonitoring for pulmonary conditions found only two studies which had conducted a detailed cost analysis of this approach.[6] The reviewers concluded that more evaluative research, utilising larger samples sizes and more robust study designs were required in order to confirm the economic viability of this kind of telehomecare program.[6]

In recognition of this, in 2009 Silver Chain applied and received funding from the Commonwealth Department of Health and Ageing to conduct a randomised controlled trial (RCT) of telehealth monitoring with Silver Chain clients who had a diagnosis of COPD.[7] COPD is a progressive and disabling chronic disease which causes restrictions in lung airflow.[8] People with COPD can often suffer from acute exacerbations which are characterised by severe shortness of breath, coughing fits and sputum production.[9] These exacerbations are not only costly in terms of increased healthcare utilisation and hospitalisations, but they can also significantly reduce the quality of life for the person living with COPD.[10]

The initial trial recruited eighty clients who had a diagnosis of COPD and were receiving an oxygen service from Silver Chain. They were randomly allocated to receive either the daily telehealth monitoring or be part of the control group who were visited by a nurse and given information about self-management of their COPD. The results of this trial were very positive with reductions in health service use for the telehealth group resulting in substantial cost savings over the six month period. Participants in the telehealth group also reported benefits relating to increased self confidence, control and awareness in relation to managing their condition, as well as an improved sense of security and reduced anxiety[7].

The research described in this report was an extension of the initial RCT and aimed to build on the positive findings of the original research by addressing some of the limitations and gaps that still exist in telehealth research. Due to funding restrictions, the initial RCT was conducted over summer, a time when people with COPD generally experience fewer hospitalisations than they would in the winter months.[11-12] Although seasonal variation has been rarely studied in other telehealth research, a recent COPD telehealth project conducted by NHS Direct[13] showed that seasonal changes in COPD were evident and that self-care, mobility, pain and discomfort deteriorated as the weather got cooler. Therefore further research was considered important to examine the effectiveness of telehealth over winter when people are more likely to have deteriorating health and an increased likelihood of exacerbations.

The sustainability of the intervention effects after the equipment and monitoring have been withdrawn is another area in which the answers are still largely unknown. "Do individuals learn via the telehealth monitoring experience to be able to better recognise signs and symptoms of a deterioration in their health and are thus better able to self manage their disease even after the equipment is removed?" and "How long is the optimal time to receive telehealth monitoring to have an impact on self-management behaviours?" Few studies have specifically examined these concepts. Dansky and Vasey[14] compared two groups of patients with heart failure. One group retained equipment for a further 180 days after the normal discharge point from a home health services which included telemonitoring, the other group did not. Patients retaining the equipment had significantly more home nursing visits but significantly fewer hospitalisations and ED presentations compared to the control group in the follow up period indicating that the benefits of telehealth monitoring were not maintained after the monitoring is ceased. Conversely, other research has found that the benefits of telehealth monitoring have been found to be sustained beyond the duration of the intervention itself, with reduced health resource use for angina patients at one year after a three month telehealth intervention.[15] It is essential that sustainability is investigated if we wish to use telehealth equipment and resources as efficiently as possible and only continue remote monitoring as long as is necessary for individuals to learn to better manage their disease.

Objectives

In order to address the issues identified, the specific objectives of the study were to:

- Determine whether the reduction in health service usage found in the telehealth group over summer in the initial COPD trial, were still evident over a further six months which included winter.
- Compare the rate and cost of health service usage for clients who received the telehealth intervention over winter with those who received the intervention over summer and those in the control group.
- Compare the rate and cost of health service usage for clients who have had their telehealth equipment withdrawn with those who retained it, and those in the control group.
- Determine whether there are any measurable changes in clients' self-assessed quality of life after receiving the telehealth intervention and ceasing it.
- Determine whether there are any changes in disease management behaviours associated with the telehealth monitoring or its removal.

METHODS

Study Design

In order to be able to investigate both the sustainability of the positive effect of the telehealth monitoring over winter and the sustainability of this effect when the equipment was withdrawn, this study utilised a cross-over design for half of the participants while retaining a parallel group design for the other half. Specifically, at the completion of the previous trial, half of the participants in the intervention group retained the equipment for another six months (Tele-Tele group) while the other half had the equipment withdrawn (Tele-Info group). Conversely, half of the control group participants were given the telehealth intervention (Info-Tele group) while the other half remained in the 'Information Only' control group (Info-Info group).

Study Population

Silver Chain clients living in the Perth metropolitan area who had a confirmed diagnosis of COPD and who were in receipt of home oxygen services from Silver Chain.

Study Sample and Size

The study sample consisted of 71 out of the 80 recruited participants who were followed for the entire six months of the initial telehealth COPD trial. Participants had been invited to take part in the original study if they met the following eligibility criteria:

- Had a confirmed diagnosis of COPD and were receiving oxygen services;
- Did not have a diagnosis of dementia;
- Could communicate in English;
- Were not receiving palliative care;
- Had a telephone land line;
- Were physically able to use the equipment; and
- Their specialist or GP agreed to take clinical governance for them whilst on the trial.

The sample size for the original study was determined on the basis that on average Silver Chain clients with a diagnosis of COPD are hospitalised 1.7 times per year and previous research on telehealth monitoring had demonstrated that a reduction in hospital admissions of up to 68% can be achieved by individuals with chronic disease[16]. Assuming a conservative reduction in hospital admissions of 45% for the telehealth intervention group it was calculated that it would be possible to detect a difference of this magnitude with 80% power and alpha=0.05, with 40 participants in each group. Eighty participants were therefore recruited into the original study.

Crossover designs require no more than half the number of participants to produce the same power as a parallel group trial[17] therefore the number of participants completing the initial trial were considered to be sufficient for this study. However, due to attrition both in the initial study and this follow up research (21% in total), the sample sizes required for statistical power were not achieved.

Recruitment

The protocol for the initial study included a final data collection visit to each participant at six months. This final data collection visit was used to invite study participants to enrol in the next study. All participants were asked to continue in the study and to ensure that all the available telehealth equipment was used, telehealth monitoring was offered to participants until 20 in each group had accepted.

All participants' specialists or GPs were informed that the trial was continuing and the specialists or GPs of those participants who were using the telehealth equipment for the first time were asked to define the parameters for what was considered normal for their patient in terms of blood pressure, pulse rate, oxygen flow rate, weight and temperature.

Study Groups

Telehealth (Continuing with Telehealth (Tele-Tele) or Commencing Telehealth (Info-Tele))

Following collection of the data for the initial study and recruitment into the new study, participants who had not previously been part of the telehealth group (Info-Tele) were trained by the telehealth Nurse to use the equipment. Participants were shown how to measure their own blood pressure, weight, heart rate and oxygen saturation levels and enter their results, and answers to questions relating to their general state of health and other symptoms, into the monitoring equipment which was programmed to reflect each participant's individual norms.

Regardless of whether the individual was new to telehealth or had used it in the initial study, the nurse provided a new calendar for them to continue recording their use of health services.

