Home telehealth for chronic obstructive pulmonary disease: a systematic review and meta-analysis

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Summary

We conducted a systematic review of the literature about home telehealth for chronic obstructive pulmonary disease (COPD) compared with usual care. An electronic literature search identified 6241 citations. From these, nine original studies (10 references) relating to 858 patients were selected for inclusion in the review. Four studies compared home telemonitoring with usual care, and six randomized controlled trials compared telephone support with usual care. Clinical heterogeneity was present in many of the outcomes measured. Home telehealth (home telemonitoring and telephone support) was found to reduce rates of hospitalization and emergency department visits, while findings for hospital bed days of care varied between studies. However, the mortality rate was greater in the telephone-support group compared with usual care (risk ratio = 1.21; 95% CI: 0.84 to 1.75). Home telehealth interventions were similar or better than usual care for quality of life and patient satisfaction outcomes.

Introduction

It is estimated that 210 million people have chronic obstructive pulmonary disease (COPD) worldwide. Three million people died of COPD in 2005, representing 5% of all deaths for that year.[1] The National Health Service in the UK spends over £800 million (US$1420 billion) annually on the management of the disease,[2] and the economic burden of COPD in the USA was approximately US$39 billion in 2005.[3] In Canada, the estimated cost (direct and indirect) of COPD exacerbations, a principal cause of bed usage in acute care hospitals, was C$646–736 million (US$622–708 million).[4]

As a result of advances in the treatment of COPD, the demand for home care services has increased.[5] Health-care providers can deliver home care services by visiting a patient's home or using information and communication technology, also referred to as home telehealth. Home telehealth is a subset of telehealth that delivers health care to the home environment by connecting the patient with medical professionals and is intended to improve the level of patient care.[6]

Home telehealth can be categorized as home telemonitoring (HTM) or telephone support (TS). Home telemonitoring is remote care delivery or monitoring that occurs between the patients in their place of residence and the health-care provider located somewhere else. Telephone support is patient or caregiver support by a health-care provider through telephone contact. It does not involve electronic transmission of patient outcome data.

We conducted a systematic review of the literature and performed a meta-analysis of clinical outcomes, patient quality of life (QoL) and the use of health-care services for home telehealth compared with those of usual care (UC) for patients with COPD. UC was considered to involve follow-up by a primary care physician or specialist after patient discharge from hospital. The systematic review was based on a health technology assessment for the Canadian Agency for Drugs and Technologies in Health on home telehealth for chronic disease management, specifically COPD, diabetes and congestive heart failure (CHF).[7]

Methods

The following bibliographic databases were searched through the Ovid interface: Medline, Medline Daily Update,

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Medline In-Process and Other Non-Indexed Citations, BIOSIS Previews, EMBASE, CINAHL and PsycINFO. Parallel searches were conducted in PubMed, Cochrane Library, and the Centre for Reviews and Dissemination (CRD) databases. The search strategy was customized for each database and included controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings) and keywords. For all databases, the main keyword combinations used were: [telehealth or telemedicine or telecare or telemonitor*] and [home* or in-home* or residen*] and [chronic obstructive lung OR chronic obstructive pulmonary OR COPD]. OVID AutoAlerts and PubMed MyNCBI were set up to send monthly updates for new literature. Monthly searches were also performed in the Cochrane Library and the CRD. Results were limited to articles published from 1998 onwards and no language restrictions were imposed.

Selection criteria

Eligible studies included patients with COPD and home telehealth as the intervention compared with UC. The outcomes of interest assessed were QOL and health-care resource utilization, such as hospitalizations, bed days of care (BDOC), emergency department (ED) visits, outpatient visits and home visits. Both randomized controlled trials (RCTs) and observational studies were included. Studies with no comparator, with patient populations with diseases other than COPD or wrong interventions (e.g. interventions that involved an at-home rehabilitation programme without the use of information or communication technologies) were excluded.

