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A feasibility study to investigate the acceptability and potential effectiveness of a telecare service for older people with chronic obstructive pulmonary disease

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ABSTRACT

Aims: To investigate the feasibility, acceptance and potential effectiveness of delivering a telecare service on the health outcomes and hospital service utilization of community-dwelling patients with chronic obstructive pulmonary disease.
Methods: Eligible participants were older people, with moderate or severe chronic obstructive pulmonary disease, and who had been admitted to hospital at least once for exacerbation during the previous year. The participants were randomly assigned to the intervention or control group. Participants in the intervention group received a telecare device kit and they were asked to monitor their oxygen saturation, pulse rate and respiration rate using the device and to transmit the data to an online network platform. A medication and purse-lip breathing reminder with a feedback function is also provided in the device kit. A community nurse monitors changes in the physiological parameters and takes immediate action to address the patients' needs. Participants in the control group received no other extra care. Study outcomes include user satisfaction, health-related quality of life, pulmonary function, hospital re-admission and use of emergency room services.

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Results: Twenty-two participants in the intervention group and 18 in the control group were included in the analysis. The mean age of all 40 participants was 72.93 years. Overall, the participants in the intervention group expressed satisfaction with the telecare service. Some patients reported difficulty in reading the screen of the mobile phone and manipulating the tiny key-in buttons. No significant differences were found between the two time points (baseline and post-test period) with regard to health-related quality of life. No significant differences in pulmonary function and in the number of emergency department visits and hospital re-admissions between the study groups were found.
Conclusion: The high level of user satisfaction indicated the feasibility of conducting a large-scale randomized control trial to evaluate the effects of a telecare service on health outcomes of patients with chronic obstructive pulmonary disease.

1. Introduction

Chronic obstructive pulmonary disease (COPD) is a broad term that covers several lung conditions, including chronic bronchitis and emphysema, and is characterized by airflow limitation that is not fully reversible [1]. The World Health Organization has estimated that COPD will become the third leading cause of death globally by 2020 [2]. Although the exact prevalence of the disease in Hong Kong is not known, a local study suggested that about 9% of people over the age of 70 years suffer from COPD [3]. This group of older people with COPD usually have poor health outcomes and a high rate of health services use. According to an epidemiological report, the 1-year hospital re-admission rate for COPD was 2.2 episodes, whereas the 1-year mortality rate was 14% [4]. Although there is currently no cure for COPD, appropriate self-care and symptom management techniques, such as adherence to medication, purse-lip breathing, and prompt medical care for any exacerbations are crucial to improve the respiratory status and health-related quality of life of these patients [5]. Such interventions were also found to be effective in reducing hospital admissions among patients with COPD [6].

The traditional health service delivery model in Hong Kong is generally facility-bound, i.e., patients have to go to a doctor's clinic or a hospital to receive care. In many instances, patients are only treated in the later stages of acute manifestations, which results in worse health outcomes and an increased need for hospitalization and emergency room visits. With an increase in aging populations, a trend to adopt proactive self-care has been seen worldwide [7]. There is accumulating evidence to suggest that telecare services play a significant role in the improvement of patients' self-care and management of chronic illnesses [8,9]. A recent systematic review of nine studies on home telehealth (home telemonitoring and telephone support) for COPD patients indicated that it was effective in reducing the use of medical services [10]. Wireless and Internet-connected devices enable healthcare providers to monitor outpatients continuously by receiving and processing critical health information. As health monitoring and prompt initiation of optimal treatment of exacerbations are the critical components in successful management of COPD, telecare may be a highly relevant model for this group of patients. However, this model has not been tested in older people with COPD in the healthcare system in Hong Kong.

A feasibility study was conducted to investigate the acceptance and potential effectiveness of delivering a telecare service, which uses a combination of modern broadband communication infrastructure, databases and software for critical decision analysis and support, on the health outcomes and hospital service utilization of COPD patients living in the community (excluding those living in nursing homes). The objectives were: (1) to examine user satisfaction with the telecare service and (2) to examine the effects of the telecare service on health-related quality of life (HRQL), lung function, and hospital service utilization in older people with COPD.

