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ORIGINAL PAPER

Effects of Telemonitoring in Patients with Chronic Obstructive Pulmonary Disease

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Abstract

The objective of this study was to determine the effects of a home-based telemonitoring device, The Health Buddy (HB), on health consumption and health-related quality of life (HRQoL) in patients with moderate to severe chronic obstructive pulmonary disease (COPD). The HB provides daily symptom-surveillance by a case manager and education to enhance disease knowledge and self-management. A nonrandomized controlled multicenter study was established comparing the effectiveness of telemonitoring as an add-on to care as usual with a follow-up of 6 months. Four hospitals took part in the experimental group and 2 hospitals formed an equivalent control group with 59 and 56 patients, respectively. HRQoL was measured by the Clinical COPD Questionnaire. Healthcare consumption was assessed using medical records in the 6 months preceding study entry and during the study. Compared with the control group, the HB group showed a significant decrease in hospital admission rates (HB -0.11 ± 1.16 vs. control $+0.27 \pm 1.0$, $p = 0.02$) and in the total number of exacerbations (HB -0.35 ± 1.4 vs. control $+0.32 \pm 1.2$, $p = 0.004$). There was a tendency toward decreased hospital days and outpatient visits. No significant changes in HRQoL were observed at follow-up between both study groups. Despite inherent limitations of the study, these findings suggest that adopting telemonitoring in everyday clinical practice is feasible and can substantially improve care and decrease healthcare utilization of patients with moderate to severe COPD.

Key words: *Health Buddy device, COPD, symptom surveillance, health-related quality of life, self-management*

Introduction

Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality across the world and its prevalence is steadily increasing.[1,2] In the coming decades, general practitioners, chest physicians, and other healthcare providers will be confronted with an increasing share of their patient population being COPD patients.[3] COPD places a significant burden on healthcare systems worldwide. A major problem associated with COPD is the occurrence of exacerbations, or periodic worsening of symptoms and lung function. Symptoms during exacerbations include increased shortness of breath, cough, and sputum production. These exacerbations result in increased utilization of healthcare services, and decline in health-related quality of life (HRQoL).[4] They are particularly managed with increased bronchodilatator medication, oral corticosteroids, and antibiotics.[5] Exacerbations requiring hospitalization contribute to a decline in health status and increased healthcare consumption and therefore are costly to the community.[4,6] Expenditures for hospitalization represent at least 70% of all COPD-related medical care costs.[7]

Community or home-based interventions aimed at decreasing hospital readmission due to exacerbations using a nurse-led case management approach are still controversial.[8] Nevertheless, a recent well-designed study by Casas et al.[9] showed promising lower re-hospitalization rates using an integrated care program with a case management approach, an educational program on self-management, and shared-care arrangements between primary care and hospital, facilitated by information technologies. Meanwhile, new technologies have been developed to permit close monitoring of patients at home and simultaneously improving self-management. Through the use of a remote telemedicine disease management program, the case manager can detect early and repeated symptoms and intervene quickly with multiple patients. In addition, telemonitoring has other potential advantages, such as enhancing patient self-management skills and cost reduction.[10] Prior studies show that exacerbated patients who are more self-managed or seek early treatment are less likely to be hospitalized.[11,12] We hypothesize telemonitoring to decrease the num-

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ber of hospitalizations. In addition, behavioral changes and intensified case-management arranged by telemonitoring could also realize direct health effects and subsequently influence the total number of exacerbations and additional medication.

In the management of diabetes and heart failure, telemonitoring has been shown to have great potential in improving health outcome and decreased hospital admissions.[13,14] To our knowledge, for COPD patients, evidence for efficacy of telemonitoring is scarce. Only 1 quasiexperimental10 and 4 observational studies[15–18] have been published with small sample sizes, substantial methodological inadequacies and varying technical methods of telemedicine (*Table 1*). A recent randomized controlled trial evaluated the use of home telehealth for patients with COPD and/or congestive heart failure (CHF). In this study, effects of telemonitoring on health and well-being of COPD patients could not be disentangled from CHF patients because results for both pathologies were combined. Nevertheless, this study emphasizes feasibility and patient satisfaction with the technology.[19] The aim of the present study is to evaluate effects of telemonitoring for patients with COPD on HRQoL and healthcare consumption.