The participants in the Tele-Tele and Info-Tele groups were instructed to measure their vital signs every day and enter them into the equipment so they could be transmitted automatically via telephone to a secure website accessed by the telehealth nurse at Silver Chain. Each participant's data were monitored daily by the telehealth nurse and any changes in vital signs indicating deterioration in health were managed using the standard protocols already in place from the initial study[7].

Information (Telehealth equipment removed (Tele-Info) or continuing no intervention (Info-Info))

Following collection of data from the initial study and recruitment into this follow-up study, the telehealth nurse provided a new calendar for participants to continue recording their use of health services. Nothing else was provided to these two groups as the information had been provided in the original study[7].

Data Collection

The data collection commenced in the first study continued for an additional six months. The following information was collected from all participants:

- ***Hospital admissions, Emergency Department presentations, GP and specialist visits*** were recorded by participants in a monthly calendar at the time they occurred and a Research Assistant phoned each participant once a month to collect the information.

- ***Service data*** from Silver Chain's information management system ComCare was used to track the number and duration of telehealth nurse visits as well as the time spent monitoring the telehealth groups.

- ***Health Related Quality of Life,*** which had been measured at baseline and six months later at completion of the first study, was measured again at completion of the current trial at twelve months, using the Chronic Respiratory Questionnaire Self-Administered Standardized Version (CRQ-SAS).[18] This tool was developed specifically to measure the quality of life of people with chronic lung disease.

- ***Participant surveys*** were conducted face to face by the Telehealth nurse in the participants' own homes for the Info-Tele and Tele-Tele groups, during their final visit at 12 months when the equipment was removed. The satisfaction survey was developed using the interview data from the initial trial. The aim of the survey was to determine how satisfied participants were with the telehealth equipment and what impact, if any, the telehealth service had made in terms of reducing hospitalisations and helping them to improve their management of their COPD. A copy of the survey can be found in Appendix 1.

  Participants who had the telehealth equipment removed at six months and continued for a further six months in the information only group were phoned for a short telephone interview at the completion of the study to determine:

  - If after completing the telehealth service they had purchased any health monitoring equipment.
  - If there were any lasting benefits after the telehealth equipment was removed.
  - If participants managed their condition any differently now after having received the telehealth service.
  - If participants thought using the telehealth equipment had been worthwhile for their health.

- ***Total costs***, which included costs of the intervention plus visit, monitoring, emergency department presentations and hospital admissions, were calculated for each group for the whole twelve month period covering both studies as well as for each six month study period separately.

Ethics

Ethics approval for this project was granted by the Silver Chain Human Research Ethics Committee.

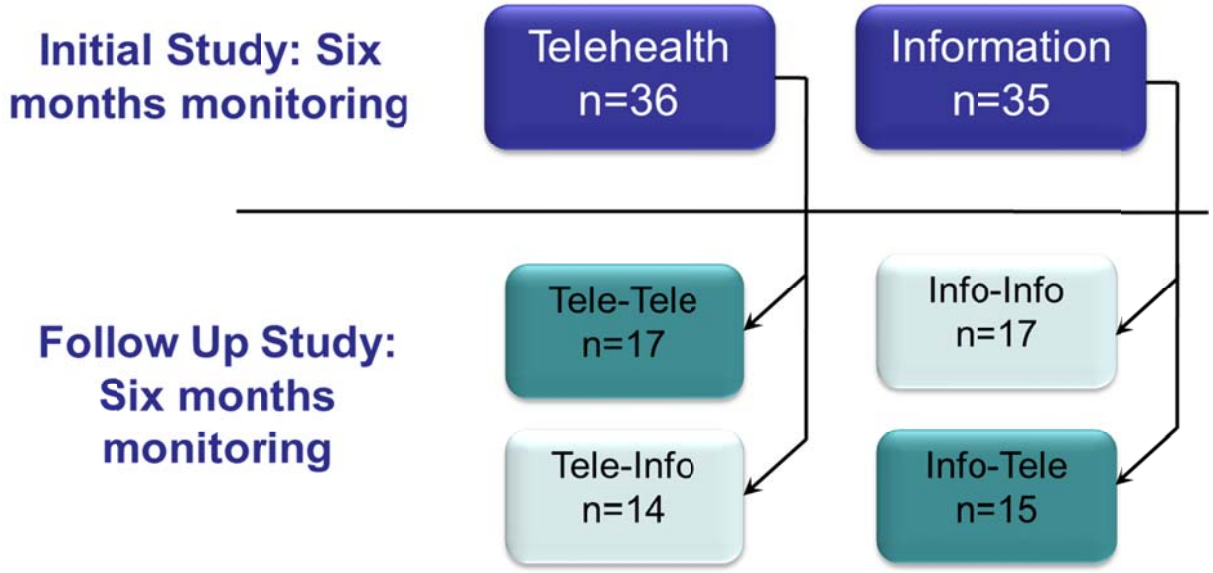
RESULTS

There were 71 participants who completed the initial six month study and of these, two people declined to continue in the crossover study for a further six months. (One was about to commence palliative care services and one was moving overseas.) Therefore a total of 69 clients were recruited into the crossover study.

Seven participants were lost to follow-up (five deceased, two withdrawn) at the completion of the twelve month study period.

Results are presented for the 63 participants who participated for the full twelve months in the trial. Figure 1 shows the final sample size of each group.

Figure 1: Sample Size of Each Group



Demographic Characteristics

Table 1 shows that the mean age for participants ranged from 70 to 75 years and there were no significant differences in age between the four groups. There was also no significant difference between the groups in terms of gender despite the Tele-Info group having a larger proportion of females than the other groups. In terms of living arrangements, the majority of participants lived with family or others except for the participants in the Info-Info group who had a significantly higher proportion of participants who lived alone (*p = .016)*. While fewer participants from the Tele-Tele group and the Info-Tele group had a carer, this difference was not statically significant.

Table 1: Demographic Characteristics

	Tele-Tele	**Tele-Info**	**Info-Info**	**Info-Tele**
Age (mean)	69.9	70.3	75.4	71.4
				p = .193
Gender n (%)				
Female	8 (50.0%)	10 (71.4%)	8 (47.1%)	7 (46.7%)
Male	8 (50.0%)	4 (28.6%)	9 (52.9%)	8 (53.5%
				p = .485
Living Arrangement n (%)				
Lives Alone	3 (18.7%)	3 (21.4%)	10 (58.8%)	2 (13.3%)
Lives with Family	13 (81.3%)	11 (78.6%)	7 (41.2%)	13 (86.7%)
				p = .016
Carer Status n (%)				
No Carer	6 (37.5%)	10 (71.4%)	12 (70.6%)	7 (46.7%)
Has a Carer	10 (62.5%)	4 (28.6%)	5 (29.4%)	8 (53.3%)
				p = .134

Health Related Quality Of Life

The questions in the CRQ-SAS are divided into four dimensions; dyspnea, fatigue, emotional function and mastery and each of these are reported separately rather than as an overall quality of life score.

