

Group Pulmonary Rehabilitation Delivered to the Home via the Internet: Feasibility and Patient Perception

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ABSTRACT

Chronic Obstructive Pulmonary Disease (COPD) is a common and debilitating lung condition. Pulmonary rehabilitation is effective in treating COPD. Rehabilitation, combining physical exercise with education, is usually undertaken in hospital or clinic-based groups led by a clinician. The support of the group is important. However, distance of travel, and mobility and transport problems can mean that patients are unable to participate. This paper describes a feasibility study to deliver a program to a group of patients in their own homes, improving accessibility. A novel videoconferencing system was installed in four patient's homes, connected to their TV and the Internet. A physiotherapist delivered a pulmonary rehabilitation program, involving twice-weekly exercise sessions for eight weeks. All were visible and audible to maintain the group-based approach of the conventional program. The technology performed well, satisfaction was high, and clinical improvements occurred in all patients, comparable to a conventional program. Larger studies are warranted.

Author Keywords

Chronic Obstructive Pulmonary Disease (COPD), healthcare, Internet, lung disease, physical exercise, pulmonary rehabilitation, rehabilitation, videoconferencing.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Design.

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a progressive and extremely debilitating lung condition, usually associated with smoking and developing from middle age onwards. The main symptoms are shortness of

breath, cough, phlegm and wheeze. With more severe COPD, normal activities such as walking, talking or bathing can become very difficult because of breathlessness. The impact of COPD on society and the UK National Health Service (NHS) is enormous. There are an estimated 900,000 people living with COPD in the UK; COPD is the fifth biggest killer in the UK and the fifth biggest killer worldwide [4].

People with COPD are advised to exercise regularly. Maintaining a level of fitness helps people to manage their condition and perform daily activities and household tasks. However, sufferers are often anxious about becoming more breathless through exercise, and so do not exert themselves, leading to further loss of fitness (deconditioning). This leads to a downwards spiral of further inactivity, social isolation, and depression. To help break this negative pattern, patients who are thought likely to benefit are referred to a pulmonary rehabilitation program.

Pulmonary Rehabilitation

Pulmonary rehabilitation is an effective and well-established part of the management regime for COPD [22,24]. A systematic review confirmed that rehabilitation relieves dyspnoea (shortness of breath) and fatigue, improves emotional function and enhances the patient's sense of control [19]. Rehabilitation, combining physical exercise with education, is usually undertaken in hospital or clinic-based groups supervised by a clinician. Most programs run over an eight-week period, three sessions per week, of which two should be supervised, each class lasting about one hour, involving about 6-10 patients. The group support element is important: people usually find that taking part with others who have similar problems helps them to carry out the exercises and improves their physical wellbeing and confidence [25]. The education element usually includes talks given by a health professional on topics such as use of inhalers or smoking reduction techniques.

However, in remote and rural areas, access to hospital or clinic-based programs can be difficult. For example, in our NHS Health Board area of Highland, Scotland, we have recently established that 47% (2,145) of COPD patients live in the most peripheral general practice areas, remote from rehabilitation facilities. Even in an urban setting, location and travel demands can lead to patients declining to participate [29]. Purely home-based individual training programs can

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produce some benefit in COPD but dropout rates are high [12], and of course the group element is absent. Thus, there is a large potential patient demand for a method of delivering pulmonary rehabilitation at home, while maintaining the group-based approach of the conventional program.

This work contributes to the body of research within HCI on therapy and rehabilitation. The main contributions are:

- A prototype design for a group pulmonary rehabilitation program delivered to the home via the Internet, improving accessibility, informed by consultation with patients and clinicians.
- Findings from the study demonstrating the feasibility of delivering such a program, with clinical outcomes comparable to a conventional program: how the technology performed well despite relatively slow broadband speeds, patient perceptions of the program, and how the technology affected interactions among the group.

We also identify challenges for successful adoption into mainstream clinical practice. The paper is organized as follows. We first review related work on the remote management of COPD at home, using Information and Communication Technology (ICT). We then describe our study context and method followed by the design and implementation details of our videoconferencing system. Thereafter, we report on the feasibility, acceptability, and clinical effectiveness of delivering pulmonary rehabilitation to the home via the Internet and videoconferencing. We conclude with directions for future work.