2. Study context

2.1. Organizational setting

Potentially eligible patients were recruited at a major acute general hospital with over 1400 beds during their follow-up clinic visits in 2010. COPD patients discharged from the hospital received follow-up care in a specialist outpatient clinic every 8–16 weeks. Community nurses offer education on self-care management to patients in their own homes.

2.2. System details

2.2.1. The ASTRI telecare system (ATS)

The ATS is a means of providing healthcare to patients through a combination of a modern broadband communications infrastructure, including Internet and wireless systems, and databases and software for critical decision analysis and support. The system comprises a device kit, an online network platform, a call center and a networking system. The device kit includes a specially designed mobile phone, a respiratory rate sensor, and a pulse oximeter (Fig. 1). Using this set of devices, patients can measure their oxygen saturation, pulse rate and respiration rate at home. The results are displayed on the mobile phone and sent to the patients' personal health database on a remote online server. A medication and purse-lip breathing reminder with a feedback function is also provided in the device kit. The patients can contact emergency services (999 police call) for urgent assistance by pressing the 'Confirm' key on the mobile phone. A platform and a server have been created, in which the personal health data are monitored and recorded (Fig. 2). A community nurse-led call center

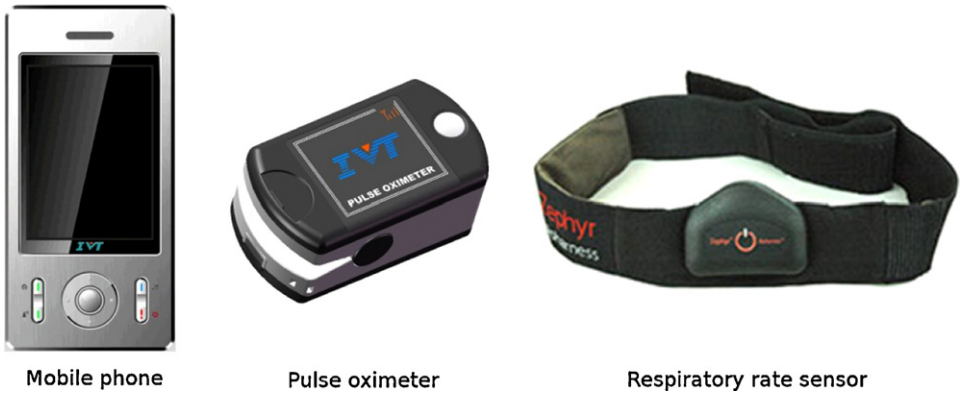

Fig. 1 – Telecare device kit.

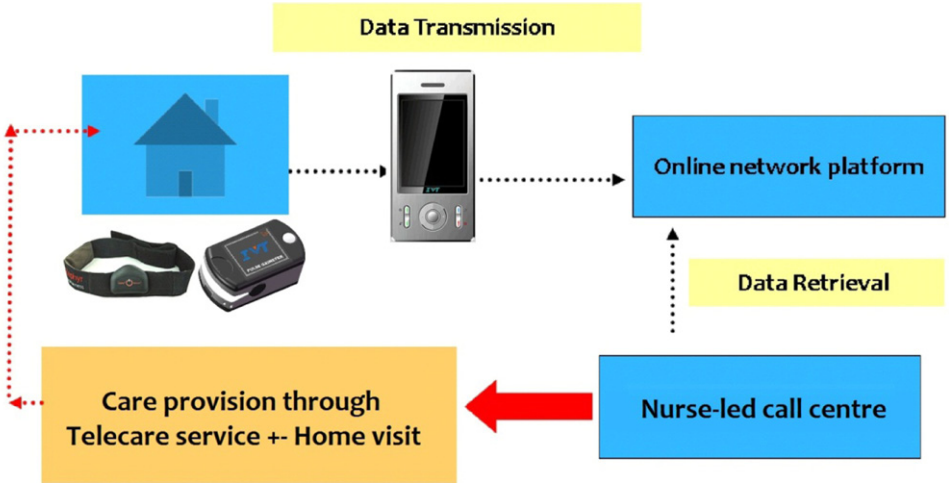

Fig. 2 – The telecare system.

was established and a community nurse monitors changes in the physiological parameters and takes immediate action to address the patients' needs. The health data are transmitted through the General Packet Radio Service to a base station and all health data can be accessed remotely by healthcare providers.