As shown in Table 2, there were no significant differences between any of the groups for any of the domains at baseline or at twelve months. There was however a significant change ($F(3,53)= 3.7$; *p=0.017*) in Dyspnea (breathing ability) between six months and twelve months. While the Info-Info group significantly declined in Dyspnea score, the Info-Tele group significantly improved.

The minimum amount of change that has found to be clinically significant or important in a respondents' day to day life is an improvement of 0.5 per question per dimension[18]. There are five questions in the domain of Dyspnea and therefore to achieve clinical significance, a change of 2.5 is required. The Info-Tele group improved by 2.67 achieving clinical significance while the Info-Info group had a clinically significant decline of 4.53 points.

Table 2: Mean Scores for CRQ-SAS by Domain and Change Over Time

	Base	6 month	12 month	Change (Base/6)	Change (6/12)	Change (Base/12)
Dyspnea						
Tele-Tele	4.11	3.48	3.72	-3.12	1.19	-1.94
Tele- Info	4.04	3.84	3.94	-1.00	0.54	-0.45
Info-Info	4.37	4.35	3.44	-0.13	-4.53	-4.70
Info-Tele	4.19	3.89	4.43	-1.47	2.67	1.20
				p = .388	***p = .017****	*p = .082*
Fatigue						
Tele-Tele	3.86	3.62	3.75	-0.94	0.50	-0.44
Tele- Info	3.75	4.16	3.66	1.64	-2.00	-0.36
Info-Info	3.03	3.1	2.93	0.27	-0.67	-0.40
Info-Tele	3.83	3.38	3.23	0	-0.60	-0.60
				p = .402	*p = .508*	*p = .999*
Emotion						
Tele-Tele	4.69	5.03	5.03	2.37	0	2.37
Tele- Info	4.91	5.06	4.56	1.09	-3.54	-2.45
Info-Info	4.35	5	4.25	4.53	-5.27	-0.73
Info-Tele	4.27	4.53	4.29	1.87	-1.67	0.2
				p =.587	*p = .071*	*p = .375*
Mastery						
Tele-Tele	5.05	5.31	4.97	1.06	-1.37	-0.31
Tele- Info	4.57	5.07	4.48	2.00	-2.36	-0.36
Info-Info	4.17	4.58	4.08	1.67	-2.00	-0.33
Info-Tele	4.48	4.67	4.22	0.73	-1.80	-1.06
				p = .893	*p = .956*	*p = .963*

* Significant at the p<.05 level.

Health Service Use

Table 3 shows the mean health service use for each of the groups for the initial six month period (summer) and the six month follow-up period (winter), as well as the mean change between summer and winter. Health service use described in this table includes both COPD related and non-COPD related health service use. (Assumptions for the coding of COPD and non COPD related health service use can be found in Appendix 2.)

Table 3 shows that the Info-Info group had an increase in all health service usage in the winter period compared to the summer period. Specifically, days in hospital increased from an average of 1.6 days per person in summer to 6.3 days in winter as well as a significant increase in GP visits ($t(32)=-3.8126$; $p=0.0006$) and specialist visits ($t(32)=-2.0809$; $p=0.045$). The mean change in the number of GP and specialist visits for the Info-Info group was also significantly greater than the other groups ($F(3,59)= 4.09$; $p=0.01$). On average, GP visits for the Info-Info group increased while they decreased for each of the other groups in winter, compared to summer.

The Tele-Tele and Tele-Info group had a small increase in mean hospital related health service use in the winter period compared to the summer period. While the Info-Tele group had the highest health service usage of all of the groups in the summer period, mean health service usage decreased for this group in winter, although this decrease was not statistically significant.

Table 4 shows the percentage increase or decrease from summer to winter in heath service use for each of the groups. The Info-Info group had large increases in health service use, particularly for time spent in hospital (LOS=296% increase) as well as ED presentations (250% increase) and hospital admissions (167% increase). The Tele-Info group, while having the highest total usage of all of the groups, still achieved reductions in health service use in winter, compared to summer for all health service usage.

Figures 2 to 6 show the mean change in COPD related and non COPD related health service usage between the six month periods in summer and winter. All of the groups show that there was an increase in COPD related health service use in the winter period compared to the summer. However, the mean change for COPD related days in hospital of the Info-Info group was larger than the other groups (3.9 vs 0.4-1.9) although this difference was not statistically significant. All of the groups had a reduced mean change in all non-COPD related health service usage (except specialist visits) apart from the Info-Info group. The Info-Info group had no decrease in health service usage at all.

Table 3: Mean Health Service Usage and Mean Change Over Time for Each Group

	Info-Info (n=17)			Info-Tele (n=15)			Tele-Info (n=14)			Tele-Tele (n=17)		
	Summer (mean)	**Winter (mean)**	**Mean Change**	**Summer (mean)**	**Winter (mean)**	**Mean Change**	**Summer (mean)**	**Winter (mean)**	**Mean Change**	**Summer (mean)**	**Winter (mean)**	**Mean Change**
Hospital admissions	0.35	0.94	0.58	1.46	1.2	-0.27	0.29	0.29	0.00	0.47	0.59	0.12
Hospital LOS	1.6	6.29	4.70	8.8	8.4	-0.40	1.14	1.28	0.14	2.82	3.88	1.06
ED	0.24	0.82	0.58	1.27	0.87	-0.40	0.36	0.21	-0.14	0.53	0.65	0.12
GP visits	3.41	6.23*	2.82*	9.6	7.33	-2.27	7.42	5.64	-1.78	7.47	6.35	-1.11
Specialist visits	2.11	4.05*	1.94*	4.07	2.73	-1.33	2.29	3.29	1.00	3.35	3.18	-0.18

*p <0.05

Table 4: Percentage Change of Health Service Usage

	GP	**Specialist**	**ED**	**Hospital**	**LOS**
Info-Info	+83%	+91%	+250%	+167%	+296%
Info-Tele	-24%	-33%	-36%	-18%	-5%
Tele-Info	-24%	+44%	-40%	0%	+12%
Tele-Tele	-15%	-5%	+22%	+25%	+35%

