Using preventive home monitoring to reduce hospital admission rates and reduce costs: a case study of telehealth among chronic obstructive pulmonary disease patients

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Summary

We studied whether preventive home monitoring of patients with chronic obstructive pulmonary disease (COPD) could reduce the frequency of hospital admissions and lower the cost of hospitalization. Patients were recruited from a health centre, general practitioner (GP) or the pulmonary hospital ward. They were randomized to usual care or tele-rehabilitation with a telehealth monitoring device installed in their home for four months. A total of 111 patients were suitable for inclusion and consented to be randomized: 60 patients were allocated to intervention and three were lost to follow-up. In the control group 51 patients were allocated to usual care and three patients were lost to follow-up. In the tele-rehabilitation group, the mean hospital admission rate was 0.49 per patient per 10 months compared to the control group rate of 1.17; this difference was significant ($P = 0.041$). The mean cost of admissions was €3461 per patient in the intervention group and €4576 in the control group; this difference was not significant. The Kaplan-Meier estimates for time to hospital admission were longer for the intervention group than the controls, but the difference was not significant. Future work requires large-scale studies of prolonged home monitoring with more extended follow-up.

Introduction

Chronic obstructive pulmonary disease (COPD) is one of the most common chronic diseases worldwide and a common cause of hospitalization.[1] It is estimated that 210 million people have COPD worldwide. In 2005, over three million people died of COPD, equal to 5% of all deaths globally.[2] In Denmark (population 5.2 million), approximately 400,000 people suffer from COPD, accounting for 20% of acute admissions to medical wards. The admission rate for COPD patients within the first month is 24%.[3]

Systematic reviews of conventional integrated care disease management programmes for COPD patients show improved health-related quality of life, improved exercise capacity and reduced hospitals admissions.[4,5,6] A systematic review of home telehealth for COPD patients concluded that clinical heterogeneity was present in outcome measures. Home telehealth was found to reduce rates of hospitalization, emergency department visits and number of hospital bed days, but there was considerable variation in results among the studies.[7] Another systematic review of two randomized trials and four evaluations of telemonitoring concluded that studies are limited, that the benefits of telemonitoring for COPD have not yet been confirmed and cited the need for large-scale implementation studies.[8] A small randomized clinical trial conducted on COPD patients receiving tele-assistance in Italy has shown that the intervention group experienced fewer hospitalizations compared to a control group who did not receive tele-assistance.[9] There are no randomized studies of COPD patients participating in preventive home monitoring across sectors in order to avoid admission to hospital.

The aim of the present study was to test whether preventive home monitoring in COPD reduced the

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admission rate to hospital and the cost of hospitalization. The study was conducted as part of the Danish TELEKAT project (Telehomecare, Chronic Patients and the Integrated Healthcare System, see http://www.telekat.eu). The TELEKAT project seeks to develop a preventive home monitoring concept for COPD patients. Patients perform self-monitoring and rehabilitation activities in their homes so that they can avoid admission to hospital.

Methods

A randomized controlled trial of the tele-rehabilitation programme was conducted. Approval was obtained from the appropriate ethics committee. The patients participating in the study were selected according to the following inclusion criteria:

(1) Over 18 years;
(2) Can understand oral and written trial information;
(3) Diagnosed COPD[10] in stage III or IV (severe or very severe COPD);
(4) COPD as primary cause of reduction in function.

Exclusion criteria were as follows:

(1) Living outside Aalborg Municipality;
(2) Heart disease that could limit physical function;
(3) Mental illness;
(4) Terminal malignant disease;
(5) Severe rheumatoid arthritis;
(6) Pregnancy.

Randomization

For power calculations, our goal was to detect a 10% change in the patients' quality of life with 90% power for exposing differences with a *P* value of 5%. When using health-related quality of life (Short Form Health Survey - SF36), a typical drop-out rate of 10% was expected, which is why it was planned to include 66 patients in the tele-rehabilitation and control group. The results on health-related quality of life will be reported in a future paper.