Selection and data extraction

Two reviewers independently read the titles and abstracts that were identified through the literature search. The full-text articles of citations deemed to be potentially relevant were then reviewed using the selection criteria. The reviewers compared their selections of included studies, and any disagreements were discussed and resolved by consensus.

Data from the included studies were extracted independently by the two reviewers using a structured data extraction form. Country of origin, study design, sample size, setting, duration, comparator arms and study outcomes were recorded. Any disagreements were discussed and resolved by consensus.

Quality assessment

The quality of the included studies was independently evaluated by the two reviewers using a modified version of a tool developed by Hailey *et al.*[8] The quality of the studies was rated on a scale from A (high quality and high degree of confidence in the study findings) to E (poor quality and unacceptable uncertainty in the study findings). The ratings were based on study characteristics (e.g. design, patient selection, description of comparators, outcomes reported) and were applicable to both RCTs and observational studies. Any disagreements were discussed and resolved by consensus. The quality assessment tool is summarised in Table 1.

Data analysis

A standard package was used for the statistical analysis (STATA 8.2). A random effects model was applied to

Table 1 Quality assessment tool

Scoring system	Score
Study design	
1. Large RCT (over 50 subjects in each arm): 5 points	
2. Small RCT: 3 points	
3. Prospective: 2 points	
4. Retrospective: 1 point	
If RCT*:	
a. Randomization appropriately described?	
b. Blinded?	
c. Blinding appropriately described?	
Study performance	
Score (0 = information missing, 1 = information limited, 2 = information satisfactory)	
1. Patient selection	
2. Description/specification of the intervention	
3. Specification and analysis of study (intention-to-treat)	
4. Patient disposal	
5. Outcomes reported	
Overall score	

Overall score	Category	Interpretation
11.5–15.0	A	High quality – high degree of confidence in study findings
9.5–11.0	B	Good quality – some uncertainty regarding the study findings
7.5–9.0	C	Fair to good quality – some limitations that should be considered in any implementation of study findings
5.5–7.0	D	Poor to fair quality – substantial limitations in the study; findings should be used cautiously
1.0–5.0	E	Poor quality – unacceptable uncertainty for study findings

*An RCT was awarded full points if it addressed all three characteristics. Half a point was deducted if one characteristic was not addressed

compute treatment efficacy to measure the average effect of the intervention across all studies where the quantitative pooling of results was appropriate. The 95% confidence intervals (CIs) were also calculated to illustrate the reliability of the summary estimate.

The statistical heterogeneity between studies was measured using the I^2 statistic, which quantifies the percentage of variation across studies that is due to heterogeneity rather than chance.[9] If substantial statistical heterogeneity ($I^2 \geq 50\%$) was found for any meta-analysis, attempts were made to explain this heterogeneity by conducting subgroup analyses by study design (i.e. RCTs and observational studies versus RCTs alone) or home telehealth intervention (i.e. HTM versus TS). Because of the limited number of studies in the subgroup analyses ($n < 10$), a meta-regression was not carried out.

Results

The literature search identified 6241 citations. From these, nine original studies (10 references) relating to 858 patients were selected for inclusion (see Figure 1). Reasons for exclusion were inappropriate study design and wrong interventions, comparators, patient population or outcomes.

Study characteristics

Four studies[10–13] compared HTM with UC, and six RCTs[14–19] compared TS with UC. One RCT compared tele-assistance for patients with chronic respiratory failure (including COPD) with patients receiving UC.[13] The patient characteristics, intervention and comparator for each study are summarised in Table 2.

