Susannah McLean, Ulugbek Nurmatov, Joseph LY Liu, Claudia Pagliari, Josip Car and Aziz Sheikh

Telehealthcare for chronic obstructive pulmonary disease:

Cochrane Review and meta-analysis

Abstract

Background
Chronic obstructive pulmonary disease (COPD) is common. Telehealthcare, involving personalised health care over a distance, is seen as having the potential to improve care for people with COPD.

Aim
To systematically review the effectiveness of telehealthcare interventions in COPD to improve clinical and process outcomes.

Design and setting
Cochrane Systematic Review of randomised controlled trials.

Methods
The study involved searching the Cochrane Airways Group Register of Trials, which is derived from the Cochrane Central Register of Controlled Trials, MEDLINE®, embase™, and CINAHL®, as well as searching registers of ongoing and unpublished trials. Randomised controlled trials comparing a telehealthcare intervention with a control intervention in people with a clinical diagnosis of COPD were identified. The main outcomes of interest were quality of life and risk of emergency department visit, hospitalisation, and death. Two authors independently selected trials for inclusion and extracted data. Study quality was assessed using the Cochrane Collaboration's risk of bias method. Meta-analysis was undertaken using fixed effect and/or random effects modelling.

Results
Ten randomised controlled trials were included. Telehealthcare did not improve COPD quality of life: mean difference –6.57 (95% confidence interval [CI] = –13.62 to 0.48). However, there was a significant reduction in the odds ratios (ORs) of emergency department attendance (OR = 0.27; 95% CI = 0.11 to 0.66) and hospitalisation (OR = 0.46; 95% CI = 0.33 to 0.65). There was a non-significant change in the OR of death (OR = 1.05; 95% CI = 0.63 to 1.75).

Conclusion
In COPD, telehealthcare interventions can significantly reduce the risk of emergency department attendance and hospitalisation, but has little effect on the risk of death.

Keywords
COPD; meta-analysis; primary care respiratory; systematic review; telehealth.

INTRODUCTION

At present, there are only a limited number of effective pharmacological interventions for chronic obstructive pulmonary disease (COPD).[1,2] It is against this background that interest in telehealthcare models of care, which involve care for patients from a distance, have captured policy interest. It has been suggested that telehealthcare will help manage the burden of COPD by making health care more efficient,[3] often by incorporating a degree of service redesign.[4]

Telehealthcare is attracting a considerable amount of investment globally; therefore, it is important and timely to scrutinise the evidence for telehealthcare in COPD and to look to resolve uncertainty regarding the effectiveness of such interventions.[5,6] The objective of this study was to systematically review the effectiveness of telehealthcare interventions for people with COPD in improving quality of life and reducing emergency department visits, hospitalisations, and mortality. This report is a synopsis of the recently published Cochrane Review.[7]

METHOD

Participants

Researchers were interested in studies involving participants with clinician-diagnosed COPD. Studies could be based in primary care, secondary care, or intermediate care settings. No exclusions were made on the basis of participants' sex, ethnicity, or language spoken.

Interventions

Miller's conceptualisation of telehealthcare was adapted to define it as 'the provision of personalised health care from a distance'.[8] This definition encapsulates the following key considerations:

- Information is obtained from individual patients; for example, in the form of a symptom score, oxygen saturation level, pulse rate.

- These data are transmitted over a distance by information and communication technology.

- A healthcare professional then exercises their clinical skills and judgement in interpreting this information and actively provides the patient with personalised feedback.

Self-care technologies, self-education, and websites without professional feedback were excluded. This study aimed to concentrate on interventions with an emphasis on 'personalised' or 'tailored' health care. This required a focus on patient–professional interactions enabled

S McLean, MSc, MBBS, MRCGP, PhD student; **U Nurmatov**, MD, PhD, research fellow; **A Sheikh**, FRCGP, MD, professor of primary care research and development, Allergy and Respiratory Research and eHealth Research Groups, Centre for Population Health Sciences, The University of Edinburgh, Edinburgh. **JLY Liu**, BA, PhD, senior research fellow, Dental Health Services Research Unit, The University of Dundee, Scottish Dental Clinical Effectiveness Programme, NHS Education for Scotland, Dundee. **C Pagliari**, BSc, PhD, FRCPE, senior lecturer, eHealth, Centre for Population Health Sciences, University of Edinburgh, Edinburgh. **J Car**, MD, PhD, director of eHealth Unit, Department of Primary Care and Public Health, Imperial College London, London.

Address for correspondence
Susannah McLean, Allergy and Respiratory Research and eHealth Research Groups, Centre for Population Health Sciences, The University of Edinburgh, Edinburgh, EH8 9AG, UK.

E-mail: susannah.mclean@ed.ac.uk

by distance communications technologies. Telehealthcare includes active professional feedback to patients, and excludes passive, automated feedback.[9]

Telehealthcare encompasses both synchronous (for example, telephone, mobile phone) and asynchronous communication modalities (for example, e-mail and text message). The synchronous approaches allow real-time communication between patient and professional, whereas asynchronous approaches enable patient data to be stored in packages and forwarded at specified intervals (for example, once a week) for review by the healthcare professional.

Comparisons

Control groups varied across the different studies in terms of the frequency and intensity of clinical contact provided. Most often, control groups featured 'usual care' although in some instances this included regular face-to-face home visits.

Design

Researchers stipulated that eligible study designs must randomise individuals/groups to the telehealthcare intervention of interest or control.