3. Methods

3.1. *Study design and participants*

This was a single-center, randomized, non-blind, parallel-group study. Eligible participants were older people (aged 60 years and over), with moderate or severe COPD according to the classification of the Global Initiative of Obstructive Lung Disease [1], who had been admitted to hospital at least once for exacerbation during the previous year. We excluded older people who were not able to communicate, had impaired cognitive function, were illiterate, had hearing problems or were unable to operate the telecare device. The final participants were randomly assigned to the intervention or control group.

3.2. *Study flow*

3.2.1. *Ethical considerations*

Ethical approval was obtained from the Clinical Research Ethics Committee of the hospital. A research nurse identified eligible patients from the clinical management system of the hospital and these were invited to the specialist outpatient clinic for baseline data collection. Prior to data collection, eligible patients were given an information sheet on the purpose and nature of the study, and their written consent was obtained. The patients were informed of their right to refuse to participate at any time without giving reasons and that refusing to participate would have no impact on the care they received from the hospital services. Patients who consented to participate were randomized to receive telecare or usual care following a simple randomization procedure (drawing a slip of paper with the group assignment marked on the slip). Pre- and post-test data were collected by research assistants who were not involved in the intervention.

3.3. *Interventions*

The community nurse conducted home visits to all participants in both groups and offered education on self-care and

symptom management techniques which included use of medication, purse-lip breathing, modification of lifestyle, and exercise. In addition, participants in the intervention group received the device kit. They were asked to monitor their oxygen saturation, pulse rate and respiration rate using the device three times a day from Monday to Friday and to transmit the data to the online network platform. Due to budget constraints, no evening and weekend services were provided in this feasibility study. The community nurse who monitored the telecare system at home instructed the participants on the use of the device for self-monitoring during the home visit through demonstration and return demonstration. Participants in the control group received no other extra care or intervention.

3.4. Study outcomes

To evaluate the feasibility of the telecare service, a number of study outcomes were measured at baseline and 2 months after the start of the study, as outlined below. Two months was chosen as the follow-up period as most patients would receive follow-up care in the specialist outpatient clinic every 8 weeks. Positive short-term clinical outcomes and high level of user satisfaction were also found in a study of a telemedicine program (home telemonitoring and nurse visit) for recently discharged older patients delivered over a 2-month period [11].

3.4.1. User satisfaction

Patient satisfaction was measured by a self-developed 10-item user satisfaction questionnaire, which measures the patients' satisfaction with using the telecare service in terms of its usefulness, acceptability, and ease of use, their level of confidence in using the telecare device, and their satisfaction with the support from the community nurse in charge of the telecare service. Each item is rated on a '1–5' Likert scale, in which a higher score indicates a higher level of satisfaction. The User Satisfaction Questionnaire also includes three open-ended questions to identify the patients' perception of the telecare system. Post-test data on user satisfaction were collected from the intervention group 2 months after the start of the study.

3.4.2. Health-related quality of life (HRQL)

HRQL was measured using the Chinese version of the Chronic Respiratory Questionnaire (CRQ), which is a 20-item tool to measure disease-specific HRQL in patients with chronic respiratory disease [12]. The scale consists of four subscales that measure dyspnea (five items), fatigue (four items), emotional function (seven items), and mastery (four items). Each item is rated on a 7-point Likert scale. The overall CRQ score can range from 7 to 28; a higher score indicates better disease-specific quality of life. The psychometric properties of the Chinese version of CRQ have been established; construct- and criterion-related validities were supported by significant correlations with the Hospital Anxiety and Depression Scale and the New York Heart Association classification, respectively [13]. High internal consistency and a 2-week test-retest reliability were reflected by a Cronbach's α of 0.95 and an intra-class correlation coefficient of 0.75, respectively. Both groups completed pre-test and post-test for HRQL.