RELATED WORK

There is significant interest in the potential offered by ICT to support independent living in an ageing society and provide care closer to home [7,15]. Definitions are still evolving, but for the purpose of this paper, telehealth is the remote monitoring of a patient's health in their own home using information and communication technologies such as the telephone, the Internet and videoconferencing. Drivers for advancement of telehealth include: equitable access to services, increased demand for services as a result of an ageing population and the associated increase in the numbers of people living with a chronic illness or disability, staffing difficulties (recruitment and retention) in remote and rural areas, and changes in healthcare policy from reactive to preventive and hospital-centered to community-based models of care. Through a series of clinical trials and pilot studies the case for telehealth is starting to strengthen. However, there is still a lack of robust evidence, something that the UK Department of Health is seeking to address through its 'Whole System Demonstrator' program [32]. Under the broad concept of telehealth, this section describes approaches to the management of COPD at home.

Home Telemonitoring

Telemonitoring uses equipment to monitor vital signs such as blood oxygen levels and weight, and symptoms such as

sputum color and severity of coughing. An education component supports patients to self-manage their condition. Data is transmitted to a web-based management system for a clinician to monitor, with changes that could indicate deterioration in condition highlighted using a color-coded display. By enabling timely interventions, telemonitoring can improve the overall management of long-term conditions and reduce the need for expensive hospital admissions. The challenge for telemonitoring is broad interoperability amongst systems and devices, something that the Continua Health Alliance is working to provide [6]. A range of home telemonitoring systems is commercially available e.g. 'Health Buddy' [10]. Several studies across a variety of ages and health conditions including COPD have used Health Buddy and reported positive health outcomes [e.g. 9,31]. However, a systematic review concluded that while home telemonitoring seems to be a promising patient management approach that empowers patients and potentially improves their medical conditions, more evidence is needed on clinical and cost effectiveness [26].

Weather Forecasting

Weather extremes (hot and cold) can affect the breathing of people with COPD. This can be made worse when there are viruses around that cause coughs and colds. The Met Office, the UK's national weather forecasting organization, and Medixine, a Finnish telemedicine company, have developed a COPD forecast alert service called 'Healthy Outlook' [11]. The winter service provides automated advanced warning telephone calls for people, on behalf of their doctor, when poor weather conditions increase their risk of illness. By being alerted in advance of impending high risk periods, people with COPD can be reminded to take appropriate action to keep themselves well, such as ensuring they have sufficient medication. Supported by the NHS, the service has been piloted in a number of areas in the UK, including in Scotland, with consistently good results. It is, however, limited to the winter months.

Self-Managed Pulmonary Rehabilitation

Pulmonary rehabilitation is effective in all settings including the hospital, the community, and the home [22]. However, supervision and group support are important factors influencing adherence [1,25]. Self-managed, home-based rehabilitation that is also supervised or monitored offers an alternative approach to centre-based programs. An exercise program has been delivered to 24 patients in their homes, involving walking to an individualized tempo of music from a program installed on a mobile phone and symptom questions, with data sent to a website for monitoring [21]. During an initial three-month training period, walking speed was readjusted at monthly visits to the clinic and adherence to protocol was reinforced by telephone. For the following nine months, patients returned to the clinic every three months but there was no further change to the walking speed or telephone reinforcement. The study results showed good compliance and clinical outcomes. However, the

program still required patients traveling to the clinic periodically during the year, and the group environment and peer support of traditional programs was absent.

Telerehabilitation

Telerehabilitation is the delivery of rehabilitation services over a distance. Kairy et al. provided the first high-quality systematic review of clinical outcomes, clinical process, healthcare utilization and costs associated with telerehabilitation [18]. That review included twenty-eight articles describing treatment studies up to 2007. Using a similar methodology, Hill updated the review with a further 17 articles describing treatment and assessment studies from 2007-2009 [13]. Both reviews conclude there is strong emerging evidence that telerehabilitation can provide patients with clinical outcomes comparable to traditional rehabilitation programs and that patients and clinicians are highly satisfied with treatment being delivered remotely, especially where this increases their access to rehabilitation programs.

Included in [18] is a study on home-based group exercise delivered via videoconferencing. A Tai Chi exercise program for improving balance in older people has been delivered to 17 patients in their own homes via the Internet, using an off-the-shelf videoconferencing device with the TV as video screen [34]. The results showed the method was acceptable and effective. Three subjects dropped out and average compliance with the program was 78%. The authors noted some problems with the videoconferencing device including transmission quality and ease of use, and approximately 40% needed replacement.