Outcomes

Data were gathered on a variety of process and clinical outcomes. Primary outcomes of interest were: quality of life scores, the number of patients with one or more emergency department visits over 12 months, the number of patients with one or more hospitalisations over 12 months and numbers of deaths. Other outcomes of interest were patient satisfaction, costs, and forced expiratory volume in 1 second (FEV1).

Protocol

Researchers specified the search strategy, study quality assessment methods, and approaches to synthesising data in a protocol, which was published in the Cochrane Database of Systematic Reviews.[10]

Searching for studies

The study involved searching the Cochrane Airways Group Register of Trials, which is derived from systematic searches of

Figure 1. PRISMA flow diagram showing selection of studies.

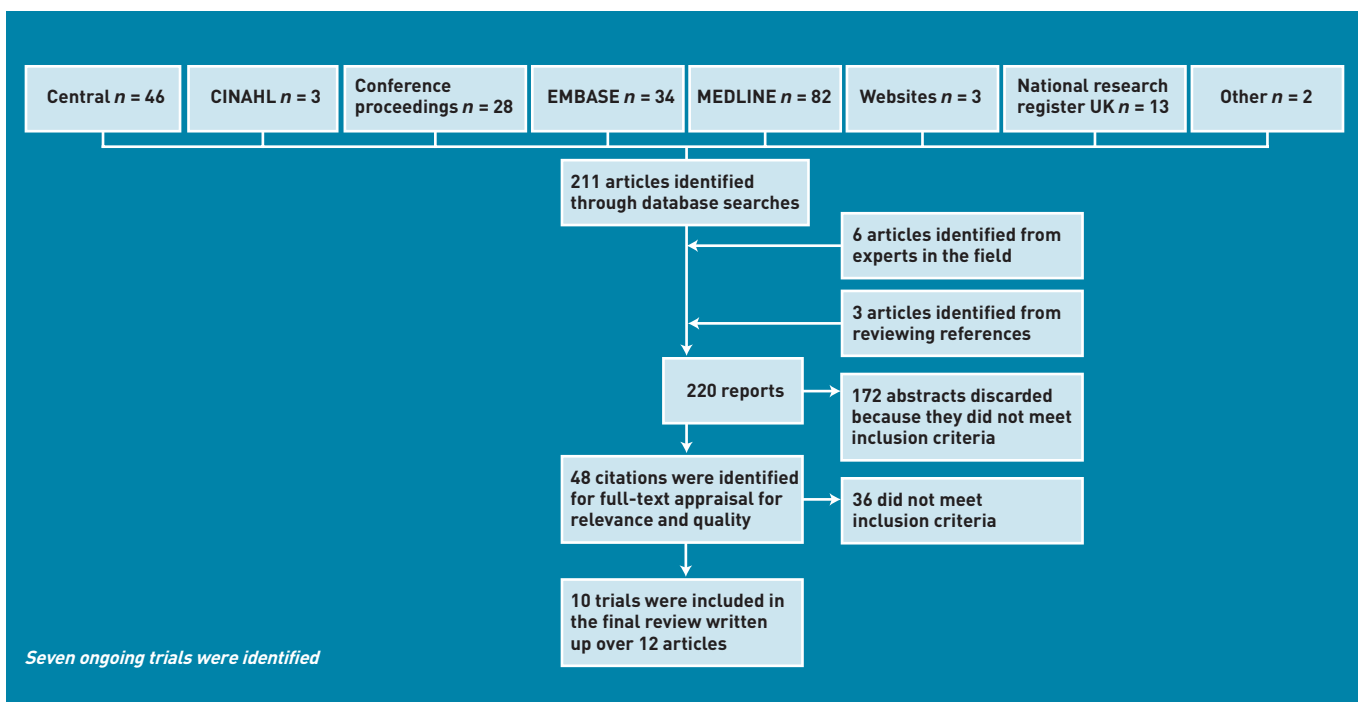
Protocol

Researchers specified the search strategy, study quality assessment methods, and approaches to synthesising data in a protocol, which was published in the Cochrane Database of Systematic Reviews.[10]

Searching for studies

The study involved searching the Cochrane Airways Group Register of Trials, which is derived from systematic searches of

Figure 1. PRISMA flow diagram showing selection of studies.
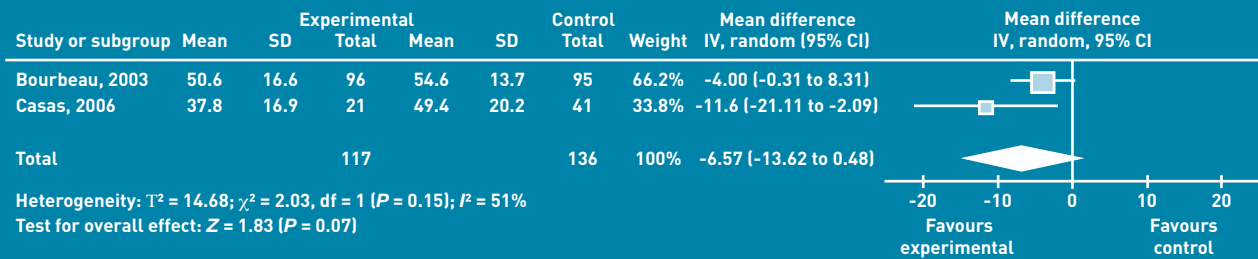
Figure 2. Mean difference between groups at end of 12 months according to St George's Respiratory Questionnaire for COPD-related quality of life. Random effects analysis.