The COPD patients were recruited to the study from a health centre, general practitioner (GP) or the pulmonary hospital ward. After confirming eligibility and obtaining written informed consent, the patients drew envelopes to see which group they would attend. The envelopes were sealed and therefore the allocation was blinded for health-care professionals, patients and researchers.

COPD patients in the tele-rehabilitation group were offered the possibility of carrying out preventive self-monitoring using a telehealth monitor. The control group followed the standard regime for rehabilitation.

Procedure

After the patients were enrolled in the study, the doctor collected baseline clinical data. The tele-rehabilitation group had a telehealth monitoring device installed in their home for four months, and a doctor prescribed how often the individual patient had to measure values during a week. Patients were instructed to monitor their symptoms so that they could contact their GP or health-care professionals at hospitals at an earlier stage than usual, in order to start treatment and avoid hospitalization. On installing the telehealth equipment in the home, the patient was taught how to measure the clinical values, how to use a step counter and was advised on how to exercise. In order to provide the patients with standardized information on exercises, they were given a set of instructional guidelines from the Danish Lung Association. The exercises included sitting exercises on a chair, stretching of neck muscles, exercises for the legs, standing exercises for arms and chest cavity, and walking exercises. A calibration exercise was conducted with the patients and their relatives in order to avoid information bias.

Using wireless technology, the telehealth monitor can collect and transmit data via a secure line. The data, including the patient's blood pressure, pulse, weight, oxygen level and lung function (spirometry) were sent to a web-based portal or to the patient's electronic health care record. Health-care professionals such as GP, district nurses, nurses and doctors at the health-care centre or hospital could assess the patient's data, monitor the patient's disease and training inputs, and provide advice to the patient. The patients and relatives could also view the data on the web portal and decide with whom they want to share their data, but this was based on the patient's written consent.

Once per month, a tele-rehabilitation team consisting of health-care professionals from primary and secondary care held a video meeting in order to coordinate and discuss the COPD patients' individual rehabilitation programme. The video meetings operated with a standardized agenda.

The control group, after inclusion in the study, was instructed on performing home exercises. Each patient was then made responsible for performing the activities by themselves, and they had no planned contact with health-care professionals regarding their home exercises. Both the intervention and control groups were informed that if they needed urgent treatment, they should contact their GP or an emergency doctor.

Admission rates and costs

Data on admission were collected over a 10-month period, beginning from the time when the patients were included in the study. The admission rate was defined as the number of participants admitted to hospital during a 10-month follow-up period. The cost of hospitalization was estimated using actual patient specific reimbursement data (Danish

DRG codes). The data were accessed via a database in the regional office responsible for collecting and storing the patients' personal data on hospital admissions and bed days of care. The mean cost of hospitalization for each group was calculated for the 10-month follow-up period by dividing the total costs by the number of hospitalized patients.

Statistical analysis

The intention to treatment approach was also used in order to compare patients according to the group to which they were randomly allocated, regardless of patients' compliance, withdrawal from the study or crossover to other treatments. The intention to treatment emphasizes greater accountability for all patients entered into the study and minimizes the influence of drop-outs and patients lost to follow up.

The Kaplan-Meier method was used to estimate the probabilities of admission over time. A log-rank test was applied to compare Kaplan-Meier estimates for the two groups. Statistical analyses were carried out using a standard package (Stata version 11, StataCorp LP, College Station, TX, USA).

Results

Due to lack of time we did not succeed in recruiting 132 patients as planned. A total of 111 patients were suitable for inclusion and consented to be randomized. 60 patients were allocated to intervention and three were lost to follow up due to worsening in their disease. Thus the intervention group consisted of 57 patients. In the control group 51 patients were allocated and three patients were lost to follow up due to personal reasons. Thus the control group consisted of 48 patients. In Table 1 the baseline characteristic of the COPD patients can be seen. Figure 1 illustrates the patient flow chart for the randomizing process. Table 2 provides an overview of the patients recruited to each arm in the study.