3.4.3. Pulmonary function

The pulmonary function of COPD patients was measured by the forced expiratory volume in 1 s (FEV_1) and the FEV_1/forced vital capacity (FVC) ratio. The FEV_1 refers to the greatest volume of air that can be breathed out in the first second of a deep breath. The FVC is the greatest volume of air that can be breathed out in a whole deep breath [1]. Normally, at least 70% of the FVC comes out in the first second (i.e., the FEV_1/FVC ratio is >70%); a lower value indicates poorer pulmonary function and more severe COPD. In this study, the Spirobank G was used to measure both FEV_1 and FVC. Pulmonary function tests were performed on patients in both groups at baseline and after 2 months.

3.4.4. Hospital re-admission and use of emergency room services

The number of hospital re-admissions and emergency room service utilization during the 2-month evaluation period were retrieved from the hospital's clinical management system for both groups.

3.5. Data analysis

Descriptive statistics (mean, standard deviations, frequencies and percentages) were used to examine the central tendency and distribution of the patients' demographic and clinical data and outcome measures. Independent *t*-tests and chi-square tests were used to examine the equivalence of the demographic and clinical data and baseline outcome measures between the intervention and control groups. The dependent variables including CRQ dimensions and FEV_1/FVC were examined for normality. Skewness, kurtosis and inspection of the normal Q–Q plot showed that these data satisfied the requirements of normality. Two-way repeated-measure analysis of variance was used to examine any difference in the study outcomes between the intervention and control groups over the evaluation period. SPSS version 17.0 (SPSS Inc., Chicago, IL, USA) was used, and the level of significance was set at 0.05.

4. Results

4.1. Participant flow

A total of 603 COPD patients had been admitted to the study hospital at least once for exacerbation during the previous year. Seventy-one patients with moderate, severe or very severe COPD were assessed for eligibility. Nine were not eligible due to illiteracy ($N = 3$), hearing problems ($N = 2$), inability to operate the telecare device ($N = 3$), or need to travel outside Hong Kong during the study period ($N = 1$). Nine did not give their consent. Fifty-three patients underwent randomization, and 30 were assigned to the intervention group. Eight withdrew before the intervention and 22 underwent it. Two patients withdrew due to worsening physical condition. Two patients withdrew due to financial reasons (no extra money to attend the follow up and not able to afford the additional cost of recharging the batteries of the device every other day). Two patients refused to use the belt to measure their respiration rate in cold weather. One refused further participation as

he commented that the device was difficult to carry around at work. Another patient found participation too demanding with regard to the frequency of telemonitoring per day. Twenty-three were assigned to the control group. Of 62 potential patients approached, 45 agreed to participate, a response rate of 72.6%. During the study, four patients in the control group were lost to follow-up. One patient in the control group was admitted to hospital during the post-test data collection. Twenty-two participants in the intervention group and 18 in the control group were included in the analysis. No patients were excluded from the analysis.

4.2. *Recruitment*

Eligible participants were recruited and were invited to visit the clinic at the time of randomization (baseline) and for the post-test examination. The mean duration of the intervention was 54.36 days; the mean duration of follow-up was 65.18 days for the intervention group and 68.44 days for the control group.

4.3. *Baseline data*

4.3.1. *Demographic and clinical findings*

The mean age of all 40 participants in the final sample was 72.93 years (SD, 6.04), with a minimum age of 60 and maximum age of 83 years. The majority were male (97.5%), married (82.5%), and had received primary (6 years of primary education, usually starting at age six) or less than primary school education (85.0%). The Eighty-five percent of them were living with families or spouses, and 15% were living alone. All were retired, four (10%) were house- or wheelchair-bound, and 30 (75%) could climb up several flights of stairs. Their mean mini-mental state examination score was 27.35 (SD, 1.79) and their mean body mass index was 21.47 (SD, 4.00).

Of the participants, 25% had moderate, 32.5% had severe and 42.5% had very severe COPD. The pulmonary function tests measured in the laboratory within the last year showed a mean FEV_1 (% predicted) of 37.8% (SD, 14.43%). The mean FEV_1/FVC ratio was 41.63%, within a range of 22–69%. The number of hospital re-admissions for COPD exacerbation over the past year ranged from one to 10 (mean, 2.62; SD, 1.93). The average length of stay in hospital due to COPD exacerbation over the past year was 7.84 (SD, 8.55) days, with a range of 2–47 days. The frequencies and frequency distributions of the baseline demographic and clinical information for each group are presented in Tables 1 and 2.