Figure 2: Mean Change in COPD and Non-COPD Related Hospital Admissions

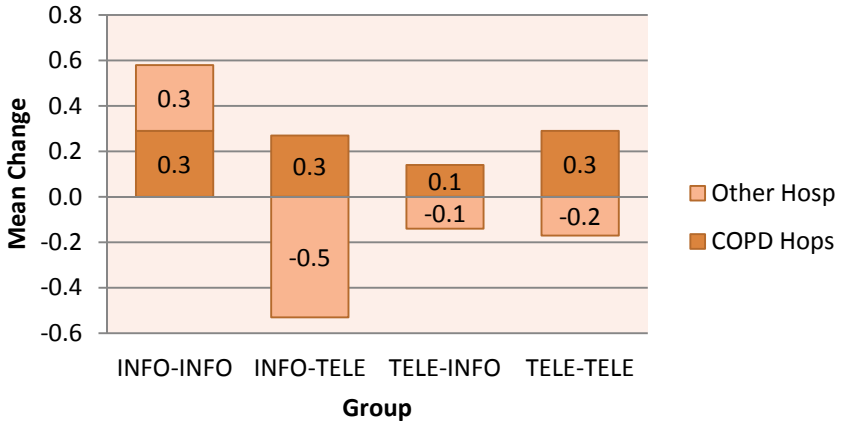


Figure 3: Mean Change in COPD and Non-COPD Related Days in Hospital

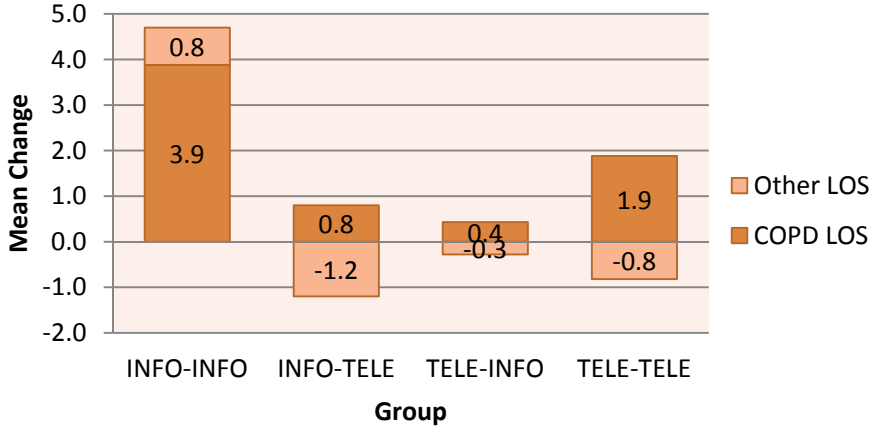


Figure 4: Mean Change in COPD and Non-COPD Related ED Presentations

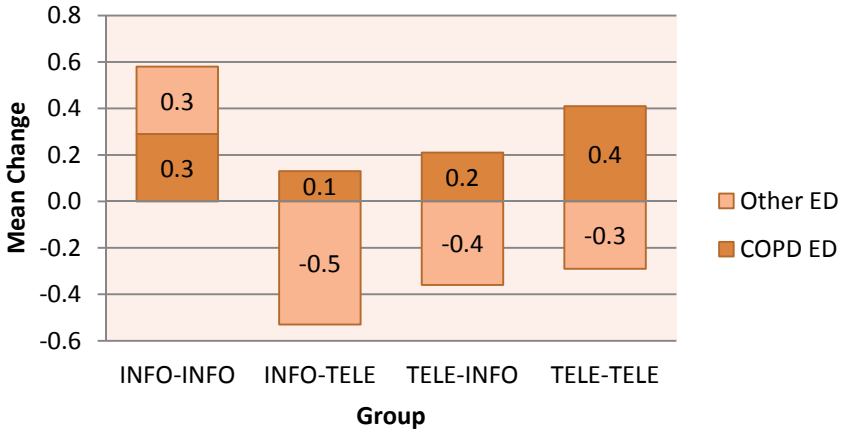


Figure 5: Mean Change in COPD and Non-COPD Related GP Visits

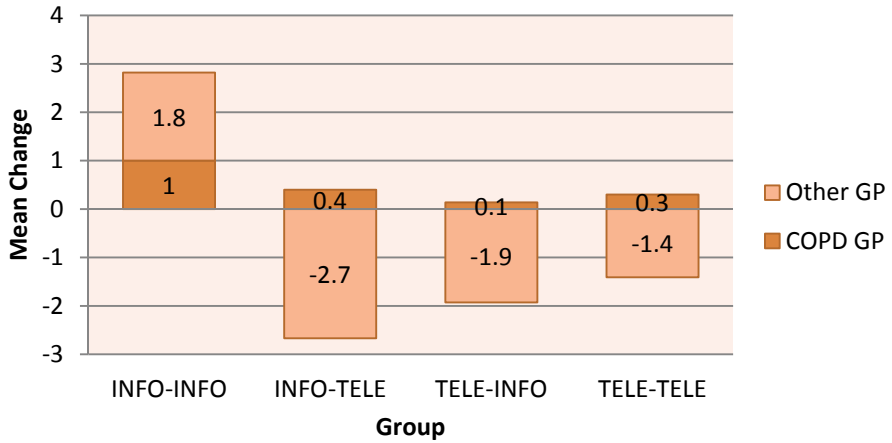
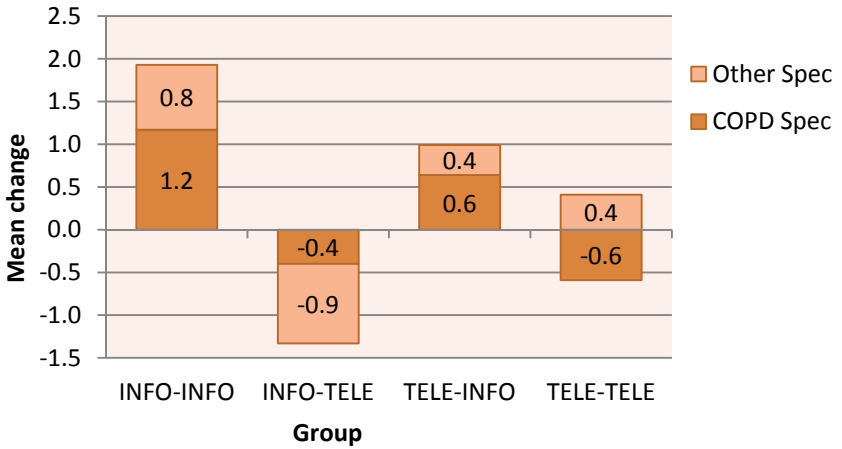


Figure 6: Mean Change in COPD and Non-COPD Related Specialist Visits



Cost Benefit

The cost benefit was calculated in two ways. Firstly, the health services, equipment and monitoring costs for each group were calculated for each six month time period and the benefit determined from the difference between the winter and summer periods. A positive difference indicated increased cost in the winter period compared to the summer period, while a negative difference indicated a reduction in cost between summer and winter (Table 5). Secondly, the cost of the entire twelve month period was calculated for each of the four groups and each of the three groups having had a telehealth intervention at some point (Tele-Tele, Tele-Info and Info-Tele) were compared to the Info-Info group (Table 6). Negative figures indicate a cost saving over the twelve months compared to the Info-Info group.

Table 5 shows that the Info-Info group had an average increase in total cost per person of $7,466 as a result of increased health service usage in the winter period. Additionally, the Tele-Tele group had an increased average cost per person of $1,344 as a result of increased health service usage during the winter period, but these costs also included equipment, monitoring and visit costs.

Despite the costs of the Info-Tele group being the highest of all groups for both summer and winter periods, the mean cost per person decreased by $46 per person in the winter period reflecting reduced health service use over that time. This decrease in costs was considerable considering that this group had the telehealth equipment and monitoring in the winter period adding to the overall cost during winter.