Materials and Methods

PATIENTS

Patients from 6 hospitals in the center of the Netherlands were recruited by their chest physician. Inclusion criteria for entry to the study were: patients over 45 years of age, post-bronchodilator forced expiratory volume in 1 second (FEV_1) less than 50% of predicted and reversibility $<10\%$ of predicted normal FEV_1 after inhalation of a bronchodilator (GOLD stage III and IV).[1] Furthermore, patients had a history of at least 1 COPD exacerbation in the preceding 6 months. Exclusion criteria for the study were: lung cancer, severe neurological, musculoskeletal, or cardiovascular disorders, severe psychological or psychiatric deficiency, cognitive deficiency, or the inability to read at a basic level. All participants were informed in detail of the characteristics of the study, and written informed consent was obtained in accordance with the Committee on Investigations Involving Human Subjects at each participating hospital.

STUDY DESIGN

The study had a multicenter prospective controlled nonrandomized design. Four hospitals took part in the intervention group. These hospitals had already indicated preparedness for implementing telemonitoring in their daily practice before the start of the trial. Two hospitals were selected by the researchers as an equivalent control group. All hospitals were located in the same region, were similar in size (COPD population), and treated COPD patients according current evidence-based guidelines.[1] All patients had usual access to their pulmonary physician, general practitioner, or respiratory nurse. Apart from the intervention, no additional case management, call-in number, education, or self-management intervention was provided in both groups. Patients in the intervention group received care as usual and used the telemonitoring device for 6 months. Patients in the control group were included in the study for 6 months and received care as usual without telemonitoring. HRQoL was measured at baseline and after 6 months. For the assessment of healthcare resources, comparisons were made between 6 months prior to and 6 months during telemonitoring utilization.

INTERVENTION

Telemonitoring was provided by Health Hero's Network technology, which gives access to a browser-based care management tool, the Health Hero® (Hero Health Network, Palo Alto, CA), iCare Desktop™ and the patient communication appliance, the Health Buddy (HB). This device has a large screen and 4 buttons for responses (*Fig. 1*). Patients answer personalized daily questions that both monitor their disease symptoms, medication compliance, and knowledge; and provide education about their condition. Each answer to a question received immediate feedback from the device: praise for a correct answer or encouragement to try again. In addition to the core immutable questions, COPD facts and trivia questions, which changed daily, were included to peak patient's curiosity and enhance learning. Patients' responses are sent via telephone line to Health Hero's secure data center. Daily responses sent by patients were automatically categorized and prioritized (color-coding). Telemonitoring was provided by respiratory nurses who reviewed patient answers Monday to Friday. The algorithm used in the HB software recognized a potential problem, compared the current reading with past results, and notified the providers through the iCare Desktop. This included recognition of changes in previously defined patterns of major and minor respiratory symptoms, possibly indicating an exacerbation.[11]

In addition, medication noncompliance and lack of disease knowledge were reported to the providers. If values were alarming, for example, due to severe levels of or rapidly changed respiratory symptoms, the patient was contacted by the respiratory nurse. In case of less alarming symptoms but judged as chronically outside of designated parameters, the patient was also contacted. When needed, the pulmonary physician or clinic was notified.

MEASUREMENTS

HRQoL was assessed using the Clinical COPD Questionaire (CCQ), which is a 10-item, self-administered questionnaire that can be

Table 1. Characteristics of Experimental Studies on Home-Telemonitoring in Patients with COPD