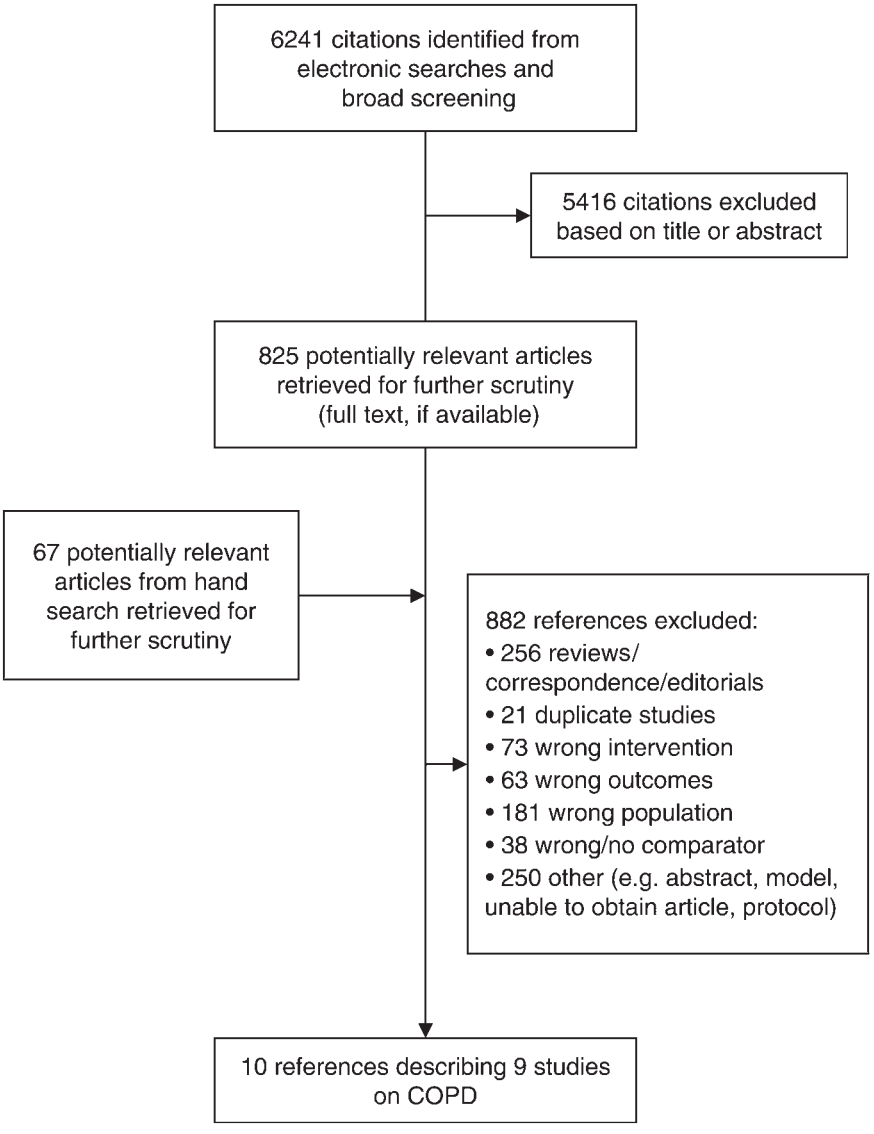

Figure 1 Selection of studies

Table 2 Study and patient baseline characteristics

First author, country of origin, year, design, length of follow-up	Number of centres, sponsor	Comparison arms (patient characteristics)	Description of intervention and comparator
Bourbeau, Canada, 2003, RCT, 12 months[16]	7 centres, industry	Telephone support (n = 96; M/F = 50/46; mean age ± SD = 69.4 ± 6.5; FEV_1 = 46; # of hospital admissions in previous years = 158)	Patients received a weekly telephone call for eight weeks (educational period), then monthly calls for the remainder of the study. Care managers were available by telephone for advice and treatment supervision throughout the study period. Patients continued to receive usual care from their specialists or general practitioners
		Usual care (n = 95; M/F = 56/39; mean age ± SD = 69.6 ± 7.4; FEV_1 = 45; # of hospital admissions in previous years = 152)	Patients received usual care from their specialists or general practitioners
Casas, Spain and Belgium, 2006, RCT, 12 months[17]	2 centres, government	Telephone support (n = 65; M/F = 50/15; mean age ± SD = 70 ± 9; FEV_1 = 43 ± 20; # of hospital admissions in previous years = 1.0 ± 1.3)	Integrated care consisted of: (1) a comprehensive assessment of the patient at discharge; (2) an educational programme on self-management of the disease administered at discharge; (3) agreement on an individual tailored care plan following international guidelines; and (4) accessibility of the specialized nurse to patients/carers and primary care professionals during the follow-up period. Weekly telephone calls during the first month after discharge were carried out to reinforce self-management strategies
		Usual care (n = 90; M/F = 79/11; mean age ± SD = 72 ± 9; FEV_1 = 41 ± 15; # of hospital admissions in previous years = 0.6 ± 1.2)	Patients received usual care from their physicians
de Toledo, Spain, 2006, RCT, 1 year[18]	Centres not reported, government	Telephone support (n = 67; M/F = 65/2; mean age ± SD = 71 ± 8; FEV_1 = 42 ± 20%)	Patients received an educational session and a home visit (24 to 72 hours post-discharge) and had telephone access to a call centre. The care team had access to a central patient management module from any location
		Usual care (n = 90; M/F = 87/3; mean age ± SD = 72 ± 8; FEV_1 = 42 ± 15%)	Patients received education and home visits as needed, but did not have access to the call centre