The Tele-Info group had a mean decrease in health service cost between the summer and winter periods of $1,448 per person. While most of the change in costs between this group's summer and winter periods is a result of no equipment or monitoring costs in the winter period, there were no increased costs associated with the removal of the equipment and monitoring in terms of increased health service use.

Table 5: Mean Change in Cost Over Time

	Info-Info			Info-Tele			Tele-Info			Tele-Tele		
	Summer $	**Winter $**	**Change $**	**Summer $**	**Winter $**	**Change $**	**Summer $**	**Winter $**	**Change $**	**Summer $**	**Winter $**	**Change $**
Equipment costs	0	0	0	0	10,160	10,160	9,482	0	-9,482	11,515	11,515	0
Visits	1,826	0	-1826	1,981	1,630	-351	2,827	0	-2,827	3,517	360	-3,157
Monitoring	0	0	0	0	5,460	5,460	9,173	0	-9,173	11,138	11,138	0
Subtotal	***1,826***	***0***	***-1826***	***1,981***	***17,250***	***15,269***	***21,482***	***0***	***-21,482***	***26,170***	***23,013***	***-3,157***
GP visits	3,944	7,208	3,264	9,792	7,480	-2,312	7,072	5,372	-1,700	8,636	7,344	-1,292
Specialist visits	2,772	5,313	2,541	4,697	3,157	-1,540	2,464	3,542	1,078	4,389	4,158	-231
ED visits	2,200	7,700	5,500	10,450	7,150	-3,300	2,750	1,650	-1,100	4,950	6,050	1,100
Hospital LOS	39,636	157,076	117,440	193,776	184,968	-8,808	23,488	26,424	2,936	70,464	96,888	26,424
Subtotal	***48,552***	***177,297***	***128,745***	***218,715***	***202,755***	***-15,960***	***35,774***	***36,988***	***1,214***	***88,439***	***114,440***	***26,001***
Total	**50,378**	**177,297**	**126,919**	**220,696**	**220,005**	**-691**	**57,256**	**36,988**	**-20,268**	**114,609**	**137,453**	**22,844**
Total cost per person	***2,963***	***10,429***	***7,466***	***14,713***	***14,667***	***-46***	***4,090***	***2,642***	***-1,448***	***6,742***	***8,085***	***1,344***

Table 6 shows the 12 months cost savings for each of the telehealth groups compared to the Info-Info control group. Over the twelve month period, only the Tele-Info group showed a cost saving in comparison to the Info-Info group. This was considerable with a cost savings of $6,633 per person. As seen in Table 6, the Info-Tele group cost the most over the 12 month period at $16,294 per person more than the Info-Info group.

Having the telehealth intervention for the entire twelve months (Tele-Tele) did not provide any additional cost benefits over the Tele-Info group where the equipment was removed and monitoring ceased, but had an increased cost, compared to the Info-Info group of $1,434.

Table 6: Cost Savings of Each Group in Comparison with Info-Info Group Over 12 Months

Items	**Costs/Cost savings ($)**		
	Info-Tele	**Tele-Info**	**Tele-Tele**
Equipment costs	10,160	9,482	23,030
Labour costs	11,827	10,500	24,327
Total costs	21,987	19,982	47,357
Health system usage cost savings	**222,425**	**-112,847**	**-22,970**
Annual cost savings	244,412	-92,865	24,387
Per person cost difference	16,294	-6,633	1,434

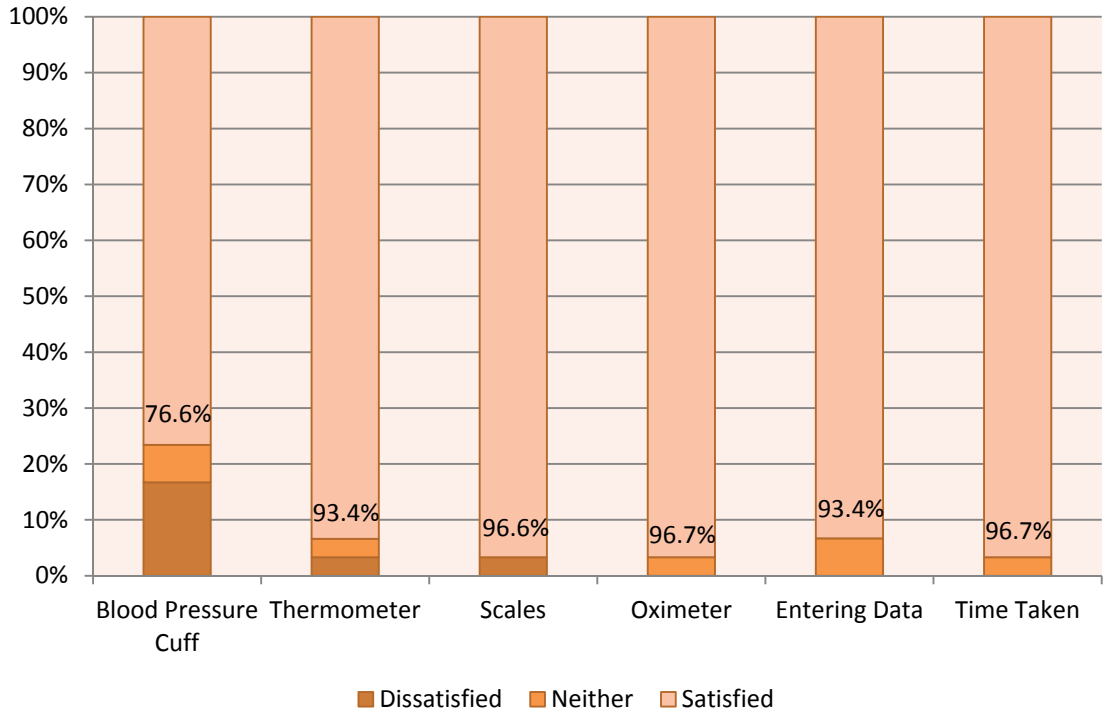
Participant Satisfaction

Using the Telehealth Equipment

The vast majority of participants found the equipment user friendly and were satisfied with the ease of entering their results into the Telehealth monitoring device. As shown in Figure 7 the only piece of equipment that posed some difficulty for participants was the blood pressure cuff. Participants described problems with the cuff being too stiff, which made it difficult to secure firmly.

Just under half of all participants who used the telehealth equipment (43.3%) required assistance to take their daily measurements. Specifically, they required assistance with fitting the blood pressure cuff and getting it secure. Three people required assistance with taking all their measurements and two people required assistance with entering their results into the telehealth equipment. Nearly all participants (96.7%) were satisfied with the time it took to enter their daily measurements, which averaged seven minutes and ranged from three to fifteen minutes.