Study or subgroup	Experimental					Control		Weight	Mean difference IV, random (95% CI)
	Mean	SD	Total	Mean	SD	Total			
Bourbeau, 2003	50.6	16.6	96	54.6	13.7	95		66.2%	-4.00 (-0.31 to 8.31)
Casas, 2006	37.8	16.9	21	49.4	20.2	41		33.8%	-11.6 (-21.11 to -2.09)
Total			117			136		100%	-6.57 (-13.62 to 0.48)

Heterogeneity: $T^2 = 14.68$; $\chi^2 = 2.03$, df = 1 ($P = 0.15$); $I^2 = 51\%$
Test for overall effect: $Z = 1.83$ ($P = 0.07$)

bibliographic databases including the Cochrane Central Register of Controlled Trials, MEDLINE®, embase™, Cumulative Index to Nursing and Allied Health Literature (CINAHL®), and other electronic sources. Manual searches of respiratory journals and meetings' abstracts also contribute to the register. All records in the register that had been coded as 'chronic obstructive pulmonary disease' were searched using the telehealthcare terms specified in the search strategy, published by Cochrane.[7]

Researchers contacted the authors of the identified articles and asked them to identify other published and unpublished randomised controlled trials. Authors searched the UK's National Research Register (http://www.nihr.ac.uk/Pages/NRRArchive.aspx). References of the included trials were searched to find further randomised controlled trials; as well as additional registers of ongoing and unpublished trials: ClinicalTrials.gov (www.clinicaltrials.gov), Current Controlled Trials (www.controlled-trials.com), and the Australian New Zealand Clinical Trials Registry (www.anzctr.org.au).

Selection of studies

Using an agreed definition of telehealthcare, two authors screened the titles and abstracts to obtain a list of potentially eligible studies. Researchers obtained full-text copies of these studies and reached

agreement through discussion regarding the final list of studies for inclusion. If agreement could not be reached, a third reviewer arbitrated.

Data extraction

The following data were extracted from the included studies and then independently verified by a second reviewer: country and setting; study design; the number of participants; a description of the telehealthcare intervention; a description of the control group; outcomes assessed and outcome data; proportion of patients with follow-up data; any harms or adverse effects.

Assessment of risk of bias

The study used the approach from *The Cochrane Handbook for Systematic Reviews of Interventions*, section 6[11] to assess the risk of bias in each trial using the following criteria:

- Was the allocation sequence adequately generated? For example, by computer randomisation.
- Was allocation adequately concealed? For example, by sealed envelopes.
- Were the patients and researchers blinded to the allocated interventions?
- Were incomplete outcome data adequately addressed? For example,

Figure 3. Numbers of patients with one or more visits each to the emergency dept over 12 month period of study. Random effects analysis. M-H = Mantel Haenszel odds ratio.
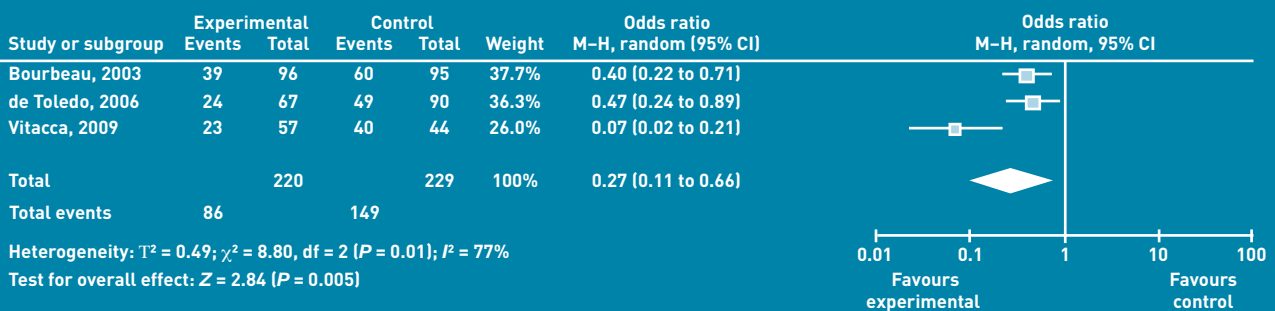

Study or subgroup	Experimental		Control		Weight	Odds ratio M-H, random (95% CI)
	Events	Total	Events	Total		
Bourbeau, 2003	39	96	60	95	37.7%	0.40 (0.22 to 0.71)
de Toledo, 2006	24	67	49	90	36.3%	0.47 (0.24 to 0.89)
Vitacca, 2009	23	57	40	44	26.0%	0.07 (0.02 to 0.21)
Total		220		229	100%	0.27 (0.11 to 0.66)
Total events	86		149			

Heterogeneity: $T^2 = 0.49$; $\chi^2 = 8.80$, df = 2 ($P = 0.01$); $I^2 = 77\%$
Test for overall effect: $Z = 2.84$ ($P = 0.005$)