Egan, Australia, 2002, RCT, 3 months[19]	1 centre, government	Telephone support (n = 33; M/F = 12/21; mean age = 67.2)	The case manager provided education for the patient or caregiver on disease management, available health-care services, arranged discharge planning and ensured that planned outcomes were achieved through telephone calls to the patient or caregiver on a regular basis
		Usual care (n = 33; M/F = 20/13; mean age = 67.8)	Patients received usual care but had no contact with case manager, no case conferences and no post-discharge follow-up
Farrero, Spain, 2001, RCT, 12 months[15]	1 centre, sponsor not reported	Telephone support (n = 60; mean age ± SD = 69 ± 8; FEV_1 = 28 ± 8; # of hospital admissions in previous years = 1.3 ± 1.4)	Patients received a monthly telephone call, home visits every three months, and home or hospital visits on a demand basis
		Usual care (n = 62; mean age ± SD = 69 ± 8; FEV_1 = 27 ± 9; # of hospital admissions in previous years = 1.4 ± 1.6)	Patients received usual care, including an initial visit and one-year visit in the outpatient department
Paré, Canada, 2006, quasi-experimental study, 6 months[10]	1 centre, government	Home telemonitoring (n = 20; M/F = 13/7; mean age =69; O_2 mean dependence =53%)	Patients provided data on peak flow rate, symptoms and medications daily through the Webphone (i.e. a touch screen and modem with a personalized protocol). Data were analysed by the system and reviewed daily by a nurse. Patients and the nurse were then alerted to readings falling outside pre-established limits
		Usual care (n = 10; M/F = 5/5; mean age =72; O_2 mean dependence =50%)	Conventional home care
Trappenburg, Netherlands, 2008, prospective study, 6 months[11]	6 centres, government	Home telemonitoring (n = 59; M/F = 27/32; mean age ± SD = 69 ± 8; FEV_1 = 42 ± 14; # of hospital admissions in previous years = 27)	Patients received usual care plus telemonitoring, provided by the Health Buddy device. Patients answered daily questions that monitored their disease symptoms, medication compliance and knowledge. The patient's responses were sent via telephone line to a data centre and were automatically categorized and prioritized. Respiratory nurses reviewed the patients' answers and provided telemonitoring to the patients
		Usual care (n = 56; M/F = 34/22; mean age ± SD = 70 ± 10; FEV_1 = 39 ± 11; # of hospital admissions in previous years = 16)	Patients received usual care

(*Continued*)

Table 2 (Continued)