Included in [13] is a study on pulmonary rehabilitation delivered via videoconferencing. A NHS Board in Central Scotland extended a hospital-based program, involving a class of 12 patients, to include three patients in a satellite group at a remote community hospital, using high-end videoconferencing equipment [5]. Clinical outcomes were comparable to those from previous pulmonary rehabilitation programs and nine patients who completed a satisfaction questionnaire reported that they would participate in a videolink again. However, this still required patients traveling to a clinic location to participate, and involved a healthcare professional to supervise the remote group and operate the equipment.

In this work, we examine the next step in widening access to pulmonary rehabilitation by investigating the use of the Internet and videoconferencing to deliver a group program to patients in their own homes. We know of one comparable study, which is in progress: in Norway, a home-based pulmonary rehabilitation program has been field-trialed as part of the 'Better Breathing' project to create a new model for continuous care of COPD patients [2]. The design and implementation of their prototype system has been published [3]. However, the detailed outcomes of the study, including satisfaction and clinical effectiveness, are not yet published.

RESEARCH QUESTIONS

The research questions were: (1) Is it feasible to deliver pulmonary rehabilitation to a group of patients in their own homes via the Internet? (2) How do patients perceive this method of delivery and is it acceptable? (3) Is the program effective in improving patients' wellbeing?

METHOD

Through consultation, a new home-based pulmonary rehabilitation program was developed, modeled on the conventional program, with patient safety a priority. The study was conducted in our NHS Board area of Highland, which serves 309,900 residents in an area of 12,507 square miles, comprising the largest and most sparsely populated part of the UK with a mountainous terrain and limited transport and communications infrastructure. As in other rural and remote regions, there are difficulties with recruitment and retention of health professionals and access to specialist services is limited, often requiring patients to travel large distances. The North of Scotland Research Ethics Service approved the study.

Design Process

Health professionals at the main hospital serving the region, Raigmore, were involved throughout the design process providing expert domain knowledge. In addition, a local patient group was consulted for their views on the important components of a home-based rehabilitation program. The 'Cheerful Chesters' is a well-established support group for people who suffer from chronic lung disease, most of whom have completed a conventional pulmonary rehabilitation program. It is led by a physiotherapist and meets weekly to undertake exercise and enjoy social interaction. A member of the research team participated in a conventional 'Cheerful Chesters' class, at the end of which she led a group discussion using a topic guide and props, with staff and about 25 members, and two other members of the research team, all seated in a semi-circle. Topics included experience with videoconferencing and the Internet and the social and motivational aspects of group exercise. The session lasted 45 minutes and was audio recorded with participants' permission, and partially transcribed. The main themes were:

- *Older people will probably not have experience of videoconferencing over the Internet.* Only two members of the group had used Internet-based videoconferencing. Such a low proportion is reflected in a 2009 survey of individuals' Internet access in the UK: nearly two-thirds (64%) of the 65+ age group reported they never used the Internet [16]. Thus, a simple interface was required that allowed patients to easily join a videoconference and perform the exercises.
- *Group exercise has a social dimension.* In line with the literature, members were unanimous that exercise is more enjoyable as a group. Some reflected that they watch others as they exercise; 'I think you do see the others'

and ‘watching others gives you the encouragement to keep going’. Members also watch the physiotherapist, mainly for timing and switching sides. Thus, a visual layout was required that allowed patients to feel part of a group despite being geographically distant.

- *Background music is motivational.* Upbeat music is a notable feature of the class. Members find music ‘keeps you going’ and ‘gives you a rhythm’, and agree ‘you get motivation from music’. Popular music e.g. “Mamma Mia” by Abba and “Rocking All over the World” by Status Quo is also played during exercise at the hospital. Background music was thereby required to make exercising more enjoyable and increase motivation.

Following the consultations, flowcharts and sketches were produced to describe the structure of the home-based program and the user experience. Once agreed by the project team, the user interface was designed, and videoconferencing hardware and software reviewed that could connect multiple sites at relatively low cost. At a follow-up discussion with the ‘Cheerful Chesters’, a member of the research team presented a mockup of the technology with options for the video display. The meeting was held at the end of an exercise class and lasted about 45 minutes. Feedback was positive and members confirmed their preference to see the whole group on the video screen. An implementation phase followed.

Prior to the start of the study, a successful practice run was performed that included two retired members of the local community interested in technology. During the trial, with participants’ permission, members of the research team observed each session in the same room with the physiotherapist and took notes on the performance of the technology and interactions among the group. A member of the team also observed each patient use the system in their home on a single occasion and collected informal feedback.