REFERENCE	DESIGN	POPULATION I) INTERVENTION GROUP C) CONTROL GROUP	TECHNOLOGY	INTERVENTION I) INTERVENTION GROUP C) CONTROL GROUP	FOLLOW-UP	OUTCOME +) POSITIVE EFFECTS −) NEGATIVE EFFECTS
Maiolo 2003	UBA	Severe COPD patients i) *n* = 20 c) *n* = 20	Comprised sensors connected to a monitoring device and a transmitting unit for ordinary telephone network	i) Twice a week monitoring of pulse-oximetry and heart rate Face-to-face medical visits every 3 months Spirometry assessment every 6 months	12 months	+ Lower number of hospital admissions (intervention 1.2 vs control 2.2) + Lower number of acute home exacerbations (intervention 0.77 vs control 1.7) + Cost saving; † 1,739 per patient, is 17% gain in 12 months with regard to control group
Mair 1999	UBA	COPD patients with a mild to moderate exacerbation i) *n* = 6	Realtime interactive, analogue video phone	i) Interactive video consults, monitoring symptoms, oxygen saturation, spirometry, temperature and heart rate Home visit	NR	NR
Paré 2006	CBA	Stable COPD patients i) *n* = 19 c) *n* = 10	Webphone with integrated touch screen and modem (New IT Technologies Inc., Montreal, Quebec)	i) Daily monitoring of data entry form: symptoms, peak flow rate, and medication c) Traditional home care	6 months	+ Lower number of hospital admissions (intervention 0.1 vs control 0.6) + Lower number of home visits (intervention 4.2 vs control 7.5) + Cost saving; $355 per patient, is 15% gain in 6 months with regard to control group − Increased length of telephone interventions (intervention 17.5 vs control 10.1 minutes)
Vitacca 2006	UBA	COPD patients necessitating mechanical ventilation i) *n* = 17	Comprised sensors connected to a monitoring device and a transmitting unit for ordinary telephone network	i) Scheduled monitoring of pulse oximetry Scheduled interview by phone of body weight, clinical stability, night-time problems Direct telephone access to case managers	9 months	+ Telemonitoring is feasible in patients receiving mechanical ventilation and useful in titration of oxygen, mechanical ventilator settings, and stabilization of relapses
Vontetsianos 2005	UBA	Well-motivated patients with advanced COPD i) *n* = 18	Home-telecare software ISDN application including realtime audiovisual connecting with the hospital using patient's TV set. Nurse use only.	i) Home-visiting nurse monitored vital signs, treatment compliance, ECG, blood pressure, spirometry, and oximetry Educational/self-management session	9 months	+ Decrease in hospital admission (37 in 12 months before intervention vs 6 in 9 months after intervention) + Decrease in emergency scheduled visits (156 in 12 months before intervention vs 86 in 9 months after intervention) + Improved disease knowledge and self-management + Improved quality of life (28% increase) + Cost saving by reduced hospital day and emergency room and other visits, († 7042 12 months before intervention vs † 1722 in 9 months after intervention)

COPD, chronic obstructive pulmonary disease; CBA, controlled before–after study; UBA, uncontrolled before–after study; NR, not reported, ECG, electrocardiography.