Figure 7: Satisfaction With The Ease of Use Of Telehealth Equipment



Impact on Health Service Use

As well as the ease of use of the telehealth technology, participants were also asked whether receiving the telehealth service had made an impact in terms of their health service utilisation and their ability to manage their chronic illness (Figure 8). Results showed that the area of greatest impact was in terms of increasing the participants' sense of security, with 80.3% of participants agreeing that the telehealth service had a medium to very large impact.

"Having the equipment is reassuring, it has given me a lot of confidence…I know all the things to watch out for, it makes you aware of your symptoms."

More than two thirds of participants also felt that there had been a medium to very large impact on their ability to self-manage their COPD and in helping them to identify earlier when they may have been getting sick.

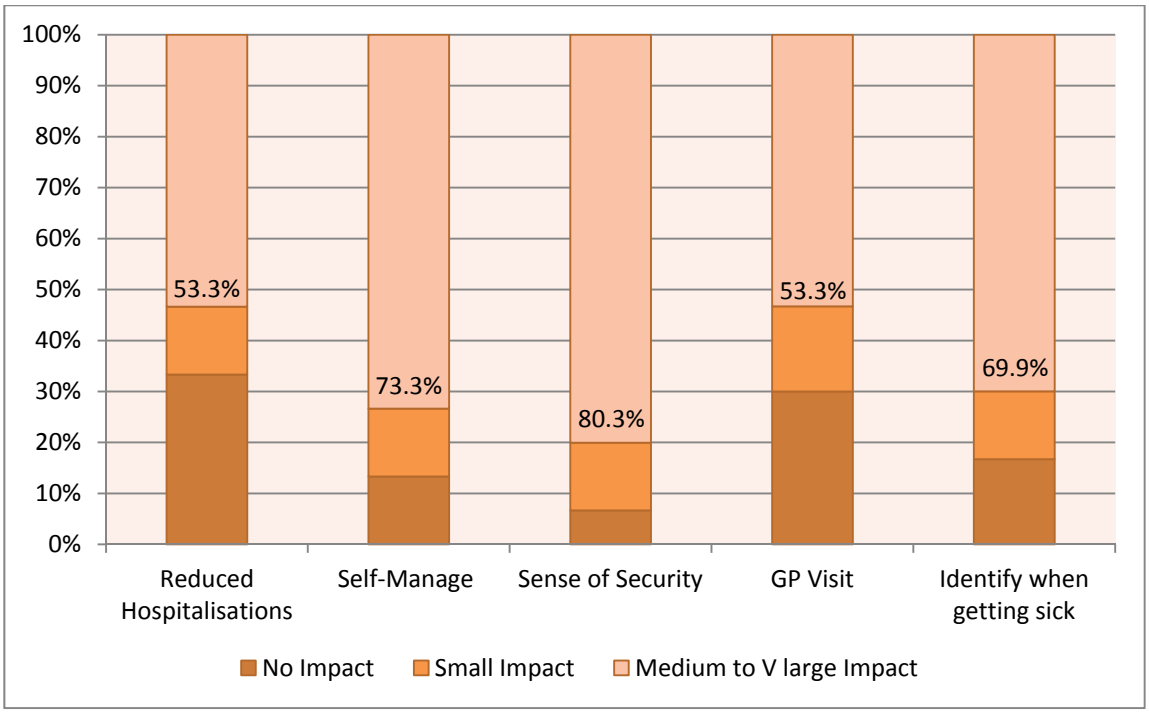
"Since having the equipment it confirms when I am getting sick and I know to increase stronger antibiotics."

Just over half the participants (53.3%), agreed that there had been a medium to very large impact on reducing the number of times they have been to hospital for their COPD and reducing the times they have needed to visit their GP.

"The equipment is great. Before I had the equipment I wouldn't know I was getting sick and I would normally end up in hospital…If I had the equipment 10 years ago I would not have been to hospital as much."

"It is good back up really, instead of going to the doctor all the time we can just check...It does save a lot of trips to the doctor."

Figure 8: Impact of Telehealth



Additional Benefits

Apart from the impacts described above, participants also described several additional benefits of telemonitoring. Some participants recorded their daily readings in a separate diary so they could discuss them with their GP/specialist and use them to describe how they had been feeling since their last visit. Just over half of the participants (58.6%) commented that they discussed their daily measurements with their GP.

"Information helped my GP monitor my condition which was an unexpected benefit."

"I think it was good for my doctor as well. I took in a book to show him my readings and I think it gave him a picture of how I was going...Instead of me thinking, now when was the last time I had high BP, I could go to my book and say, on this day it was high."

Additionally some carers said that it provided them with reassurance knowing that someone else was monitoring their relative/friend on a daily basis.

"I feel like I am not trying to deal with it all on my own, I feel safer with him having the equipment."

Future Use

Nearly all participants (96.5%) reported that they were either satisfied or very satisfied with the telehealth service as a whole and there were no negative experiences reported. When asked if the equipment was provided for free and they only had to pay for the daily phone call would they want to continue using the telehealth service, 81.5% of people said yes.

Withdrawing the Telehealth Equipment

Of the 14 participants in Tele-Info group, just over a third (35.7%) purchased either an oximeter or BP monitor after the telehealth equipment had been removed. One of these participants also purchased a thermometer and scales. Of the remaining participants, six (42.87%) did not purchase any equipment and three participants already had their own BP monitor.

In terms of lasting benefits, 71% (10 out of 14) participants agreed that there had been some form of lasting benefit six months after the equipment was removed. The main benefit described was that they were more aware of their symptoms, had an increased understanding of the fluctuations in their condition and were now in the habit of monitoring their condition more closely.

"I guess I am more into a pattern for checking and I am more aware of things."

"I can now recognise when I am a bit short of breath and notice when my oxygen levels are dropping...I recognise that when I am feeling a bit short of breath I should take a rest for a while."

"I am more aware of the way I feel in general each day, it creates awareness that if you don't feel right BP wise or pulse wise, you can do something about it…I guess you are more cognisant of your symptoms."

Approximately 50% of participants reported that they managed their condition differently since having had the telehealth service. Participants described paying more attention to their symptoms and managing these symptoms more proactively.

"I am more diligent about my condition now. I will go to the doctor's for little things, rather than waiting for them to become big problems, which is what I would have done before."

"I take more notice of things, and take remedial measures if things aren't right…for example, if I'm feeling a bit off, I will take it easy and have a nap, I won't try to push myself."

"I manage better, I don't worry so much."

When asked if they thought using the telehealth equipment had been worthwhile for their health, 78.6% (11 out of 14) agreed.

"Yes, it has helped me to understand my condition, taught me not to panic and when I should go to the doctors."

"It gave me insight into what was really happening. When you go to the doctor's, sometimes they explain things and you nod and say yes, yes, yes when you don't really understand. Now I understand more about what is being said."

Improvements

Participants were asked if they thought there was any way the telehealth service could be improved. The main comments were that they would have liked to keep the equipment for longer and that at installation it would have been beneficial to discuss the participants' thresholds for their average vital signs so that they would know what is normal for them[a].

"I would have liked the equipment a bit longer…things happened after and if I still had the equipment I may have picked them up."