Patient Eligibility and Recruitment

The Physiotherapy Department at Raigmore Hospital maintains a waiting list of patients referred for pulmonary rehabilitation. A physiotherapist screened the specialist referrals to determine the patients’ eligibility for the study. Inclusion criteria included aged 18 or over, with moderate to severe COPD (MRC dyspnoea grade 3-5). A letter was sent from a respiratory specialist to eligible patients, together with an information sheet explaining the research and a consent form, inviting them to take part in the study as an alternative to the hospital program. For logistical reasons, subjects living reasonably close to the hospital were chosen.

Up to eight patients were to be recruited, based on a staff/patient ratio guideline in the UK of 1:8 for supervision of exercise classes [22]. Twelve patients were contacted, of whom eight declined to participate. Some gave specific reasons, including current admission to hospital and wanting to keep their illness private from family (the study equipment would have raised questions). Six of these eight

patients also declined conventional rehabilitation, despite having previously accepted referral.

Four patients aged 65-79 (three males, one female) with moderate to severe COPD enrolled for the study. Their homes were located 3-15 miles from the hospital.

Procedure

The study took place in Spring 2010. A physiotherapist from Raigmore Hospital delivered a standard pulmonary rehabilitation program from a central location on a 4MB synchronous broadband connection. All patients owned a large-screen TV (minimum 32 inch). Two patients required installation of a broadband Internet connection, the cost of which was met by the project budget. Members of the research team installed the equipment and explained how to use it. When the program ended, the equipment was removed and the broadband accounts closed.

Patients attended Raigmore Hospital pre- and post- program for clinical assessment. The first session of the program was also held at the hospital to allow patients to meet the other members of the group face-to-face and to go through the exercises. The exercises were based on a series that the hospital has developed for patients to do at home once each week, unsupervised, in addition to the twice-weekly classes at the hospital. The exercises use resistive elastic bands (Thera-Band) and objects found in the home in place of specialized gym equipment e.g. cans of food serve as arm weights. The exercises are: lifting a stick above the head, sit to stand, bending the elbow, wall press ups, straightening the elbow, marching on the spot, lifting small weights above the head, and stair step ups. In order to keep patients in camera view, wall press ups and stair step ups were substituted with heel raises and straightening the knee.

Over the next eight weeks, patients took part in classes twice-weekly from home led by the physiotherapist, increasing the duration of each exercise as their fitness improved. Throughout, they could see and speak to the physiotherapist and the other members of the group. Patients were asked to do a third exercise session each week, unsupervised, or equivalent activity e.g. walking the dog. The physiotherapist and a respiratory nurse delivered talks on topics such as the use of inhalers and breathing control techniques, and self-management and medication.

Outcome Measures and Analysis

Pre- and post- program clinical assessment data were collected in the same way as for all patients undergoing pulmonary rehabilitation. It was analyzed by the clinical care team within the hospital to ensure that each patient had gained the expected benefit, and by the Chief Investigator of the study. Pre- and post- assessment includes completion of: Chronic Respiratory Questionnaire (CRQ) [33] and Hospital Anxiety and Depression Scale (HADS) [28], to assess breathing difficulties and general wellbeing; incremental shuttle-walking test, to assess exercise capacity

[27]; and blood oxygen saturation measurements, to assess if supplemental oxygen would be needed during exercise. The latter assessment is essential as some COPD patients can suffer significant falls in blood oxygen during exercise.

In addition, the patients completed an anonymous satisfaction questionnaire, comprising 10 questions developed by the project team to evaluate their perceptions of the program, together with the more generic Client Satisfaction Questionnaire (CSQ) [20]. The physiotherapist also completed a brief satisfaction questionnaire. The Chief Investigator analyzed the data.

HARDWARE AND SOFTWARE

Informed by feedback from the focus group and by [16], we constructed a videoconferencing system that allowed patients to take part in a rehabilitation group from their own home, and to see and speak to the physiotherapist and the other members of the class while carrying out the exercises. The system combined standard videoconferencing hardware, and commercial and custom software. In putting the elements together, we strived for elegance and simplicity of use, particularly regards the patient PC box. A criticism of telehealth is that teams of clinicians and engineers develop much of this new technology, where the emphasis is on functionality and consideration for the user experience is limited. Thus, products tend to have a medical aesthetic that can be found ugly and intrusive when placed in the home.