Outcomes

The admission rates and costs of hospitalization for the two groups are shown in Table 3. There was a significant difference ($P = 0.041$) between the groups for the rate of admissions.

The Kaplan-Meier estimates for the tele-rehabilitation and the control groups are summarized in Figure 2. The tele-rehabilitation group showed better progress than the control group over a longer time period. However, there was no significant difference between the groups ($P = 0.09$).

Discussion

Reviews[7,8,9,11] of home telehealth for COPD patients indicate a lower level of hospital admissions compared to patients who do not receive telehealth monitors, but these studies are not similar to the present study. In the TELEKAT project, a preventive approach was used in the tele-rehabilitation programme, and the study was conducted across sectors. We have found no studies where tele-rehabilitation was conducted across sectors with representatives from the health-care centre, GP, hospital and district nurses, and where the health-care professionals were able to share data and meet virtually. The small sample size in our study precluded us from conducting a subgroup analysis on disease severity and health sector.

Overall, the tele-rehabilitation group had an admission rate of 0.48 per 10 months compared to 1.17 for the control group. There was also a trend towards the tele-rehabilitation group having a longer time to first admission to hospital than the control group (see Figure 2) with a lower proportion of telerehabilitation patients admitted to hospital.

There was a drop out of three patients in both the trial groups. The patients gave reasons such as worsening in their disease and personal reasons for dropping out. Although relatively few patients dropped-out of the study, the matter requires consideration. Is preventive home monitoring for everybody? If they have worsening symptoms, do patients have the psychological capacity to monitor themselves and accept the associated responsibility? This raises the question of whether we need to screen patients more intensively before offering them home monitoring. We have not been able to find studies that focus on this question.

The long-term effect of tele-rehabilitation needs to be addressed in studies, using a longer duration of home monitoring and a more extended period of follow-up. There is a need for large scale randomized studies in multicentre settings in order to obtain solid evidence for implementing tele-rehabilitation. Polisena *et al.*[12], in an economic review,

Table 1 Baseline characteristics of the two groups. Values in parentheses represent the interquartile range (IQR)

	Tele-rehabilitation ($n = 57$)	Control ($n = 48$)	*P* value
Age, y	68 (45; 82)	68 (46; 89)	0.67
Forced expiratory volume in 1 second, L	0.90 (0.26; 2.09)	0.93 (0.33; 2.13)	0.36
Bodyweight, kg	72.9 (39.0; 118.0)	69.3 (38.0; 123.7)	0.44
Body mass index, kg/m^2	25.5 (16.0; 41.0)	24.6 (13.5; 38.5)	0.14
Oxygen saturation, %	93.5 (89.0; 99.0)	94.3 (86.0; 98.0)	0.57
Blood pressure, mmHg	136/81 (97/52; 180/126)	134/78 (107/57; 165/98)	0.44
Heart rate,/min	82 (57; 111)	80 (46; 115)	0.56
MRC dyspnoea score	3.6 (2; 5)	3.8 (2; 5)	0.16