Table 1. Description of characteristics of included studies

Study, year	Number of participants, country, setting	Intervention studied	Main outcomes of interest
Bourbeau 2003[12]	191 participants, Quebec, Canada, participants were recruited by hospital clinic and were recruited if they had been hospitalised at least once in the preceding year for an acute exacerbation of COPD	COPD self-management programme consisting of 1 hour/week teaching delivered to the patient at home for 7 weeks. Supervised by respiratory nurses. Followed by weekly telephone calls for 8 weeks. Then monthly telephone calls	Medication profile, spirometry, 6-minute walk test, dyspnoea measurements after exercise, quality of life as measured by the SGRQ, healthcare use (emergency department visits, hospitalisations, unscheduled and scheduled general practice, and specialist visits), costs and cost effectiveness
Casas 2006[13] (Garcia-Aymerich 2007[22])	155 participants, Barcelona, Spain, Leuven, Belgium, patients were recruited from two tertiary hospitals immediately following discharge. All patients had been admitted for COPD exacerbation for more than 48 hours	Physical and social assessment and education were delivered with coordination by a case manager working between hospital and primary care. A web-based call centre facilitated coordination and weekly educational phone calls were made for the first month following discharge	Hospital re-admission, quality of life as measured by SGRQ, clinical features of current exacerbation, comorbid conditions, treatment, including concordance and observed skills for inhaling drugs and oxygen, healthcare use, and mortality
Chandler 1990[15]	13 adult patients in Kentucky, US with COPD, asthma, or both who were receiving theophylline from pulmonary medicine outpatients	The intervention group measured their theophylline level at home using a blood spot test, then phoned the clinic for advice on drug dosage	Lung function at each clinic visit, degree of dyspnoea at each clinic visit, night and day coughing, wheezing and breathlessness were measured on visual analogue scales, drug-related adverse events. Patients' health attitudes and beliefs were assessed using the Krantz Health Opinion Survey and the Multidimensional Health Locus of Control
de Toledo 2006[14]	157 participants, in Spain all recruited during their tertiary hospital admission for an exacerbation of COPD	Videoconferencing with patients in their own homes supported by a web-based patient record which also supplied education to patients and professionals. Patients had 24-hour access to the multidisciplinary team via a call centre	Number of readmissions, number of visits to emergency department, mortality, acceptability to professionals, patterns of use, equipment, and communication costs
Finkelstein 2004,[23] 2006[16]	68 participants, in Minnesota, US an unspecified number of whom had COPD, congestive heart failure, or chronic wounds. The study took place between the central site and the home environment, where either the patient, or a carer, had to be physically and cognitively able to use the homecare equipment	Two intervention groups: 1) standard care plus videoconferencing. 2) standard care plus videoconferencing plus physiological monitoring; for example, spirometry for COPD	Termination from home care or loss of eligibility for home care, time to discharge to a higher level of care such as a nursing home or hospital, mortality, morbidity patient perception of telehealthcare (Telemedicine Perception Questionnaire), Patient satisfaction Home Care Client Satisfaction Instrument, quality and clinical usefulness of virtual visits, patient use of services, cost for both subjects and service providers
Johnston 2000[17]	Patients who had been referred for home health care because they suffered from a chronic condition in Sacramento, California, US via a health insurance organisation. 102 intervention patients, 110 control patients. 29 intervention patients had COPD, 19 control patients had COPD, the other patients had congestive heart failure, stroke, cancer, diabetes or needed wound care. All patients were projected to need two or more visits a week	Both groups received routine home health care with face-to-face visits and access to telephone contact. However, the intervention group also had a remote videoconferencing system with equipment for testing cardiopulmonary status. This could provide a virtual visit at any time of day or night	Use of services, costs for inpatient and outpatient services, visits to emergency departments, costs for pharmacy services, clinicians, emergency department visits, inpatient treatment, home healthcare costs and videoconferencing costs, patient compliance with medication regimen, patient knowledge about their illness, patient ability to move towards self care, patient satisfaction survey. Results for patients with COPD were not presented as separate from the other illnesses
Nguyen 2008[18]	50 patients with moderate to severe COPD (all of whom could use the internet) in San Francisco and Seattle US were assigned to either internet-based dyspnoea management (intervention) or face-to-face dyspnoea management (control). Patients were recruited from web and non-web sources, including chest clinic referrals	Internet based dyspnoea management focused on education, skills training and ongoing support and was delivered via a hand-held computer. The control intervention delivered the same content using face-to-face methods	Dyspnoea with activities of daily living and quality of life as measured with the Chronic Respiratory Questionnaire, exercise behaviour, and exercise performance, COPD exacerbations, self-efficacy and social support, and patient satisfaction

...continued

Table 1 continued. Description of characteristics of included studies

Study, year	Number of participants, country, setting	Intervention studied	Main outcomes of interest
Vitacca 2009[19]	240 chronically ill respiratory patients, Lumezzane, Italy all of whom require home oxygen, some were on home mechanical ventilation, 101 had COPD, other reasons for respiratory failure included amyotrophic lateral sclerosis, restrictive chest disease, or other neuromuscular disease. Inclusion criteria: patient had had one hospitalisation for respiratory illness in the previous year. This study was conducted in the home setting	The intervention was a teleassistance programme based on continuous 24-hour on-call service. Patients had pulse oximetry, and modem to transmit through the home telephone line. The teleassistance nurse was available by phone during working hours and out of hours the pulmonologist on duty was contacted	Reduction in hospitalisations, reduction in urgent GP calls, acute emergency department admissions, also costs after paying for set-up of equipment
Whitten 2007[20]	Patients with a diagnosis of COPD and/or congestive heart failure who were prescribed home-healthcare services by their insurer were recruited Michigan, US. Intervention group = 83 patients and control group = 78 patients, The study was conducted in the home setting	Intervention was a combination of traditional face-to-face home health care and virtual telemedicine visits	The Short Form 36, Outcome and Assessment Information Set and patient charts were used to collect outcome data. Qualitative work, in the form of telephone interviews, collected patient perceptions of home telecare services
Wong 2005[21]	60 patients with COPD were recruited from an acute care hospital setting, in Hong Kong. The intervention was post-discharge telephone follow-up	Intervention was post-discharge telephone follow-up provided by an experienced respiratory nurse. Two phone calls were made in the first 4 weeks after discharge from hospital	Self-efficacy (a person with high self efficacy feels more confident about engaging in activities and makes more effort to overcome challenges), as measured by the Chinese Self-Efficacy Scale, number of visits to emergency department, number of hospitalisations, and unscheduled visits by clinicians

COPD = chronic obstructive pulmonary disease. SGRQ = St Georges Respiratory Questionnaire.

were all patient withdrawals accounted for?