First author, country of origin, year, design, length of follow-up	Number of centres, sponsor	Comparison arms (patient characteristics)	Description of intervention and comparator
Vitacca, Italy, 2008, RCT, 12 months[13]	1 centre, sponsor not reported	Home telemonitoring Note: 57 (48%) patients had a COPD diagnosis. Patient characteristics for this subgroup were not provided Usual care Note: 44 (43%) patients had a COPD diagnosis. Patient characteristics for this subgroup were not provided.	Patients had access to a 24 h on-call service and were able to transmit a pulse arterial saturation trace through their home telephone line. Nurses in the tele-assistant programme were available during office hours to provide real-time teleconsultation Outpatient follow-up regimen in patients requiring oxygen therapy or home mechanical ventilation
Vontetsianos, Greece, 2005, pre-post study, pre: 12 months and post: 9 months[12]	Centres not reported, sponsor not reported	Home telemonitoring Note: Patient baseline characteristics apply to both arms (n = 18) Previous 12 months (# of hospital admissions in previous year = 37)	Initial phase: patients created an electronic health record for evaluation by each team member and for self-management identification of exacerbation and anxiety control. Chronic phase: the nurse visited the patient's home to monitor the vital signs and treatment compliance, and transmit data to the hospital. The nurse was also able to communicate with rehabilitation team members Not reported
Wong, China, 2005, RCT, 1 and 3 months[14]	1 centre, sponsor not reported	Telephone support (n = 30; M/F = 27/3; mean age ± SD = 72.8 ± 8.3) Usual care (n = 30; M/F = 20/10; mean age ± SD = 74.4 ± 7.4)	A nurse contacted patients twice (days 3–7 and days 14–20) and was guided by a protocol comprising assessment, management options and evaluation Patients received routine care without telephone follow-up

FEV_1 = Forced expiratory volume in 1 second; O_2 = oxygen

The length of follow-up ranged from three months[14,19] to 19 months.[12] Two studies were from Canada,[10,16] two were from Spain,[15,18] one was from Spain and Belgium,[17] one was from Australia,[19] one was from the Netherlands,[11] one was from Greece,[12] one was from Italy[13] and one was from China[14]. Five studies received funding from the government,[10,11,17–19] one study received funding from industry[16] and four studies did not report their source of funding.[12–16]

The number of participants ranged from 18[12] to 191[16] (median = 101). Participants in all studies had a mean age greater than 60 years, and a mean forced expiratory volume in 1 second (FEV_1) between 27%[15] and 46%.[16] Patients with terminal illness, lung cancer, cognitive impairment, mental illness, language barriers and other major chronic diseases were excluded in most studies.

One study by de Toledo *et al.*,[18] was a subset of the patient population in Casas *et al.*'s study,[17] also included in the systematic review. A quality assessment was conducted for Casas *et al.*'s study.

Quality assessment

In the quality assessment of the four studies on HTM, one was rated A (high quality),[13] one was rated B (good quality),[11] one was rated C (fair to good quality)[10] and one was rated D (poor to fair quality).[12] Two RCTs on TS were rated A (high quality),[16,17] two were rated B[14,15] and one was rated D.[19]

Outcomes

The number of studies and patients for each outcome in our review and whether these outcomes were analyzed using meta-analysis are shown in Table 3. Due to variation in the control arms, study design and reporting of clinical outcomes in some studies, a formal meta-analysis was not attempted. Instead, these studies were described individually.

Number of patients hospitalized

One RCT reported a lower proportion of patients in the TS group who were admitted to a hospital compared with the UC group (46% versus 66%; $P = 0.03$).[18] Another RCT reported a lower proportion of patients in the TS group who were hospitalized at least once compared with the UC group (32% versus 51%; $P = 0.01$).[16]

Number of patients who visited the emergency department

One RCT found that a lower proportion of patients in the TS group visited the emergency department (ED) at least once compared with the usual care group (39/96 versus 60/95; $P = 0.002$).[16]

Mortality

Three RCTs provided data for a meta-analysis on the mortality rate between the TS and UC groups.[15–17] There was a higher risk of mortality in the TS group (Figure 2), although the difference was not significant (RR = 1.21; 95% CI: 0.84 to 1.75). There was no heterogeneity between studies ($I^2 = 0\%$).