Table 1 – Frequency and frequency distributions of the baseline demographic information. Values are percentages unless stated otherwise.

Demographic variables	Intervention ($N = 22$)	Control ($N = 18$)
Sex		
Male	21 (95.5)	18 (100.0)
Female	1 (4.5)	0 (0)
Age (mean (SD))	73.50 (6.05)	72.22 (6.13)
Educational level		
Less than primary	10 (45.5)	8 (44.4)
Primary	9 (40.9)	7 (38.9)
Secondary	3 (13.6)	3 (16.7)
Marital status		
Married	18 (81.9)	15 (83.3)
Divorced/separated	1 (4.5)	1 (5.6)
Widowed	3 (13.6)	2 (11.1)
Occupation		
Retired	22 (100.0)	18 (100.0)
Height (cm) (mean (SD))	162.32 (7.23)	163.28 (7.67)
Weight (kg) (mean (SD))	54.58 (11.28)	59.59 (10.09)
Living arrangement		
Living alone	5 (22.7)	1 (5.6)
Living with spouse	6 (27.3)	8 (44.4)
Living with family	11 (50.0)	9 (50.0)
Functional status		
House-bound	1 (4.5)	0 (0)
Wheelchair-bound	3 (13.6)	0 (0)
Outgoing but could not walk on level ground	2 (9.1)	4 (22.2)
Could climb up several flights of stairs	16 (72.8)	14 (77.8)

Table 2 – Frequency and frequency distributions of baseline clinical information. Values are percentages unless stated otherwise.

Variables	Intervention ($N = 22$)	Control ($N = 18$)
Stages of COPD		
Moderate	4 (18.2)	6 (33.3)
Severe	9 (40.9)	4 (22.2)
Very severe	9 (40.9)	8 (44.5)
Pulmonary function test (mean (SD))		
FEV_1 (% predicted)	38.0 (12.86)	37.7 (16.52)
FEV_1/FVC ratio (%)	42.14 (10.82)	41.0 (12.06)
Cognitive function		
MMSE (mean (SD))	27.36 (2.04)	27.33 (1.50)
Hospital re-admission		
Number of re-admissions for COPD exacerbation over the past year	2.41 (1.56)	2.89 (2.32)
Average length of hospital stay due to COPD exacerbation over the past year	7.66 (7.36)	8.06 (10.04)

4.3.2. *Pulmonary function and quality of life of participants at baseline*

The mean and SDs for FEV_1 (% predicted), FEV_1/FVC ratio (%) as measured by Spirobank G, and HRQL measured by the CRQ assessed after randomization are presented in Table 3.

The activities that caused shortness of breath in most participants with COPD at baseline include: walking, performing activities of daily living (e.g., bathing, showering, eating or dressing), participating in social activities, and performing chores (e.g., housework, shopping for groceries).

4.3.3. *Group comparability*

Comparisons were made between the intervention and control groups to detect any significant group differences in baseline demographic and clinical characteristics as well as other variables being studied. Independent *t*-test results indicated no significant group differences between the mean age, body mass index, mini-mental state examination, FEV_1 (% predicted), FEV_1/FVC ratio (%), and dimension scores of CRQ (dyspnea, fatigue, emotion, and mastery), all of which had p

Table 3 – Mean and standard deviations of pulmonary function and quality of life of participants at baseline.

	Intervention, mean (SD)	Control, mean (SD)
Pulmonary function		
FEV_1 (% predicted)	33.59 (14.86)	43.89 (29.1)
FEV_1/FVC ratio (%)	48.32 (18.43)	50.78 (14.21)
CRQ dimension		
Dyspnea	4.27 (1.23)	4.20 (0.83)
Fatigue	4.09 (1.26)	4.40 (0.99)
Emotion	4.84 (1.47)	5.24 (1.42)
Mastery	4.60 (1.43)	4.94 (1.16)

Table 4 – Mean and standard deviations of the patients' satisfaction with the use of telecare ($N = 22$).