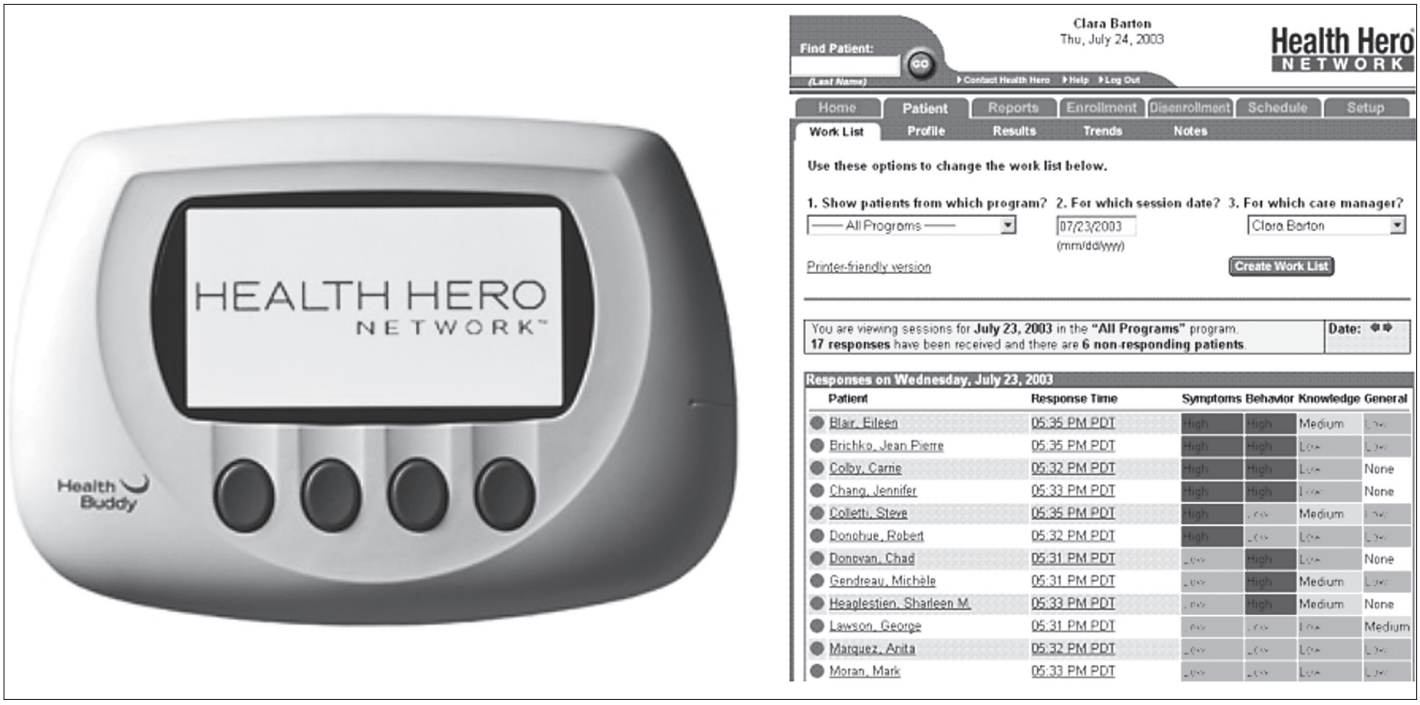

FIG. 1. Photograph of the Health Buddy (Health Hero Network, Palo Alto, CA) and the iCare Desktop patient result page showing the patient population risk-stratified based on their Health Buddy answers.

completed in less than 2 minutes. Items are divided into 3 domains: symptom, functional state, and mental state; patients are required to respond to each item on a 7-point Likert scale where 0 = asymptomatic/no limitation and 6 = extremely symptomatic/total limitation. The final score is the mean of all 10 items, and scores for the 3 domains can be calculated separately if required. Higher scores represent a lower HRQoL. The CCQ has been validated and has shown strong discriminative properties, test–retest reliability, and responsiveness.[20] A difference of 0.40 points of the CCQ total score was determined as clinically important.[21]

The patient's medical record in the hospital was analyzed to provide a description of the patient's healthcare consumption. The following parameters were taken into account: inpatient hospital admissions, inpatient hospital days, emergency care unit visits, reported exacerbations, and type and quantity of prescribed medication.

To quantify the average time investment of telemonitoring, the respiratory nurses were asked to register their activities at 15-minute intervals during 1 normal working week (5 days for 8 hours/day). The diary was developed based on the workload measures used in the Second National Study of Diseases and Activities and adjusted for the purpose of this study.22 The following activities were registered: 1) monitoring of patients, 2) consultation with physician, and 3) telephone contact with patients.

DATA ANALYSIS

SPSS version 14.0 (Chicago, IL) was used to perform the analysis. Results are expressed as mean ± SD, or as percentages in the corresponding categories. Comparisons between the HB group and control group at baseline and changes during the follow-up period were performed using independent *t*-tests, Mann-Whitney *U*-test, or the chi-square test. To improve sensitivity of treatment comparisons in case of baseline differences, responses were adjusted to baseline by analyzing the change between groups (=response − baseline).[23] Only patients for whom healthcare consumption data were available 6 months prior to and during the study period were included in the analyses. *P* values of 0.05 were considered the limit of significance in all analyses.

Table 2. Baseline Characteristics

	HEALTH BUDDY GROUP (n = 59)	CONTROL GROUP (n = 56)	p VALUE
Age, yr	69 ± 8	70 ± 10	
Males	27 (46%)	34 (61%)	
FEV1 % pred	42 ± 14	39 ± 11	
Former or current smoker	55 (93%)	48 (86%)	
Current smoke	17 (29%)	12 (19%)	
Packyears smoked, yr	42 ± 21	37 ± 20	
No. inpatient hospital admissions	0.76 ± 1.3	0.48 ± 1.1	0.02[a]
0	32 (54%)	40 (72%)	
1	17 (29%)	12 (21%)	
2	10 (17%)	4 (7%)	
No. inpatient hospital days	9.1 ± 20.6	6.56 ± 14.3	
No. exacerbations	1.00 ± 1.45	0.69 ± 1.32	0.03[a]
No. outpatients visits	3.5 ± 2.0	2.1 ± 1.7	0.001[a]
No. visits of emergency care unit	0.13 ± 0.4	0.02 ± 0.1	0.03[a]
Short-acting bronchodilators			
Never	19 (32%)	18 (32%)	
In episodes	9 (15%)	5 (9%)	
Always	31 (53%)	33 (59%)	
Long-acting bronchodilators			
Never	16 (27%)	24 (43%)	
In episodes	13 (22%)	10 (18%)	
Always	30 (51%)	22 (39%)	
Inhaled glucocorticosteroids			
Never	40 (68%)	38 (68%)	
In episodes	10 (17%)	5 (9%)	
Always	9 (15%)	13 (23%)	
Oral glucocorticosteroids			
Never	40 (68%)	42 (75%)	
In episodes	14 (24%)	10 (18%)	
Always	5 (8%)	4 (7%)	
Antibiotics			
Never	45 (76%)	48 (85%)	
In episodes	13 (22%)	6 (11%)	
Always	1 (2%)	2 (4%)	