Videoconferencing Hardware

Our approach was to use a PC-based system rather than a commercial product with proprietary hardware and software, such as the all-in-one units employed in [5, 34], in order to customize to the specific needs of the program.

Patient Hardware

- PC: mini-ITX PC with Windows XP Operating System.
- Camera: Logitech QuickCam Pro 9000 Webcam.
- Speakerphone: ClearOne Chat 150 USB Speakerphone.
- Video screen: TV screen.
- Pulse oximeter: Nonin 9560 Wireless Fingertip Pulse Oximeter (Continua certified).

A mini PC was re-boxed in a simple black perspex sleeve with a large illuminated on/off button, in order to create an accessible aesthetic and interaction (Figure 1). The PC was connected to the patients' own TV using a VGA cable (it can also connect to older-style TVs using a S-Video cable into a SCART adapter, though the quality of video is not as high). A TV rather than a computer screen was chosen to display the video because a TV is a familiar technology, now relatively commonplace in the home, with a screen size suitable for watching several feet away while carrying out the exercises. A speakerphone rather than a (wireless) headset was chosen due to the potential for the sound of patients breathing heavily to be troublesome; we also found



Figure 1. A mini PC was re-boxed in a simple case with a large on/off button. It was connected to the patient's TV with a webcam and speakerphone, and wired to the Internet.

both headsets we tested (Plantronics Voyager 510 and CS60) fiddly to use. The PC used a wired (Ethernet cable to router) connection to the Internet, which is more reliable than a wireless connection for videoconferencing. Use of the 3G mobile network was not considered, due to lack of coverage in some areas of Highland.

Physiotherapist Hardware and Media

- PC: Desktop PC with Windows XP Operating System.
- Camera: Logitech QuickCam Pro 9000 Webcam.
- Speakerphone: ClearOne Chat 150 USB Speakerphone.
- Video screen: 40-inch widescreen, 1024x768 resolution.
- Support screen: 20-inch widescreen with remote control.
- CD Player and music CDs.

Commercial Software

The videoconferencing solution we selected is a desktop videoconferencing service called 'JVCS Desktop' that is available to the JANET community [17]. JANET is the UK's education and research network. JVCS Desktop uses a new videoconferencing software application by Tandberg called 'ConferenceMe' that works with a Multipoint Control Unit (or bridge). ConferenceMe allows up to 12 users to dial-in to a videoconference from a desktop or laptop PC at home running Windows operating system.

Screen layouts were selected for the patients and for the physiotherapist whereby everyone was shown on the video screen, to allow people to feel part of a group despite being geographically distant (Figure 2). For clarity, the patient layout showed the physiotherapist in a larger pane. The physiotherapist did not need to, or want to, see herself larger than the rest, thus all appeared in equal-sized panes.

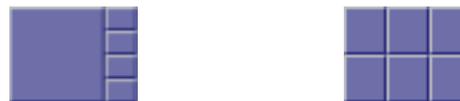


Figure 2. All participants were visible on all video screens to create a group spirit. Left: patient view with the physiotherapist in a larger pane. Right: physiotherapist view.

Custom Software

Custom software was developed to: simplify and automate patients’ experience of joining a videoconference, provide an exercise timer for the physiotherapist that also allowed patients to see time remaining, capture real-time data from the pulse oximeters and convey this information to the physiotherapist in a straightforward manner. The software was developed in Microsoft’s .NET framework and written in C# (C-Sharp) language. Communication between the physiotherapist PC and the patient PCs was established using an Internet socket connection.

Joining a Videoconference

Patients turned on their TV and the mini PC and switched to the video channel using their TV remote control. After Windows XP loaded, if the session had started, patients were automatically joined to the videoconference, displayed full screen. Outside of session times, a holding page was displayed that showed: the day and time of the next class, a reminder that patients would be automatically joined to the class, and a fun graphic indicating number of sessions completed and remaining (Figure 1).

Timing the Exercises

A smaller screen was positioned below the main screen of the physiotherapist’s set-up to display: patient names, exercise durations, an exercise timer, and pulse oximetry readings (Figure 3).

Exercise training in pulmonary rehabilitation is progressive, meaning the duration or intensity of exercise is gradually increased through the program. Raigmore Hospital’s strategy is to set the duration of exercise at 30 seconds and then increase the exercise period by 10-second increments towards the target duration of 60 seconds. This is done on an individual basis as each patient works at his or her own pace. A simple screen timer was provided to time the exercises, controlled by pressing a start/stop button on a presentation remote (Figure 4). An ‘end’ graphic appeared by patients’ names as a prompt that they had reached their duration of exercise. A corresponding timer, counting down



Figure 3. A supporting screen was added to the physiotherapist’s set-up to display patient and timer information. When a patient turned on their PC, his or her name bar changed from muted grey to colour.