- Were study reports free of any suggestion of selective reporting?
- Was the study apparently free of other problems that might cause bias?

Analysis and data synthesis

Summary statistics for primary outcomes were calculated where there were sufficient data to pool outcomes. Mean difference for available quality of life scores were calculated, as well as odds ratios (ORs) for other variables using fixed effect meta-analysis in the absence of significant heterogeneity ($I^2 < 40\%$) and random effects meta-analysis where significant heterogeneity was present. Pooled data were presented graphically as Forest plots. The information that could not be pooled in meta-analysis was narratively summarised.

RESULTS

Searches revealed 220 potentially relevant studies. Following review of titles and abstracts, full text of 48 reports were obtained for appraisal of relevance and quality. Finally, 10 trials were selected,[12–21] published in 12 reports[12–23] (Figure 1) studying a total of 1004 patients.

Description of studies

A summary of the key characteristics of all 10 trials is given in Table 1.[12–21] Some of the studies[14,16,17,20] relied on videoconferencing or telephone communication to set up 'virtual consultations', sometimes in addition to face-to-face consultations. Key outcomes of emergency department visits and hospitalisations were studied across most studies, but only those four studies which investigated a period of 12 months contributed to meta-analysis.[12–14,19]

Risk of bias

A summary of the risk of bias in the included studies can be found in Table 2.

Effectiveness of telehealthcare

Results regarding the effectiveness of the interventions on outcomes from all studies are summarised in Table 3.

Impact on quality of life

Two studies[12,13] reported health-related quality of life using the validated St George's Respiratory Questionnaire (SGRQ). Negative change on this questionnaire's scale indicates improvement; the minimal clinically significant difference in health status is a change of four points.[24] Meta-

| Study or subgroup | Interventions | | Control | | Weight | Odds ratio M–H, fixed, (95% CI) | Odds ratio M–H, fixed, 95% CI |
	Events	Total	Events	Total			
Bourbeau, 2003	31	96	48	95	32.9%	0.47 (0.26 to 0.84)	
Casas, 2006	29	65	60	90	28.0%	0.40 (0.21 to 0.78)	
de Toldedo, 2006	31	67	59	90	27.2%	0.45 (0.24 to 0.86)	
Vitacca, 2009	40	57	35	44	11.9%	0.61 (0.24 to 1.53)	
Total		285		319	100%	0.46 (0.33 to 0.65)	
Total events	131		202				

Heterogeneity: $\chi^2 = 0.50$, df = 3 ($P = 0.92$); $I^2 = 0\%$
Test for overall effect: $Z = 4.49$ ($P<0.001$)
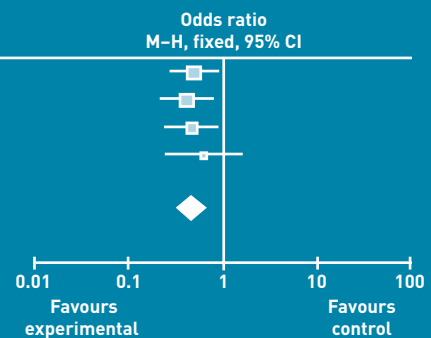
Figure 4. Number of patients with one or more hospitalisations over 12 months. Fixed effects analysis. M-H = Mantel Haenszel odds ratio.

analysis (Figure 2) of these studies revealed a potentially important clinical improvement of −6.57 (95% CI = −13.62 to 0.48), but this pooled estimate was imprecise: the wide 95% CI indicated there was insufficient evidence to demonstrate clear benefit. A third study[18] used the validated Chronic Respiratory Questionnaire (CRQ). Given concerns about the appropriateness of pooling these data with those derived from the SGRQ, it was decided not to include these data in the meta-analysis.[25] After 6 months of this study[18] the difference across the control and intervention group in CRQ scores was not significant.

Emergency department visits

Three studies[12,14,19] reported data on emergency department visits over 12 months. Intervention group patients were significantly less likely to attend the emergency department than patients in the control group: OR 0.27 (95% CI = 0.11 to 0.66; Figure 3).

Hospitalisation

Four studies[12–14,19] reported on hospitalisations. The number of patients with one or more hospital admissions during the 12-month period of follow-up in these trials was significantly lower in the intervention group: OR 0.46 (95% CI = 0.33 to 0.65; Figure 4).

Another study[21] reported that there was insufficient evidence of a difference between telehealthcare follow-up and the control group in hospitalisation rates at 3 months ($P = 0.182$). In addition, one study[16] examined the outcome measure of 'discharge to a higher level of care' (hospital or nursing home), and found that telehealthcare intervention patients were less likely to be discharged to a higher level of care than usual care patients OR 0.29 (95% CI = 0.08 to 1.05), but this result was again imprecisely estimated.