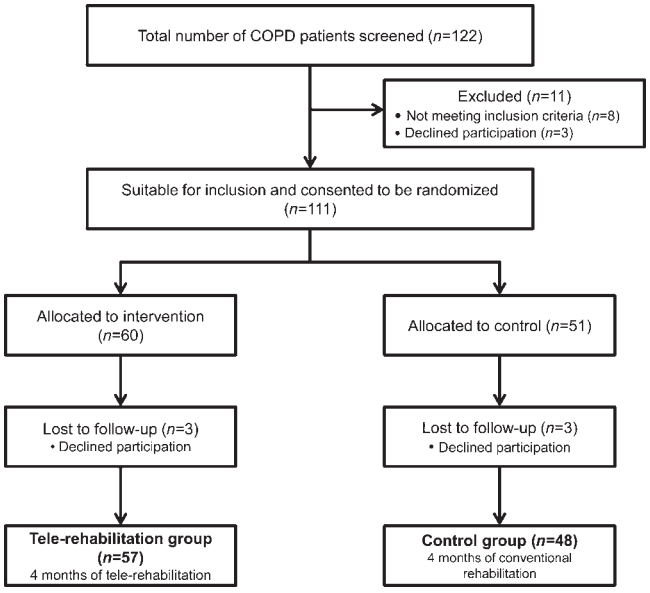

Figure 1 Patient flow chart

Table 2 Numbers of patients recruited to the two groups

Source of recruiting	Tele-rehabilitation	Control
GP	15	6
Hospital	10	12
Health-care centre	20	20
District nursing	15	13
Total	*60*	*51*

Table 3 Hospital admission rate and cost of admissions in the two groups

	Tele-rehabilitation (n = 57)	Control (n = 48)
Admission rate per patient over a 10-month period	0.49 (0.28; 0.70)	1.17 (0.65; 1.69)
Mean cost of admissions per patient (Euro)	3461 (679; 6243)	4576 (2476; 6677)

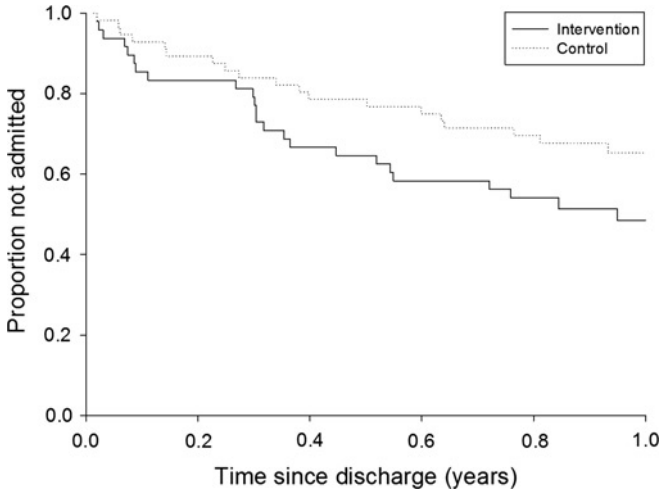

Figure 2 Time to first admission to hospital

found that most studies of home telehealth resulted in savings when seen from a health-care system and provider perspective. They thus concluded that home telehealth has the potential to reduce health-care costs.

Our own qualitative analysis of COPD patients in the TELEKAT project[13] found that preventive home monitoring taught many patients to identify symptoms at an earlier stage so that they contacted a doctor. The patients reported that the technology helped them to visualize the data and obtain an overview of the development of symptoms. Most of the patients reported feeling empowered to handle their illness in their everyday lives, and better equipped to avoid re-hospitalization. They also reported that their interaction with the health-care professionals[14] became a mutual learning process and that their relationship moved from subservience to a medical authority to a more reciprocal dialogue with nurses, doctors and health-care providers. This helped them to better manage their illness in everyday life. The fact that most of the COPD patients felt empowered to deal with their illness in their everyday lives may help to explain why patients' admission rates decreased. However, the question is how long will this period of empowerment last? It is necessary to study the effects of the intervention over a longer time period in order to be able to assess the long-term effect of preventive home monitoring.

Learning from the TELEKAT study[14] shows that telehealth technologies promote patient engagement in handling their own disease and taking more responsibility. However our study also shows that the technology cannot stand alone as it has to be combined with a programme for rehabilitation activities, continuous dialogues and contact with health-care professionals.

Conclusion

The tele-rehabilitation group had significantly fewer admissions during the 10-month follow-up period. The tele-rehabilitation group also improved more than the control group for a longer period, with a lower proportion of them in need of hospitalization. Future work requires large-scale studies of prolonged home monitoring and more extended follow-up.

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