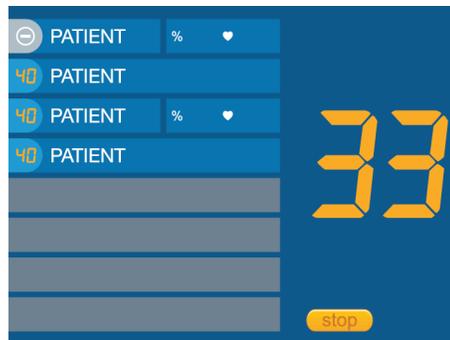


Figure 4. An exercise timer was displayed on the physiotherapist’s supporting screen, counting up.

in seconds, was displayed in the top left quadrant of the patients’ TV screens. The screen timer was easier for the physiotherapist to monitor than a physical stopwatch as she performed the exercises, watching the patients on the main screen, and it allowed the patients to see time remaining.

Capturing and Displaying Pulse Oximetry Data

As noted, patients’ blood oxygen saturation is assessed before they start the hospital program. Measurements are taken using a device called a pulse oximeter attached to their finger once while they are resting and again after exercise, to check for desaturation (a fall in the blood oxygen level). In a conventional class, for any patient in whom a significant fall is likely, a staff member takes spot check measurements after exercise. A lightweight oximeter was sourced that came without troublesome wires or cables (Nonin Onyx II, 9560). Patients simply inserted a finger into the device to turn it on. Their oxygen saturation and pulse rate shortly appeared on the LED displays, and was transmitted to the mini PC via Bluetooth wireless technology. The data was sent over the Internet to the physiotherapist’s PC and displayed on the supporting screen for her to assess (Figure 5). The oximeter automatically turned off after the patient removed their finger, conserving battery power.



Figure 5. Patients’ oxygen saturation and pulse rate were displayed on the physiotherapist’s supporting screen.

RESULTS AND DISCUSSION

Program Compliance

All patients completed the program. One patient enrolled late having attended four sessions at Raigmore Hospital. This was considered allowable, as this was a feasibility study not a formal efficacy trial. The average attendance rate was 82% (range 63%-100%), which is comparable to attendance rates reported for conventional programs [e.g. 8]. On average there were three patients per session (range 1-4).

	Attended	Reason for Not Attending
P1	11/16	Unwell (2) Medical appointment (3)
P2	10/16	Attending Funeral (1) In hospital – exacerbation (3) In hospital – routine operation (1) Unable to connect to Internet (1)
P3	16/16	
P4	15/16	No electricity (1)

Table 1. All patients completed the program. The average attendance rate ranged from 63% to 100%.

The main reasons for not attending were because the patient was feeling unwell or in hospital following an exacerbation (a worsening of COPD symptoms), or attending pre-arranged medical appointments (Table 1). One patient missed a class due to a temporary problem connecting to the Internet. Another missed a class because their home was without electricity for a day due to local authority works.

Feasibility and Patient Satisfaction

Installation and Reliability of the Technology

Installing the system was mostly straightforward; an unexpected challenge was scheduling home visits with patients to install and remove the equipment. In two homes, the broadband router was in a room adjacent to the TV room. As the system uses a wired connection to the Internet, the ramification was an Ethernet cable running from one room to the other. The cable was carefully placed so as not to be bothersome to either patient (one of whom was used to navigating a trailing oxygen cable), nonetheless it presented a potential trip hazard. In a future version, HomePlug technology could be used to create a wired Internet connection without cables [14]. A single adjustment was needed to the TV room of one patient; for each session, the sofa needed to be pushed back and replaced with a perching stool to be in camera view (some of the exercises required to be seated in a chair).

Overall, the technology performed well. Apart from the single Internet connection failure noted, patients encountered no problems using the videoconferencing system and were able to operate it independently. Also, the set-up allowed equipment to be moved outside of session

times e.g. one patient’s wife did not want to face the camera while watching regular TV, although she hadn’t noticed it was there until we pointed it out.