Death

In terms of deaths, the Vitacca *et al* study[19] included data from patients who did not have COPD; however, when stratified for diagnosis, mortality rate did not differ between the two arms of the study. The best estimate comes from a pooled fixed effect meta-analysis which was undertaken with data from three studies[12–14] to give OR 1.05 (95% CI = 0.63 to 1.75), an imprecise estimate close to no effect (Figure 5). The only other study[16] which included deaths reported no statistically significant difference in mortality between the groups; however, raw data were not available for

Figure 5. Deaths over 12 months in the control group and telehealthcare group of the studies. Fixed effects analysis. M-H = Mantel Haenszel odds ratio.

| Study or subgroup | Intervention | | Control | | Weight | Odds ratio M–H, fixed (95% CI) | Odds ratio M–H, fixed, 95% CI |
	Events	Total	Events	Total			
Bourbeau, 2003	5	96	9	95	30.3%	0.53 (0.17 to 1.63)	
Casas, 2006	12	65	14	90	33.9%	1.23 (0.53 to 2.87)	
de Toledo, 2006	14	67	15	90	35.8%	1.32 (0.59 to 2.97)	
Total		228		275	100%	1.05 (0.63 to 1.75)	
Total events	31		38				

Heterogeneity: $\chi^2 = 1.88$, df = 2 ($P = 0.39$); $I^2 = 0\%$
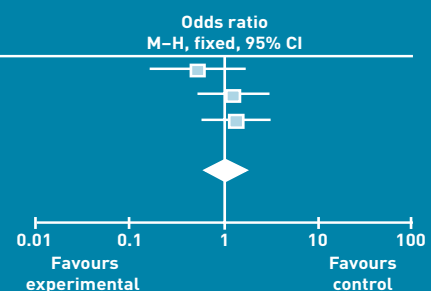Test for overall effect: $Z = 0.18$ ($P = 0.86$)

Table 2. Cochrane risk of bias rating

Study, year	Adequate sequence generation	Allocation concealment	Blinding	Incomplete outcome data addressed?	All outcomes Free of selective reporting	Free of other bias
Bourbeau 2003[12]	+	+	+	+	+	−
Casas 2006[13,29] (Garcia-Aymerich 2007[22])	O	O	−	+	O	−
Chandler 1990[15]	+	O	+	−	−	−
de Toledo 2006[14]	O	O	−	O	+	−
Finkelstein 2004,[23] 2006[16]	O	O	−	−	−	−
Johnston 2000[17]	O	O	−	O	−	−
Nguyen 2008[18]	+	+	−	−	+	+
Vitacca 2009[19]	+	−	−	−	+	−
Whitten 2007[20]	O	O	O	−	+	−
Wong 2005[21]	+	O	+	O	+	+

+ = criterion fulfilled. − = criterion not fulfilled. O = insufficient information.

this study and so these were not included in the meta-analysis.

Other outcomes

Exacerbations. Only the Bourbeau *et al*[12] study recorded the total number of exacerbations of COPD. Over the 12 months of follow-up, there were 362 exacerbations in the control group (n = 95) and 299 exacerbations in the intervention group (n = 95). The between group difference was significant, favouring intervention: relative risk 0.83 (95% CI = 0.74 to 0.92).

Secondary outcomes. Patient satisfaction data showed that patients were largely satisfied with telehealthcare as long as they could have a face-to-face consultation on request. FEV1 was recorded in two studies and did not show a significantly different increase from start of trial to trial end across the two arms of the trials.

DISCUSSION

Summary
There was consistent evidence that the numbers of visits to the emergency department and also the number of hospitalisations were significantly reduced with telehealthcare over 12 months. In terms of quality of life, the evidence was inconclusive as the confidence intervals were wide.[12–14,18] There was evidence of almost no effect on the OR of mortality.

Strengths and limitations
The main strength of this review is its broad search strategy designed with the Cochrane Airways Group to identify 10 completed and seven ongoing relevant trials. The definition of telehealthcare used was conceptual and consistently applied: all included studies thus featured an interaction with a healthcare professional providing personalised feedback over a distance.

It can be challenging to decide whether or not to synthesise data quantitatively and, on balance, researchers thought it appropriate because the intervention approach that was being investigated; that is, facilitating personalised care from a distance was conceptually coherent thus making comparisons logical and consistent. An alternative approach would be to organise a series of reviews focusing on distinct technologies, but this was not the aim of the current study as, given that technologies are rapidly evolving and continually emerging, this would necessitate undertaking many separate reviews. Another potential limitation includes the possibility that the study did not uncover all relevant research.

Comparisons with literature
It is relevant to consider the meta-analysis in the Polisena *et al*[6] review, where there is a transposition of the deaths in the Bourbeau *et al*[12] study between the intervention and control groups which has a major impact on the mortality meta-analysis. Researchers of the current study have informed the authors of this. In addition, Polisena *et al*[6] did not limit inclusion criteria to only randomised controlled trials and so there is a risk of bias from less methodologically rigorous studies.