"While I was on the study I didn't know what my average BP values should have been, and it would have been interesting to know what the typical values should be, for monitoring my own health, so that I would have an idea if I was a bit out."

DISCUSSION

This research has shown that remote monitoring of patient vital signs can reduce health service use and improve health outcomes for individuals living with COPD. The positive results found in the initial COPD trial over summer were also evident over the winter with those who did not receive the telehealth intervention at all having the highest percentage increase in all health service use from summer to winter.

The largest impact of the telehealth intervention can be seen on the health service usage of the Info-Tele group. For the first six months this group were provided with information only and then received the telehealth remote monitoring for six months over winter. During the first six months the health service use of this group was the highest of all of the groups. Their average total LOS in hospital over summer was almost nine days compared to the other groups' LOS which ranged from one to three days. On average they had more ED presentations, hospitalisations and GP and specialist visits in the summer indicating that as a group, they were probably the group experiencing the most exacerbations of their COPD. In the winter period, in terms of average health service use per person, the group still had the most days in hospital, hospital admissions and ED presentations. However, in comparison to the summer period, all of the health service usage was decreased. Additionally, based on the use of health services by the Info-Info group in winter compared to summer, if the Info-Tele group had not received the telehealth intervention, their average number of days in hospital could have been expected to increase four-fold (like the Info-Info group). This would have meant that over winter they would have on average spent approximately 30 days in hospital.

The improvement seen in the Info-Tele group compared to the Info-Info group was also apparent in the Dyspnea domain of the quality of life tool, CRQ. There was a measurable improvement at twelve months that was not apparent at six months in the Info-Tele group's mean score. None of the other groups showed an improvement in this domain from summer to winter. In comparison, the Info-Info group's mean Dyspnea score was markedly lower indicating they were experiencing more difficulties breathing.

[a]It should be noted that the Telehealth nurse did discuss the thresholds with participants during the installation process and there was only one person who commented on not receiving this information.

An unexpected finding in this trial was that the telehealth intervention was associated with a reduction in non-COPD related health service use. This was not found in the initial trial where the differences between the groups were due mainly to COPD related health service usage. In this trial, there were fewer differences in COPD related health usage (except for LOS) between the Info-Info group and the other groups and the main differences were due to decreases in non-COPD related health service use. In hindsight this could perhaps have been predicted as the average age of the participants was 70 or older and they were therefore likely to have one or more co-morbid chronic conditions which would benefit from vital sign monitoring. Recent analysis of the hospital admissions of Silver Chain clients showed that the best predictor of frequent and long hospitalisations was the number of co-morbidities a client had.[19] To date most telehealth research has targeted single conditions and ascribed any reductions in hospital admissions to improved management of the target condition.[20] While this research also targeted just one condition – COPD, the collection of health service data that identified whether services were COPD or non-COPD related has highlighted the potential benefits of telehealth monitoring for co-morbid conditions. Future research needs to determine whether a whole of person approach that tailors monitoring to the particular diagnostic profile of the individual can increase the effectiveness of the telehealth intervention.

The second aim of this study was to determine whether the benefits of telehealth remote monitoring are sustained when the telehealth equipment has been removed. The results showed that the group which had the telehealth equipment removed after six months of monitoring sustained a lower than average health service usage over the winter period. They also showed the smallest increase in COPD related health service use between summer and winter of all of the groups. Clearly the removal of the equipment did not have a negative impact on the health of the participants. This was recognised by the clients themselves. When interviewed, they described the telehealth intervention as having given them lasting benefits even after the equipment was removed. They described the main benefits as having become more aware of their symptoms; having an increased understanding of fluctuations in their condition; and having acquired the habit of monitoring their condition more closely. This was evidenced by more than half of them having purchased their own monitoring equipment following the end of the initial trial so they could continue to actively manage their condition. It would seem that being remotely monitored for a six month period provided this group with the self-confidence, motivation and knowledge to successfully self-manage their COPD.

The differences between the groups in terms of health service use are of course reflected by the cost data. Over the winter period the Info-Info had an average increase in health service costs of $7,466 per person as compared to summer. Participants who had the telehealth service for the entire 12 months (Tele-Tele) also cost more over winter compared to the summer period, although to a lesser extent-$1,344 on average per person. The two groups which had the telehealth service for only half of the twelve months both had reduced costs over winter compared to summer. Participants who had telehealth in the second six month (winter) period (Info-Tele)had an average reduction of $46 per person, while the Tele-Info group cost $1,448 less per person in the winter compared to the summer.

If service costs for the intervention groups are examined over the entire twelve month period and compared to the Info-Info group as the control group, only the Tele-Info group showed a cost saving. These savings amounted to $6,633 per person. Access Economics[24] estimates that 5.6% of Australians have COPD Stages II to IV and for a population in Australia of 21,874,920[25], the number of people with COPD Stages II to IV is 1,224,996. In addition, 13% of this group have COPD Stage III or IV and 10% of them require long term oxygen therapy[24]. Therefore, 15,924 Australians could benefit from the Tele-Info intervention. At a savings of $6,633 per patient, the health system in Australia could save up to $52.8 million per annum if there was to be a 50% take-up of the Tele-Info intervention by those who are eligible.

LIMITATIONS

The conclusions that can be drawn from this research are limited by two flaws in the study design. Firstly the sizes of the groups were smaller than anticipated. While the original design was powered adequately to determine statistical differences between the groups, it did not allow for attrition. By the end of the initial trial, nine of the participants had been lost to follow-up, and by the end of the cross-over trial a further seven participants had dropped out. Consequently, the differences reported between the groups, although quite large, did not achieve statistical significance.

The second limitation was the failure to collect co-morbid diagnoses at the beginning of the first trial and collect more detailed information regarding health service usage that was not directly COPD related. The restricted data we did collect only allowed us to conclude that the telehealth intervention had an impact on conditions other than COPD. We were however, unable to draw any conclusions as to what impact and why. Further research is needed that examines whether the benefits of telehealth self-monitoring can be increased by tailoring the monitoring to an individual's specific disease profile.

CONCLUSIONS

This research clearly shows that:

1 Telehealth remote monitoring can reduce health service use by people with COPD, over both winter and summer periods, and thus produce cost savings.

2 The health benefits of telehealth monitoring are sustained when the equipment has been removed.

3 Having the telehealth equipment and remote monitoring for the entire twelve month period did not provide any increased benefit as measured by health service usage or added cost savings.

These results suggest that the maximum benefit of telehealth remote monitoring, for the individual and the community (in terms of cost effective use of resources) may be achieved via short rather than long term interventions. Further research to test this hypothesis and establish the optimal monitoring period for achieving long lasting benefits is required.