The audio was satisfactory, although we experienced problems in one-third of the sessions: either a patient(s) couldn’t hear the physiotherapist or the physiotherapist couldn’t hear a patient(s). This was resolved by restarting the PC, which took little more than a minute. ConferenceMe is currently undergoing a revision by Tandberg to make the audio take priority over video, which it doesn’t at the moment. The background music worked reasonably well, with no feedback.

The video was also satisfactory. This is encouraging as Broadband speeds in the study locality are the slowest in Scotland [23]. Reasonable quality videoconferencing requires a bit rate in the region of 256kbps (upload and download). One patient occasionally experienced low-quality video because of a slow broadband speed e.g. the download speed sampled during one of the sessions was 117kbps. Although the patient’s maximum connection speed was 2.5MB (the average Broadband speed for the area), the speed will fluctuate depending on line length and contention. Also, use of visual aids was not as straightforward as in a conventional class. The physiotherapist experienced some difficulty assessing and training bronchodilator technique due to screen resolution.

Two patients were issued with a pulse oximeter. Both experienced no difficulty using it and the batteries did not require changing. Oxygen saturation and pulse rate readings were displayed on the physiotherapist’s screen shortly after the oximeter was activated. The occasional reading was not displayed: factors that affect the performance of the oximeter include poor pulse quality and cold hands, and Bluetooth problems. However, the patients were comfortable giving readings over the videolink.

Level of Satisfaction

Patients reported that they had felt comfortable (2) or very comfortable (2) with taking part by videolink before the program and all were very comfortable after the program. All reported watching the physiotherapist some or most (3) of the time during exercises, but watching other class members only some of the time (2) or not at all (2). However, all reported that they felt part of a group and felt safe. All found the program beneficial, and all were able to control their breathing more easily. While one reported their way of life improved considerably, others reported a little improvement (2) or no change (1). However all reported that they went out more often for social purposes after the program. Generic satisfaction scores on value of service received were high: CSQ values 29-32. (32 = maximum possible score). All reported that they would definitely come back to the program if they were to seek help again, and that they would recommend the program to a friend in need of similar help.

The physiotherapist, who had used videoconferencing before for other clinical purposes, reported that she felt comfortable with introducing this system for pulmonary rehabilitation. In free text comments, she observed that it was more difficult to discuss individual problems with patients during the session, although this could be resolved by telephone calls outwith the class. She also commented that this method of delivering pulmonary rehabilitation might be particularly valuable for patients who would be barred from attending conventional groups because they are carriers of antibiotic-resistant bacteria.

Interactions Among the Group

Group support is a fundamental component of pulmonary rehabilitation programs. Initially, there was limited interaction between the patients. Two had missed the first session at the hospital and two were less likely to start a conversation; one was hard of hearing and the other had damaged vocal cords. Also, a slight audio delay made engaging in conversation less natural and consequently more challenging. Initially, when the physiotherapist put a question to the whole group, patients would both start and stop speaking at the same time or none would answer. Thus, the physiotherapist learnt to address people by name. As time went on, the level of conversation was perceived to have increased between all members of the group, presumably because people became more comfortable with each other and the method of participating in a class. Generally, a higher number of participants resulted in more conversation. The general tone of the program was casual and good-natured e.g. patients teased the physiotherapist that she used the easiest level of resistive elastic band.

Interestingly, although the ‘Cheerful Chesters’ told us that watching others exercise in the conventional group setting was an incentive, the patients in this feasibility study focused mainly on the physiotherapist, although they did report feeling part of the group. That may be a result of presenting the physiotherapist in a large pane and the group members in relatively small panes. Also, the patient who had attended several sessions at Raigmore remarked on the greater opportunity to socialize in the hospital setting e.g. as patients moved between workstations. While telerehabilitation may reduce isolation for those unable to attend a centre-based program, the potential to increase isolation also exists [13]. More research is needed to investigate whether a home-based program can adequately replicate the group support of conventional programs.

Inevitably, the sessions incorporated background events in patients’ homes e.g. a doorbell or phone ringing and family members passing by. One patient’s wife joined in with each session just within camera view, performing the exercises with her husband. The single frustration felt by one of the patients, was that a member of the group was exercising on a wooden floor that echoed during marching on the spot. Comparing the sound to a metronome, she found it distracting while seeking to work at her own pace.

Proximity to the microphone heightened sounds that may have been lost in the open setting of a gym; an option would be to ask people to mute the microphone while exercising.