A recent review by Bolton *et al*[8] concentrated on telemonitoring in COPD and included interventions without the same degree of healthcare professional

Table 3. Results from the 10 included trials

Study, year	Quality of life	Emergency department visits	Hospitalisations	Deaths	Drop outs	Patient satisfaction	Costs	Other outcomes
Bourbeau 2003[12]	On the SGRQ, QoL life improved with mean difference, −4.00 (95% CI = −8.31 to 0.31) where negative change is improving	There were fewer emergency department visits for the intervention group with an OR of 0.40 in comparison with the control group	There were fewer hospitalisations for the intervention group with an OR of 0.47 in comparison with the control group	There were 5 deaths out of 96 patients among the intervention group and 9 deaths out of 95 patients in the control group. OR 0.53 (95% CI = 0.17 to 1.63)	26 patients dropped out after randomisation, 1 was lost to follow up, and 11 found the burden of evaluation to be too great		Total per-patient cost of self management was US$3778: mostly accounted for by the case manager's salary. Each case manager supervised 14 patients and there was no significant difference between costs for the two arms	The differences from baseline lung function across the groups were not significantly different for either of the measures of FEV1 or FVC
Casas 2006[13,29] (Garcia-Aymerich 2007[22])	On SRGQ, QoL improved with mean difference −11.60 (95% CI = −21.11 to −2.09)		There were fewer hospitalisations for the intervention group with an OR of 0.40 in comparison with the control group	There were 12 deaths out of 65 patients in the intervention group and 14 deaths out of 90 patients in the control group. OR 1.23 (0.46 to 1.75)	After randomisation 35 patients were excluded from the trial = 35%: 26 deaths, 2 cases of cancer, 3 changed address, and 4 patients moved to palliative care			Differences from baseline lung function increased more in the usual care group but not significantly ($P = 0.6$)
Chandler 1990[15]			No hospitalisations		2 patients due to moving and financial reasons	No comparisons were statistically significant between the groups	Home theophylline measuring kit (Acculevel) cost US$15, (1990) in comparison with routine measurement (>US$30) or physician visit (>US$25), other costs to be calculated include: clinician time, follow-ups visits and long-distance telephone calls	Symptomology was measured by visual analogue scale, there was no significant difference between groups. FEV1 decreased by a greater amount over the study in the control group ($P > 0.05$)
de Toledo 2006[14]		Significant reduction in emergency department attendance OR 0.47 (95% CI = 0.24 to 0.89)	Significant reduction in hospitalisations OR 0.50 (0.29 to 0.85)	No significant difference in deaths. 14 patients died in the intervention group of 67 and 15 patients died in the control group of 90			Cost of the equipment: €36,469, cost of communications: €1656, 1 day hospitalisation for COPD costs €220. The reduction in hospitalisations will pay for the system by 1 year. 157 patients	
Finkelstein 2004,[23] 2006[16]				No statistically significant difference in mortality across the groups		Home care client satisfaction instrument scores were significantly higher for patients who had experienced virtual visits	Breakdown of costs according to type of interaction. Virtual visits cost an average US$22.11, monitoring visits, US$33.11; and face-to-face visits, US$48.27 due to nurse and travel time	Discharge to a higher level of care (nursing home or hospital): 42% of control participants, 21.4% of video care participants and 15% of telemonitoring participants

Table 3 continued. Results from the 10 included trials

Study, year	Quality of life	Emergency	Hospitalisations department visits	Deaths	Drop outs	Patient satisfaction	Costs	Other outcomes
Johnston 2000[17]		Reported that mean number of visits per patient was 1.79 for intervention patients and control patients 1.53		Results are not given separately for different conditions		Over 95% of both groups said that they agreed or strongly agreed with statements made pertaining to patient satisfaction. There was no difference between the groups	Total mean cost of patients in the control group was US$2674 (standard deviation [SD] 6313) and in the intervention group US$1948 (SD 3681) note large SDs	
Nguyen 2008[18]	Groups were compared using the Chronic Respiratory Questionnaire	Only one patient attended the emergency department			50 patients were randomised, 39 remained after 6 months, 5 control patients dropped out, 7 intervention patients 4 of whom were unable to access the website	Satisfaction scores for both arms were similar: 2.7 and 2.6.		
Vitacca 2009[19]		Marked reduction in emergency department visit in intervention arm OR 0.07 [95% CI = 0.02 to 0.21]	Reduction in hospitalisations, however CIs cross the line of no-effect OR 0.61 [95% CI = 0.24 to 1.53]	No significant difference for deaths (COPD deaths are not reported separately)	111 patients were excluded because of reduced cognitive status, insufficient family cultural requisites or refusal		ICU admission accounted for almost 50% of the total costs of hospitalisation in both groups. Mean overall cost per COPD intervention patient was more than 50% cheaper than for the control group	COPD patients and tracheostomised patients requested the most assistance for ventilation. Fewer exacerbations were experienced by patients using teleassistance
Whitten 2007[20]						Interviews were conducted with 49 patients who were overall very satisfied with the telehealthcare programme.		Data of patients with COPD and CHF were analysed together
Wong 2005[21]		There was a greater mean number of visits per patient in the control group: OR 0.17	There was no significant difference between the telephone and the control group in hospitalisation rates at 3 months $P = 0.182$		4 patients refused to answer the second wave of questions and had their answers replaced by the group mean			

CHF = chronic heart failure. COPD = chronic obstructive pulmonary disease. CRQ = Chronic Respiratory Questionnaire. FEV1 = forced expiratory volume in 1 second. FVC = forced vital capacity. ICU = intensive care unit. OR = odds ratio. QoL = quality of life. RR = relative risk. SGRQ = St George's Respiratory Questionnaire. US$ = United States dollars. € = Euros.

interaction that formed part of the inclusion criteria in the current study. They included both randomised and non-randomised studies which introduces a high risk of bias. They found only two randomised controlled trials, one of which was included in this study[19] and the other trialled a self-management intervention[27] which was excluded.

Implications for research and practice

Telehealthcare research for COPD needs to involve large scale trials with rigorous cost-effectiveness assessments built in. In this context, the full report of the results of the Whole System Demonstrator Project is eagerly awaited.[28] Telehealthcare aims to keep those with COPD out of emergency departments and hospital. However, such a change may result in unintended consequences. For example, reducing the intensity of the care of such patients may be expected to impact unfavourably on the death rate. However, almost no evidence of this was found in the current meta-analysis ($n = 503$).