Data are expressed as means 6 SD, %, or n (%).
[a]Mann–Whitney U test nonparametric test for independent samples.
FEV, forced expiratory volume in 1 second.

Results

A total of 101 patients enrolled in the intervention group and 64 patients in the control group. After 6 months, 68 patients (67%) in the intervention group and 56 patients (88%) in the control group were eligible for follow-up at 6 months. Reasons for loss to follow-up in the intervention group were: technical problems (n = 11), lack of motivation to participate in the project (n = 10), death (n = 2), moving out of the area and unable to continue telemonitoring (n = 5), or no response to the follow-up questionnaire (n = 5). An important cause of technical problems occurred when patients already used an Asymmetric Digital Subscriber Line (ADSL) (5 of 11 dropouts).* Reasons for loss to follow-up in the control group were: death (n = 2), and no response to the follow-up questionnaire (n = 6). Medical files on 9 patients were not available at the time of the study. The remaining patient population for this study, therefore, consisted of 59 patients in the intervention group and 56 patients in the control group. Patients who were lost to follow-up did not differ from the patients who remained in the project with respect to age, gender, disease severity, smoking history, or healthcare consumption (data not shown).

At baseline, no differences were observed in terms of demographic characteristics and airway obstruction (FEV_1) between the 2 groups (*Table 2*). Nevertheless, patients in the intervention group showed initial significantly higher health consumption as expressed by the number of inpatient hospital admissions, number of exacerbations, number of outpatient visits, and number of emergency care unit visits.

Table 3 shows results regarding HRQoL. No significant changes in CCQ scores were observed at follow-up either within or between groups. The proportion of patients for whom QOL scores improved, maintained, or deteriorated based on the minimal clinical important differences of 0.40 points on the CCQ total score was not significantly different between both groups. In the intervention group, 20%

Table 3. Outcomes in Quality of Life Using the Clinical COPD Questionnaire (CCQ) at Baseline and 6 Months

	HEALTH BUDDY GROUP		CONTROL GROUP	
	BASELINE	6 MONTHS	BASELINE	6 MONTHS
Symptoms, points	2.7 ± 1.0	2.8 ± 1.2	3.1 ± 1.3	3.0 ± 1.2
Functional, state	2.8 ± 1.2	2.9 ± 1.3	3.1 ± 1.5	3.2 ± 1.5
Mental, state	1.6 ± 1.2	1.6 ± 1.4	1.5 ± 1.4	1.8 ± 1.5
Total, points	2.5 ± 0.9	2.6 ± 1.1	2.7 ± 1.2	2.9 ± 1.2

Data are expressed as means ± SD.

*In the meantime, technical problems with the HB and ADSL have been resolved.

(12/59) of the patients improved in QOL compared with 16% (9/56) in the control group. QOL deteriorated in 29% (17/59) of the intervention group compared with 36% (20/56) in the control group.

Data on changes in exacerbations and healthcare consumption between the 6 months prior to enrolment and the 6 months following enrolment are presented in *Table 4*. A significant decrease in average hospital admissions of 0.11 was observed in the intervention group compared with an increase of 0.27 in the control group ($p = 0.02$). More detailed analysis on hospital