Items	Mean	SD
Understanding of the use of telecare equipment is adequate	3.50	1.10
Telecare equipment is difficult to operate	2.45	0.80
Satisfied with the medication prompt	3.55	0.80
Automated health care advice is not necessary	2.77	0.87
Prefer telecare device service to monitor respiratory condition at home	3.59	0.80
Explanation for the use of telecare equipment was adequate	3.86	0.56
Satisfied with the support from the nurse	4.32	0.48
Telecare service is not useful to help manage disease at home	2.82	0.96
Recommend telecare service to others	3.14	0.89
Overall satisfied with the telecare service	3.95	0.58

values greater than 0.05. Pearson chi-square tests were performed to compare group differences in education level and stages of COPD and were not statistically significant.

4.3.4. *Satisfaction with telecare services: quantitative findings*

Twenty participants (91%) indicated that they were satisfied with the telecare service. Over 60% of participants were satisfied with the medication prompt and preferred telecare service to monitor their respiratory condition at home. All participants (100%) were satisfied with the support from the nurse offering the telecare service, and most (86.3%) commented that the explanation on the use of telecare equipment was adequate. Half of the participants indicated that automated health care advice was necessary, and 54.5% indicated that the telecare service was useful to help manage their disease at home. The negative items of the questionnaire were reverse scored and all items had a mean score above 3. A total user satisfaction score was calculated from total scores and ranged from 28 to 42 (mean = 35.86; SD = 4.17) (Table 4).

4.3.5. *Satisfaction with telecare service: qualitative findings*

4.3.5.1. Overall comments. Open-ended comments on the telecare service were also invited. Overall, the participants expressed satisfaction with the telecare service because it facilitated clinical monitoring of patients in their homes. They commented that the telecare service facilitated timely care and easy access to a qualified health professional, who could assess their health status, assess the seriousness of the problem, and help them to decide on the best possible action. The majority of participants stated that they preferred to use the telecare device to monitor their respiratory condition at home and would like an extension of the study period. Their positive comments included 'I feel my health has improved…', 'I had a better understanding of my health…', and 'I want to stay connected with the nurse for future enquires'. One participant remarked that he was pleased to see an improvement in his oxygen saturation level immediately after performing the purse-lip breathing.

Negative comments included: 'I cannot see much difference as the intervention itself is not curative…' One participant expressed anxiety while using the self-monitoring device and stated that "I think my health is not good when the readings go down quickly" (as shown on the pulse oximeter).

4.3.5.2. Satisfaction with the nursing service. Nine participants commented that the nurse offering the telecare support was helpful in terms of timely care and prompt follow-up actions. The explanations on how to use the telecare device were clear and thorough. The health education and advice provided by the nurse were regarded as very useful.

4.3.5.3. Comments on the telecare device and medication prompt. With regard to technical issues, some participants stated that they encountered no difficulties in using the telecare device. Five of the participants commented that the mobile phone provided was far too technologically advanced for them and they did not know how to operate it when unexpected characters or screen displays (e.g., SMS, different layout on screen) appeared. Some reported that the data transmission from the pulse oximeter and respiratory rate sensor to the mobile phone were very unstable with a few failures. Some mobile phones broke down and the nurse was required to fix the problems.

In this study, although the majority of participants were able to read the screen with eyeglasses, some participants stated that the mobile phone display screen was too small and the words were too small to read. The small touch screen also created problems due to decreased sensation and poor control of the finer movements of hands. Some patients required the help from a family caregiver to transmit the data. In addition, the push buttons of the mobile phone were very small. The large push button used to initiate an emergency call to the police was also too sensitive.

Quite a few participants experienced problems in using the 'belt' to measure their respiratory rate. Their concerns included: 'It is difficult to strap the belt in the correct position level', 'It makes me more short of breath…', 'The switch button is difficult to press when it's on my body' and 'I won't be able to finish the measurement without the help from my caregiver'. Some participants stated that it was inconvenient to use the belt in winter because of the cold weather and bulky winter clothing. With regard to the mobile phone, pulse oximeter and the respiration rate sensor, the participants needed to recharge the batteries every other day. The procedure was reported to be a complicated process that involved different electric wires and adaptors. The power supply connection

Table 5 – Difference in pulmonary function and HRQL between groups.