Table 3 Details of included studies

Clinical outcomes	Home telehealth intervention	Number of studies	Total number of patients	Pooled outcomes
Number of patients hospitalized	HTM	0	NA	NA
	TS	1[16]	248	Not pooled
Number of patients who visited ED	HTM	0	NA	NA
	TS	1[16]	191	Not pooled
Mortality	HTM	0	NA	NA
	TS	3[15–17]	468	Pooled
Number of hospitalizations	HTM	3[10,11,13]	246	Not pooled
	TS	5[14–17,19]	594	Not pooled
Bed Days of Care	HTM	3[10,11,14]	163	Not pooled
	TS	3[14–16]	373	Not pooled
Number of ED visits	HTM	1[12,18]	18	Not pooled
	TS	3[14–16]	430	Not pooled
Number of primary care visits	HTM	0	NA	NA
	TS	1[16]	191	Not pooled
Number of specialist visits	HTM	0	NA	NA
	TS	1[16]	191	Not pooled
Number of office visits	HTM	1[11]	115	Not pooled
	TS	1[14]	60	Not pooled
Number of home care visits	HTM	1[10]	30	Not pooled
	TS	0	NA	NA

Number of hospitalizations

One RCT[13] reported fewer hospital admissions per month in the HTM group compared with the control group (0.17, SD 0.23 versus 0.30, SD 0.30; $P < 0.019$) and two observational studies[10,11] also found the number of hospitalizations to be lower among patients using HTM versus those receiving usual care ([0.1 and 0.6; measures of variation not reported][10] and [0.65, SD 1.3 and 0.75, SD 1.2; $P < 0.02$]).[11] A lower mean number of hospitalizations per patient was reported in one trial for the TS and UC groups (0.6 versus 1.1; measures of variation not reported[14]).

The heterogeneity among five RCTs comparing the TS group with the UC group was high ($I^2 > 50\%$), so a meta-analysis was deemed inappropriate.[14–17,19] Lower mean numbers of hospitalizations per patient were reported in all trials for TS compared with UC groups (0.96 versus 1.76; measures of variation not reported,[16] 1.5, SD 2.6 versus 2.1, SD 3.1; $P = 0.03$,[17] 2.1 versus 2.6,[19] 0.5, SD 0.86 versus 1.29, SD 1.7; $P = 0.001$,[15] and 0.6 versus 1.1; measures of variation not reported[14]).

Bed days of care

One observational study reported a higher mean number of BDOC in the HTM group than the UC group (13.5 versus 7.3; measures of variation not reported),[10] while two other observational studies reported a lower mean number (6.6, SD 24.0 versus 7.46, SD 19.9; $P < 0.05$[11] and 3.6 versus 17.5; measures of variation not reported[12]).

The heterogeneity among three RCTs that compared the TS group with a UC group was substantial ($I^2 > 50\%$), so a meta-analysis was not appropriate.[14–16] Two RCTs reported a lower mean BDOC in the TS group compared with the UC group (7.2, SD 19.5 versus 12.5, SD 21.2; $P = 0.01$[16]) and (7.4, SD 15.6 versus 18.2, SD 24.6; $P = 0.01$[15]). The other RCT found a slightly higher mean number of BDOC in the TS group compared with the UC group (19.6 versus 17.3; measures of variation not reported).[14]

Number of emergency department visits

One pre-post study on HTM for patients with COPD reported a lower mean number of ED and scheduled visits per patient after the study compared with the baseline (4.8 versus 8.7; measures of variation not reported).[12] One trial reported a lower mean number of ED visits per patient in the TS group compared with the UC group (0.1 versus 0.4; measures of variation not reported).[14]

Because of substantial heterogeneity among four RCTs ($I^2 > 50\%$), a meta-analysis was not conducted.[14–16,18] All trials reported a lower mean number of ED visits per patient in the TS group compared with the UC group (0.36, SD 0.98 versus 0.54, SD 1.12; $P = 0.15$),[18] 1.58 versus 2.47; measures of variation not reported,[16] 0.45, SD 0.83 versus 1.58, SD 1.96; $P = 0.0001$,[15] and 0.1 versus 0.4; measures of variation not reported[14]).