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APPENDIX 1: CLIENT SATISFACTION SURVEY

SILVER CHAIN

CLIENT SATISFACTON SURVEY

TELEHEALTH RESEARCH ACROSS THE COMMUNITY

	How satisfied are you with the following aspects of the Telehealth Equipment?	very dissatisfied	dissatisfied	neither satisfied or dissatisfied	satisfied	very satisfied
a	Ease of use of Blood Pressure Cuff	☐1	☐2	☐3	☐4	☐5
b	Ease of use of Thermometer	☐1	☐2	☐3	☐4	☐5
c	Ease of use of Scales	☐1	☐2	☐3	☐4	☐5
d	Ease of use of Oximeter (Finger Pulse)	☐1	☐2	☐3	☐4	☐5
e	Ease of entering your measurements into the Telehealth Machine	☐1	☐2	☐3	☐4	☐5
f	Time it took to take and enter your daily measurements	☐1	☐2	☐3	☐4	☐5

2 How long did it to take to do your daily measurements? _____ minutes

3 If you had any difficulties using any of the equipment please describe the difficulties you had.

_____

_____

_____

_____

_____

_____

_____

4a Did you require assistance from anyone to do your daily measurements? Yes ☐1 No ☐2

4b If Yes, what did you require assistance with?

_____

_____

_____

		No impact	Small impact	Medium Impact	Large Impact	Very Large Impact
5	**How much impact has the Telehealth Service had in terms of the following:**					
a	**Reducing the amount of time you have been to hospital for your COPD?**	☐1	☐2	☐3	☐4	☐5
b	**Helping you to better self-manage your COPD?**	☐1	☐2	☐3	☐4	☐5
c	**Providing a sense of security?**	☐1	☐2	☐3	☐4	☐5
d	**Reducing the amount of times you have needed to visit your GP?**	☐1	☐2	☐3	☐4	☐5
e	**Helping you to identify when you may have been getting sick earlier?**	☐1	☐2	☐3	☐4	☐5

6 **If you received any other benefits, please describe them below.**

_____

_____

_____

_____

_____

_____

_____

		very dissatisfied	dissatisfied	neither satisfied or dissatisfied	satisfied	very satisfied
7	**How satisfied were you with the phone calls from the Telehealth nurses regarding your daily results?**	☐1	☐2	☐3	☐4	☐5

8 **Did the Telehealth nurse ever recommend to you to visit your GP as they thought you were getting sick?** Yes ☐1 No ☐2

9a **If Yes, did you act on their advice?** Yes ☐1 No ☐2

9b If No, why not?

_____

_____

_____

_____

10a Did you have any negative experiences from being involved in the Telehealth Study? Yes ☐1 No ☐2

10b If Yes, please describe the negative experiences you had.

_____

_____

_____

_____

_____

_____

_____

11 If the equipment was provided to you for free and you only had to pay for the daily phone call would you want to continue receiving the Telehealth Service? Yes ☐1 No ☐2

12a Did you fill out your monthly calendar? Yes ☐1 No ☐2

12b If no, why not?

_____

_____

_____

13a Did you read the COPD Educational Booklet that was given to you at the start of the service? Yes ☐1 No ☐2

13b If yes, did you learn anything new from reading the booklet? Yes ☐1 No ☐2

14 Did you ever discuss your daily results with your GP? Yes ☐1 No ☐2

15 **Is there any way that we could improve the Telehealth Service?** Yes ☐1 No ☐2

16 **If yes please describe how we could improve the Telehealth Service**

_____

_____

_____

_____

_____

_____

_____

		very dissatisfied	dissatisfied	neither satisfied or dissatisfied	satisfied	very satisfied
17	**Over all how satisfied were you the Telehealth service as a whole?**	☐1	☐2	☐3	☐4	☐5

Thank you for completing the survey.

KDS [Telehealth 4 Jun 10]

APPENDIX 2: CODING OF COPD FOLLOW-UP PHONE CALL DATA – ASSUMPTIONS

GP Visits (COPD Related)

Only coded if the GP visit could be directly attributed to being related to COPD, including:

- If it was explicitly stated that the visit was for issues related to COPD.
- If the visit was for breathlessness.
- If the visit was for chest pains.
- If the visit was for pneumonia.
- If the visit was for asthma.
- If the visit was for a chest infection.
- If the visit was for either a cold or the flu (but not for flu vaccinations).
- If the visit ended up in the client going to hospital for COPD related issues (such as if the GP called an ambulance.
- If the visit was a post hospital visit, ie if the hospital visit was for COPD, and the GP visit was a follow up for this.

Specialist Visits (COPD Related)

Only if the visit was directly linked to COPD, including:

- Respiratory specialists.
- Any specialist visits related to lung surgery/transplants.
- Any visits to hospitals for respiratory functioning tests, including walk tests.
- Any visits to hospitals for respiratory outpatient visits or to breathing clinics.

Emergency Department Visits (COPD Related)

Only if related primarily to respiratory functioning, including:

- Chest infections and associated administrations of Intravenous Antibiotics (IVABs).
- Pneumonia, asthma and other respiratory conditions.
- If the client was taken to hospital via ambulance, it has been classed as an ED visit.

***If a client was admitted to a private hospital on the basis of a recommendation of their GP or Specialist, even if the issue was an emergency, it is not included here. It is only included as a hospital admission further down.

Emergency to Hospital Admission (COPD Related)

If the trip to emergency was followed directly by admission to a hospital for COPD related issues.

Hospital Admission (COPD Related)

If the client was in hospital for their COPD for longer than a day, ie overnight.

Length of Hospital Admission in Days (COPD Related)

Length of admission is based on the day the client went into hospital being day 0. Therefore, if a client went to hospital one day and left the next, the length of their admission would be one day. Similarly, if a client went to hospital in the morning and left at night, this would not be counted as a hospital admission.

If a hospital admission went over the date of the follow up call, the number of days in hospital is split between months ie if a client spent 8 days in hospital, 3 before the follow up call due date, and 5 after, the number of days in hospital would be counted as 3 in the first month, and 5 in the second. Furthermore, this episode would only be counted as a hospital admission in the first month. In the second month, there would be no recorded hospital admission, despite the client spending time in hospital (to ensure admissions are not double counted).

GP Visits (Non-COPD Related)

Any GP visits coded as for scripts, blood tests or check-ups were included here. Even if the visits were probably associated with COPD, ie for respiratory medications, unless the visit notes that it was for COPD, it is included here.

Specialist Visits (Non-COPD Related)

Any visits to specialists that are not directly associated with COPD (even if they are closely linked), including cardiologists, haematologists and oncologists.

In some cases, a client has had a number of visits listed, with a note saying that visits were for different reasons, such as COPD. In this case, if it does not explicitly say how many visits were for COPD, it is assumed that only one visit was for COPD, and any others would be included here.

Emergency Department Visits (Non-COPD Related)

Includes any visits associated with non-COPD issues, such as falls, heart attacks or other medical problems.

Emergency to Hospital Admission (Non-COPD Related)

If the Emergency Department visit was immediately followed by a hospital admission for issues other than COPD.

Hospital Admission (Non-COPD Related)

If the client was in hospital for longer than a day for issues not related to COPD.

Length of Hospital Admission in Days (Non-COPD Related)

See COPD related above.