	Intervention ($N = 22$)		Control ($N = 18$)		p-Value
	Baseline (mean (SD))	Post-test (mean (SD))	Baseline (mean (SD))	Post-test (mean (SD))	
Pulmonary function					
FEV_1 (% predicted)	33.59 (14.86)	33.64 (14.57)	43.89 (29.11)	39.83 (15.36)	0.48
FEV_1/FVC ratio (%)	48.32 (18.43)	44.09 (13.85)	50.78 (14.21)	50.78 (16.63)	0.24
CRQ dimension					
Dyspnea	4.27 (1.23)	3.97 (1.17)	4.20 (0.83)	4.45 (0.96)	0.11
Fatigue	4.09 (1.26)	4.11 (1.25)	4.40 (0.99)	4.79 (1.07)	0.27
Emotion	4.84 (1.47)	4.92 (1.40)	5.24 (1.42)	5.61 (1.17)	0.37
Mastery	4.60 (1.43)	4.61 (1.62)	4.94 (1.16)	4.88 (1.27)	0.84

Note: Higher FEV_1 and FEV_1/FVC ratio were indicative of better lung function. Higher dyspnea, fatigue, emotional and mastery dimension scores were indicative of better HRQL.

trough was too small and confusing which made plugging it in too difficult for older people. In addition, a long time was needed to recharge the batteries fully and the battery life was too short. Concerning the medication alert, some participants stated that they remembered to take their medications and managed their illness well, so the medication prompt was not very helpful to them.

4.3.6. *Suggestions for improvement*

Some suggestions for improvement from the patients' perspectives included adding a blood pressure monitor to the multi-parameter devices, and extending the telecare service to weekends and public holidays. Suggestions from the community nurse included adding more options and capabilities to the ATS. These included a built-in program that analyses the health parameters, customizes reports, and creates easy-to-read charts and graphs showing the trends of oxygen saturation and respiration rate. Built-in functions to print, save and convert the results from any page would also facilitate patient monitoring and easy access to information.

4.3.7. *Changes in pulmonary function and health-related quality of life over time*

Two-way repeated-measure analysis of variance was used to identify any differences in the change in values of FEV_1 (% predicted), FEV_1/FVC ratio (%), and dimension scores of CRQ between the study groups across the baseline and post-test period. No significant differences were found between the two time points with regard to dyspnea, fatigue, emotion or mastery dimensions of CRQ. Two-way repeated-measure analysis of variance also demonstrated no significant pre-test and post-test differences in pulmonary function (FEV_1 and FEV_1/FVC ratio) for either the intervention and control groups (Table 5).

4.3.8. *Health service utilization and hospital readmission*

Fisher's exact tests were used to identify any significant differences in the number of emergency department visits and hospital re-admissions between the study groups and none were observed (Table 6). The total number of emergency/hospitalization visits due to COPD for the intervention group during the study period was seven. One patient admitted twice during the study period. Three out of these seven admissions happened during weekend. There were five episodes where the nurse detected an increase in the patient's respiration rate and advice on the use of bronchodilator inhaler and breathing exercise was found to be helpful in relieving their breathlessness. Only one patient visited emergency department and subsequently admitted despite telecare service.

Table 6 – Emergency department visits and hospital re-admissions due to COPD during the study period. Values are numbers (percentages) unless stated otherwise.

Variables	Intervention group ($N = 22$)	Control group ($N = 18$)
Number of emergency department visits		
0	15 (68.2)	15 (83.3)
1–2	7 (31.8)	3 (16.7)
Number of hospital readmissions		
0	15 (68.2)	15 (83.3)
1–2	7 (31.8)	3 (16.7)
Average length of hospital stay in days (mean (SD))	2.16 (4.69)	0.78 (1.93)

4.3.9. *Compliance with self-monitoring of oxygen saturation and respiration rate regimen*

On average, 79% of the participants in the intervention group successfully transmitted their oxygen saturation data to the ASTRI system three times a day, and 60% transmitted their respiratory rates. About 98% of the participants successfully transmitted their oxygen saturation data to the ASTRI system once a day, and 83% transmitted their respiratory rates.