Effectiveness of the Program

This was a feasibility study, not a clinical trial powered to test effectiveness. However, outcome measures were recorded to assess whether patients gained expected benefit from the program. Clinical improvements occurred in all patients, comparable to those in a conventional program. Incremental shuttle walking distances improved in all patients by at least 50 metres (mean 88 metres); the minimal clinically important difference (MCID) is 48 metres (Table 2). CRQ Scores improved in all four domains: dyspnoea, emotion, fatigue and mastery (Table 3).

	Pre	Post	Difference
P1	200	330	130
P2	200	250	50
P3	120	190	70
P4	140	240	100
Mean	165.0	252.5	87.5
SD	41.2	58.0	35.0

Table 2. Incremental Shuttle Walking Distance pre- and post- program (metres).

	P1	P2	P3	P4	Mean	SD
Dyspnoea						
Pre	11	14	7	9	10.3	3
Post	20	18	11	24	18.2	4.7
Difference	9	4	4	15	8.0	5.2
Emotion						
Pre	32	16	19	35	25.5	9.4
Post	33	21	24	45	30.8	10.8
Difference	1	5	5	10	5.3	3.7
Fatigue						
Pre	17	12	7	16	13	4.5
Post	19	14	11	19	15.8	3.9
Difference	2	2	4	3	2.8	1
Mastery						
Pre	24	10	13	17	16	6.1
Post	25	13	18	24	20	5.6
Difference	1	3	5	7	4.0	2.6

Table 3. CRQ Scores pre- and post- program.

	Anxiety			Depression		
	Pre	Post	Diff	Pre	Post	Diff
P1	13	9	-4	7	4	-3
P2	9	13	4	9	10	1
P3	8	6	-2	9	7	-2
P4	3	0	-3	7	2	-5
Mean	8.3	7.0	-1.3	8.0	5.8	-2.3
SD	4.1	5.5	3.6	1.2	3.5	2.5

Table 4. Hospital Anxiety and Depression Scores pre- and post- program.

HADS anxiety and depression scores improved in three patients and worsened in one patient (Table 4). Among patients (n=26) undergoing the conventional hospital-based program in 2010, the mean (range) change in incremental shuttle-walking test was +42 meters (-180-+330); HADS anxiety +1.1 (-7-+11); HADS depression -0.1(-5-+5); CRQ – dyspnoea 4.3 (-9-+17); emotion 1.6 (-16-+27); fatigue 2.3 (-10-+16); mastery 1.7 (-13-+13).

Context of the Design

In Scotland, there is significant support from Government to integrate telehealth and telecare into clinical practice. This includes investment in videoconferencing facilities in clinical settings and the establishment of the Scottish Centre for Telehealth (SCT) in 2006 to provide practical help to NHS Boards in the delivery of telehealth projects and the transition from projects into programs. For example, the SCT supported [5] and is now working towards a Scotland-wide service. A key feature of [5] is that it utilized existing videoconferencing infrastructure and equipment i.e. it was low cost. A significant challenge to NHS Boards (including Highland) adopting a home-based telerehabilitation model is the provision of broadband to homes that do not already have it. A recent survey put Scotland as the least connected nation in the UK with just 61% of the population owning broadband [30]. However, funding has just been allocated by the UK Government to provide superfast broadband across the Scottish Highlands and Islands that will expedite and boost the use of new technology in rural healthcare delivery. The greatest challenge to mainstream adoption is scaling up e.g. organizational structure and processes such as training, awareness, installation and maintenance of the technology, and funding (in the tougher economic climate).

CONCLUSION AND FUTURE WORK

While our results are preliminary, they demonstrate the feasibility of delivering a pulmonary rehabilitation program to the home via the Internet and videoconferencing, and show evidence of acceptability. The sample size is small, but we stress that this study was designed to develop and test feasibility of this method of delivery. It was not powered as an efficacy trial but should inform a future

larger scale clinical trial. The patients who participated were to some extent a self-selected group, all of whom reported that they had been comfortable with use of a videolink at the outset. The uptake of 33% among those offered the program suggests that not all patients will be so enthusiastic, although this was offered in the context of a trial with extensive accompanying documentation that patients had to read before agreeing to take part. That may have been off-putting for some, and might not be reflected if the service were offered as part of routine clinical care.

Future work will explore delivery of home-based programs on a wider scale and further development of the technology to automate other aspects of data collection, e.g. symptom scores, together with issues of cost-effectiveness, sustainability and training requirements, the latter three issues having been highlighted in previous reviews as requiring further study [13,18].

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