Table 4. Outcomes on Exacerbations and Healthcare Consumption

	HEALTH BUDDY GROUP ($n = 59$)			CONTROL GROUP ($n = 56$)			p VALUE (Δ)
	BASELINE	6 MONTHS	Δ	BASELINE	6 MONTHS	Δ	
No. exacerbations	1.0 ± 1.5	0.65 ± 1.4	20.35 ± 1.4	0.69 ± 1.3	1.01 ± 1.4	10.32 ± 1.2	0.004[a]
No. inpatient hospital admissions	0.76 ± 1.3	0.65 ± 1.3	20.11 ± 1.16	0.48 ± 1.1	0.75 ± 1.2	10.27 ± 1.0	0.02[a]
0 (between groups)	32 (54%)	39 (66%)	17 (12%)	40 (72%)	33 (59%)	27 (12%)	0.03[b]
1 (between groups)	17 (29%)	13 (22%)	24 (7%)	12 (21%)	12 (21%)	0 (0%)	
≥2 (between groups)	10 (17%)	7 (12%)	23 (5%)	4 (7%)	11 (20%)	17 (13%)	0.03[b]
No. inpatient hospital days	9.1 ± 20.6	6.6 ± 24.0	22.5 ± 15.2	6.56 ± 14.3	7.46 ± 19.9	10.9 ± 19.4	
No. outpatients visits	3.5 ± 2.0	3.23 ± 2.2	20.27 ± 24	2.1 ± 1.7	2.3 ± 1.3	10.2 ± 1.9	
Short-acting bronchodilators							
Never	19 (32%)	19 (32%)	0 (0%)	18 (32%)	14 (25%)	24 (7%)	
In episodes	9 (15%)	1 (2%)	28 (14%)	5 (9%)	5 (9%)	0 (0%)	0.008[b]
Always	31 (53%)	39 (66%)	18 (14%)	33 (59%)	37 (66%)	14 (7%)	
Long-acting bronchodilators							
Never	16 (27%)	17 (29%)	11 (2%)	24 (43%)	20 (36%)	24 (7%)	
In episodes	13 (22%)	3 (5%)	210 (17%)	10 (18%)	2 (4)	28 (14%)	
Always	30 (51%)	39 (66%)	19 (15%)	22 (39%)	34 (60%)	112 (21%)	
Inhaled glucocorticosteroids							
Never	40 (68%)	45 (76%)	15 (9%)	38 (68%)	40 (71%)	12 (4%)	
In episodes	10 (17%)	2 (3%)	28 (14%)	5 (9%)	4 (7%)	21 (2%)	
Always	9 (15%)	12 (20%)	13 (5%)	13 (23%)	12 (21%)	21 (2%)	
Oral corticosteroids							
Never	40 (68%)	41 (70%)	11 (2%)	42 (75%)	38 (68%)	24 (7%)	
In episodes	14 (24%)	9 (15%)	25 (9%)	10 (18%)	8 (14%)	22 (4%)	
Always	5 (8%)	9 (15%)	14 (7%)	4 (7%)	10 (18%)	16 (11%)	
Antibiotics							
Never	45 (76%)	46 (78%)	11 (2%)	48 (85%)	45 (80%)	23 (6%)	
In episodes	13 (22%)	9 (15%)	24 (7%)	6 (11%)	8 (14%)	12 (4%)	
Always	1 (2%)	4 (7%)	13 (5%)	2 (4%)	3 (6%)	11 (2%)	

Data are expressed as *n* (%) or means ± SD.

[a]Mann–Whitney *U* test nonparametric test for independent samples.

[b]Chi-square test.

admissions shows a significant 12% increase in the proportion of patients without admission in the intervention group ($p = 0.03$). In addition, the proportion of patients with at least 2 admissions significantly decreased, with 5% in the intervention group compared with a 13% increase in the control group. The intervention group showed a decrease in the number of hospital days, exacerbations, and outpatient visits. Only the change in the number of exacerbations was significantly higher compared with the control group ($p = 0.004$). Emergency department visits slightly increased in the intervention group, but this difference was not statistically significant. With regard to medication use, the only change between the 2 groups was a shift in short-acting bronchodilators in the intervention group from use in episodes to constant use ($p = 0.008$).

The average time spent by the telemonitoring respiratory nurses was 13.70 6 0.60 minutes per patient per week. The actual telemonitoring of patients took 76.7% of this time, telephone contact with patients took 18.7%, and consultation with a physician 4.6% of the total time spent telemonitoring.

Discussion

In COPD, predominantly exacerbations and subsequent hospitalizations have high impact on a patient's quality of life and healthcare expenditure.[4,7] Attempts to establish new interventions targeting improving patient outcome and a decrease in healthcare consumption are imperative. Telemonitoring provides the assessment of a patient's state of health on a more frequent basis than in conventional clinical procedures. It can alert clinicians to the early change of signs and symptoms, providing the opportunity for intervention before patients become severely ill and require hospitalization. In addition, telemonitoring potentially can enhance patients' disease knowledge, self-management, and medication compliance.