5. Discussion

This study was limited by the short duration of implementation and the small number of participants. No blinding of outcome assessors may also have introduced bias. Despite the existence of these limitations, however, the high level of user satisfaction indicated the feasibility of conducting a large-scale randomized control trial to evaluate the effects of a telecare service on health outcomes of community-based patients with COPD.

Through self-monitoring and the provision of automated self-care prompts, the older people in this study felt able to manage their respiratory disease at home better. As effective self-care management is a cornerstone of the successful management of chronic diseases, this service is of great importance to COPD care. Because COPD is a long-term respiratory disease that is associated with frequent exacerbations and hospitalizations, it is imperative to adopt an innovative care model to improve the health outcomes of these patients. This was the first study to examine the effects of a telecare service on respiratory status, symptom control, HRQL, and the use of health services among older Chinese people with COPD in Hong Kong. By connecting a nurse station to the patients' home environment, the telecare system close monitors patients at home so that a nurse can intervene quickly following the early detection of worsening symptoms. The system simultaneously improves self-management through the use of personalized reminders to take medication and perform breathing exercises. Nevertheless, this study did not demonstrate the positive effects of the telecare service on the use of health services by COPD patients as reported in previous studies [10,14,15]. This may be related to the short evaluation period (2 months) used in this study, whereas other studies followed the patients for about 6 months to 1 year. With regard to HRQL and disease severity, although we used a more sensitive disease-specific measure to capture subtle changes in these outcomes, the findings were similar to those reported previously, i.e., that telecare was not effective in this domain [14,15]. In this study, we only recruited 40 participants due to time constraints, and future studies should use a larger sample. Moreover, we only measured short-term outcomes and it would be helpful if participants were followed up for a longer period.

User friendliness and acceptability are top priorities in designing telemonitoring and telecare devices [16]. COPD mainly affects older people who are more liable to have a lower literacy level, reduced sensory and psychomotor functions, and a reduced activity tolerance level. In this study, some patients reported difficulty in reading the screen of the mobile phone and manipulating the tiny key-in buttons. Moreover, some patients also indicated that the use of separate health monitoring devices for oxygen saturation and respiratory rate was rather complicated. The physical exertion associated with putting on the chest belts to monitor respiratory rate triggered dyspnea in a few patients, and some had difficulty in switch this device on. With regard to the pulse oximeter, the frequent need to recharge the battery also increased the patients' energy consumption.

In conclusion, this study indicated that the telecare service is a feasible and acceptable model to enhance the care of community-based older Chinese people with COPD. The high level of patient satisfaction with this service implies the need to consider expanding its use to the management of COPD. Improvements are needed to ensure the ease of use of the telecare device, such as a larger touch screen and keypad buttons. For the monitoring device, a design with multi-monitoring functions and power-saving characteristics could be adopted to simplify its operation and avoid causing the patients unnecessary physical exertion. To help nurses to use the telecare system, simplified charts and/or graphic diagrams could be used to show key patient information. A large-scale randomized control trial is currently being planned to examine the effects of a newly improved telecare device kit to enhance the care of patients with COPD.

Summary points

What was known before?

- Evidence suggests that home telehealth for COPD patients was effective in reducing the use of medical services.
- Wireless and Internet-connected devices enable healthcare providers to monitor outpatients continuously by receiving and processing critical health information.

What the study has added?

- This study indicated that the telecare service is a feasible and acceptable model to enhance the care of community-based older Chinese people with COPD.
- COPD mainly affects older people who are more liable to have a lower literacy level, reduced sensory and psychomotor functions, and a reduced activity tolerance level. These factors need to be taking into account when designing telecare device to facilitate monitoring of patients in their homes.

Authors' contributions

JPCC, DTFL, DSFY, SYC, and AYMC were responsible for study conception and design; JPCC, AFSL, WCY, YKC performed the acquisition of data; JPCC analyzed the data; and JPCC, DTFL, DSFY, and SYC prepared the manuscript.

Conflict of interest

No conflict of interests.

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