Number of office visits

One observational study found a greater mean number of office visits per patient in the HTM group (3.2, SD 2.2 versus 2.3, SD 1.3; *P* value not reported).[11] One RCT reported a lower mean number of office visits in the TS group compared with the UC group (5.0 versus 6.0; no measures of variation reported).[14]

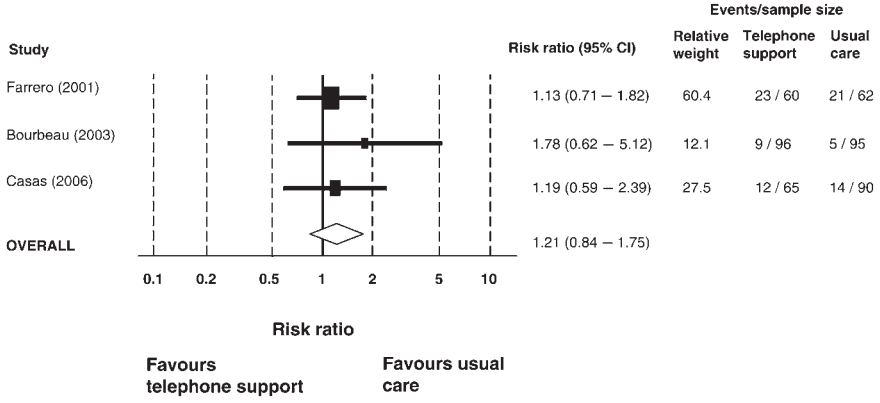

Figure 2 Risk ratio of mortality of COPD patients between telephone support and usual care

Number of primary care visits

One RCT reported a lower mean number of primary care visits per patient in the TS group compared with the UC group (0.48 versus 1.18; measures of variation not reported).[16]

Number of specialist visits

One RCT reported a slightly lower mean number of specialist visits per patient in the TS group compared with the UC group (0.25 versus 0.27; measures of variation not reported).[16]

Number of home care visits

One observational study reported a lower mean number of home care visits per patient in the HTM group compared with the UC group (4.2 versus 7.5; measures of variation not reported).[10] One RCT reported a lower mean number of office visits in the TS group compared with the UC group (5.0 versus 6.0; no measures of variation reported).[14]

Quality of life and patient satisfaction

The QoL outcomes were not pooled as there was variation in the measurement instruments used across studies, e.g. Chronic Respiratory Questionnaire (for QoL), Clinical COPD Questionnaire. Four studies reported QoL or patient satisfaction[11,12,15,16] (see Table 4). No differences between groups in QoL or patient satisfaction were found in two studies,[11,15] and two studies reported that home telehealth improved patients' QoL and satisfaction.[12,16]

Discussion

Nine studies related to home telehealth for COPD were included in our systematic review. The quality of these studies ranged from very high (three RCTs[13,16,17]) to very low (one RCT[19] and one observation study[12]). The available evidence on home telehealth for COPD is, therefore, rather limited.

Home telehealth (HTM and TS) was found to reduce rates of hospitalization and ED visits, while findings for BDOC varied among studies. In contrast, there was a higher mortality rate among patients with COPD using home telehealth, but the number of original studies was few and sample sizes were relatively small (see Table 3). One RCT indicated that the cause of death in most cases was related to COPD exacerbations.[15] Although QoL and patient satisfaction were measured with different instruments, study results were consistent across studies. None of the studies discussed patient adverse events. Home telehealth for COPD can be a costly and labour intensive intervention. The economic impact of home telehealth for chronic disease management, including COPD, has been reported elsewhere.[20]

Clinical heterogeneity was evident in most outcomes of interest primarily due to diverse study populations (e.g. variation in disease severity and age) and study design (RCTs versus observational studies). For example, subjects in observational studies are assigned to an intervention group by a participating physician rather than via a randomized process, thereby increasing the chance of confounding. In addition, there is no double-blind process in observational studies to reduce the risk of a placebo effect.[21] Despite these fundamental differences, one report concluded that the inclusion of observational studies would