In the present study, besides a small proportional increase in the number of patients with clinically relevant improvement, no significant differences were seen in change in HRQoL between both groups. In the HB group, there was a decrease in hospital rates and in the total number of exacerbations. These results substantiate the findings from the study by Maiolo et al., despite the fact that the latter also monitored oxygen saturation and heart rate.15 In our study, telemonitoring also showed a tendency toward a decrease in the number of hospital days and outpatient visits. Interpretation of these results in healthcare consumption has to be done with caution because it is impossible to separate the effect of education from the effect of the more intense monitoring of patients' state of health both provided by the HB device. We believe that early detection on changing signs and symptoms by the case manager is expected to have accelerated adequate treatment. This might have decreased the number of exacerbations or prevented exacerbations that require hospitalization. During the telemonitoring period, although not statistically significant, the intervention group seemed to have more frequently visited the emergency department compared with the control group. Probably the case manager invited patients at risk to come to the hospital sooner. Although behavioral changes were not assessed, the positive differences in healthcare utilization might also partly be due to enhanced self-management skills. Previous studies in asthma and heart failure patients confirmed that home telemonitoring with the use of the HB improves self-efficacy.[24,25]

Telemonitoring with the HB was well accepted by the involved caregivers. They evaluated the telemonitoring activities to fit well into their daily activities. Results of 1 week of time registration showed that after 5 months of telemonitoring, the average time spent by the respiratory nurses was somewhat less than one quarter of an hour per patient per week, which equates to about 3 minutes per patient per day. In hospitals with larger case loads, this represents a substantial investment. Eventually, future research including cost-effectiveness analysis should determine whether this workload is worth investing. Within the total time investment, the actual telemonitoring itself was the most time-consuming activity followed by telephone contact and consultation with a physician.

Scientific evidence for telemonitoring in patients with COPD is relatively limited. Nevertheless, telemonitoring seems feasible in COPD care, with patients and providers being satisfied with the technology. In addition, reported effects are promising in reducing healthcare utilization and costs. Further randomized controlled trials with sufficient sample size and longer follow-up are needed to assess the effects and optimal content and technology of telemonitoring. In addition, more research is needed to evaluate how and to which extent telemonitoring results in individual changes in behavior, knowledge, and self-management skills.

LIMITATIONS

There were some limitations in our study. A confounding factor in interpreting the results of this nonrandomized controlled trial is that the intervention group turned out to have a significantly higher use of healthcare resources in the 6 months preceding baseline assessment as expressed by a higher number of hospital admissions, exacerbations, outpatient visits, and emergency care unit visits. These differences do not seem to be caused by disease severity because this was similar in both groups (FEV_1 predicted, intervention group = 42%, FEV_1 predicted, control group 39%). For logistic reasons, this study was quasi-experimental. Variations in sociodemographic factors, and different policies between hospitals and between general practitioners might have resulted in heterogeneity in baseline healthcare utilization between groups.

We did not perform an intention-to-treat design, because not all follow-up data were available for patients who dropped out or were not motivated to participate in the project. Although these patients had similar baseline characteristics, excluding them from the analysis might have biased outcome. Still, a substantial part of the missing response was caused by technical problems ($n = 11$) or moving out of the area ($n = 5$) and therefore most likely random and independent of the outcome. The only technical necessities to allow HB use are an existing telephone line and power source. Our COPD population in most cases neither owned a computer nor had an internet connection. For the time being, this argues for the use of regular telephone lines in telemedicine for COPD patients. Nevertheless, some technical problems occurred in patients who did have a computer in combination with ADSL connection. Meanwhile, these problems have been resolved by the manufacturer.

Conclusion

In conclusion, we evaluated the efficacy of a home-based interactive health communication device, the HB, in patients with moderate to severe COPD. The HB was designed to monitor symptoms transmitted to a case manager through a secure Web site. This device was able to provide both symptom surveillance and patient education. This study represents the results of a nonrandomized controlled, 6-month trial in patients with moderate to severe COPD. Compared with a group of patients receiving care as usual, in the HB group there was a decrease in the number of exacerbations and hospital admissions. It seems likely that adopting telemonitoring in everyday clinical practice is feasible and can substantially improve care and decrease healthcare utilization of moderate to severe COPD patients.

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