Table 4 QOL and patient satisfaction outcomes

Study	Instrument used	Treatment	Data	Conclusions
Bourbeau (2003)[16]	St George's Respiratory Questionnaire for: (1) respiratory symptoms; (2) activities; and (3) impact (a measure of disturbance of daily life, social function and well-being)	Home telemonitoring	Symptoms: 1.8 (−4.2 to 7.8) Activity: 0.6 (−4.2 to 5.3) Impact: −4.7 (−9.5 to 0.01) Total: −2.0 (−5.9 to 1.8)	The impact subscale and total scores were significantly improved in the intervention group, but only the impact subscale showed a significant difference between treatment groups
		Usual care	Symptoms: −4.9 (−8.9 to −0.9) Activity: 0.2 (−3.1 to 3.5) Impact: −1.4 (−4.5 to 1.8) Total: −1.5 (−3.9 to 1.0)	
Farrero (2001)[15]	CRQ for QoL for: (1) dyspnoea; (2) fatigue; (3) emotional fatigue; (4) mastery (how patients cope with their illness)	Telephone support	Data not shown in the study	There was no difference in QoL in any of the four domains between the two groups
		Usual care	Data not shown in the study	
Trappenburg (2008)[11]	Clinical COPD Questionnaire for health-related QoL	Home telemonitoring	Symptom: 2.8 ± 1.2 Functional: 2.9 ± 1.3 Mental: 1.6 ± 1.4 Total: 2.6 ± 1.1	There were no significant changes in the scores at follow-up between groups
		Usual care	Symptom: 3.0 ± 1.2, NS Functional: 3.2 ± 1.5, NS Mental: 1.8 ± 1.5, NS Total: 2.9 ± 1.2, NS	
Vontetsianos (2005)[12]	CRQ for patients' QoL satisfaction	Home telemonitoring	Data not reported in study	There was significant improvement in both patients' QoL and patients' satisfaction
		Pre-home telemonitoring	Data not reported in study	

CRQ = Chronic Respiratory Questionnaire

increase summary estimate precision and might provide valid results.[21] Other factors contributing to clinical heterogeneity include length of follow-up (which ranged from three months[14,19] to 19 months[12]) and interventions (HTM and TS).

The present study had certain limitations. There was an insufficient number of studies ($n < 10$) to measure the potential of publication bias related to clinical and health services utilization outcomes. Nonetheless, the literature search was comprehensive, reducing the risk of reporting bias for outcomes. Several studies did not report patient characteristics that might have affected clinical outcomes and use of health services, such as mechanical ventilation, enrolment in long-term oxygen therapy and participation in rehabilitation sessions. Patients with cognitive impairment, mental illness, a language barrier, no telephone line or computer to transmit data, or a life expectancy of less than one year were excluded from most COPD studies, so the applicability of the study findings for such patient populations may be limited.

Four RCTs that compared home telehealth programmes (combining telephone support, home care visits or an education programme) with UC (consisting of primary care visits, home care visits or an education programme) for patients with COPD were included in the systematic review.[15,16,18,19] As the interventions were a mixture of treatments, it is difficult to determine the effect of TS alone on clinical and health services use outcomes. The outcomes were, however, similar to those in the other studies.

Future research should include more studies of higher methodological quality (e.g. multicentre RCTs) with a longer study period to measure the long-term clinical effectiveness of home telehealth interventions. Studies should also include more diverse patient populations with COPD to increase the external validity of their outcomes, and studies comparing real-time versus asynchronous modalities may provide further information on the best disease management strategy for COPD. Studies should always include clinical outcomes, such as a disease marker or patient QoL to determine if reduced use of health services is a result of limited access to health services versus the need for these services. A common approach to the evaluation of home telehealth would facilitate comparisons of different programmes.

Home care represents a significant component of the chronic disease management model, and home telehealth is an extension of health-care delivery in a patient's home environment. The present review demonstrated that home telehealth is generally clinically effective, and no adverse events were reported in the selected studies. Evidence on the effect of health services utilization was limited. More robust research on home telehealth for COPD is necessary in the future.

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