More qualitative research is also needed to help understand why particular interventions are (or are not) successful. Telecommunications technology should only be one element of the delivery of a substantially enhanced package of integrated chronic illness care.[4] Successful interventions involve the provision of tailored and timely information to the individual. Personalised feedback from a healthcare professional is important. The telehealthcare models adopted in these studies often involved a mix of face-to-face and 'virtual' consultations with a specialist nurse or physiotherapist who had additional training in the management of COPD and who used a variety of techniques including early intervention, breathing exercises, and other elements of pulmonary rehabilitation to maintain patients' health.

There has been much recent optimism regarding the potential for telehealthcare to reduce the cost of health care in patients with COPD. Although largely consistent, the studies in the review are small, with follow-up to only 12 months. Nonetheless, these data do indicate that telehealthcare-based models of COPD care can significantly reduce emergency department attendance and hospitalisation. The best evidence for telehealthcare involves redesigning the care pathway into a personalised interaction across a distance to deliver feedback from a healthcare professional in response to specific patient data. These benefits are still to be demonstrated when telehealthcare is implemented routinely on a larger scale.

Discuss this article

Contribute and read comments about this article on the Discussion Forum: http://www.rcgp.org.uk/bjgp-discuss

REFERENCES

1. Qaseem A, Snow V, Shekelle P, *et al*. Diagnosis and management of stable chronic obstructive pulmonary disease: a clinical practice guideline from the American College of Physicians. *Ann Intern Med* 2007; **147(9):** 633–638.

2. National Clinical Guideline Centre. *Chronic obstructive pulmonary disease: management of chronic obstructive pulmonary disease in adults in primary and secondary care*. London: NICE, 2010.

3. Darzi A. *High quality care for all: NHS next stage review final report*. London: Department of Health, 2008. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_085825 (accessed 24 Sep 2012).

4. McLean S, Sheikh A. Does telehealthcare offer a patient-centred way forward for the community-based management of long-term respiratory disease? *Prim Care Respir J* 2009; **18(3):** 125–126.

5. Whitten PS, Mair FS, Haycox A, *et al*. Systematic review of cost effectiveness studies of telemedicine interventions. *BMJ* 2002; **324(7351):** 1434–1437.

6. McKinstry B, Pinnock H, Sheikh A. Telemedicine for management of patients with COPD? *Lancet* 2009; **374(9691):** 672–673.

7. McLean S, Nurmatov U, Liu JLY, *et al*. Telehealthcare for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2011; **(7):** CD007718.

8. Miller EA. Solving the disjuncture between research and practice, telehealth trends in the 21st Century. *Health Policy* 2007; **82(2):** 133–141.

9. Bolton CE, Waters CS, Peirce S, Elwyn G. Insufficient evidence of benefit: a systematic review of home telemonitoring for COPD. *J Eval Clin Pract* 2011; **17(6):** 1216–1222.

10. McLean S, Nurmatov U, Liu JL, *et al*. Telehealthcare for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2011; **(7):** CD007718.

11. Higgins J, Green S. *Cochrane handbook for systematic reviews of interventions*. Version 5.1.0 edn. Oxford: The Cochrane Collaboration, 2011.

12. Bourbeau J, Julien M, Maltais F, *et al*. Reduction of hospital utilization in patients with chronic obstructive pulmonary disease: a disease-specific self-management intervention. *Arch Intern Med* 2003; **163(5):** 585–591.

13. Casas A, Troosters T, Garcia-Aymerich J, *et al*. Integrated care prevents hospitalisations for exacerbations in COPD patients. *Eur Respir J* 2006; **28(1):** 123–130.

14. de Toledo P, Jimenez S, Pozo F, *et al*. Telemedicine experience for chronic care in COPD. *IEEE Trans Inf Technol Biomed* 2006; **10(3):** 567–573.

15. Chandler MH, Clifton GD, Louis BA, *et al*. Home monitoring of theophylline levels: a novel therapeutic approach. *Pharmacotherapy* 1990; **10(4):** 294–300.

16. Finkelstein SM, Speedie SM, Potthoff S. Home telehealth improves clinical outcomes at lower cost for home healthcare. Telemed J E Health 2006; **12(2):** 128–136.

17. Johnston B, Wheeler L, Deuser J, Sousa KH. Outcomes of the Kaiser Permanente Tele-Home Health Research Project. *Arch Fam Med* 2000; **9(1):** 40–45.

18. Nguyen HQ, Donesky-Cuenco D, Wolpin S, *et al*. Randomized controlled trial of an internet-based versus face-to-face dyspnea self-management program for patients with chronic obstructive pulmonary disease: pilot study. *J Med Internet Res* 2008; **10(2):** e9.

19. Vitacca M, Bianchi L, Guerra A, *et al*. Tele-assistance in chronic respiratory failure patients: a randomised clinical trial. *Eur Respir J* 2009; **33(2):** 411–418.

20. Whitten P, Mickus M. Home telecare for COPD/CHF patients: outcomes and perceptions. *J Telemed Telecare* 2007; **13(2):** 69–73.

21. Wong KW, Wong FKY, Chan MF. Effects of nurse-initiated telephone follow-up on self-efficacy among patients with chronic obstructive pulmonary disease. *J Adv Nurs* 2005; **49(2):** 210–222.

22. Garcia-Aymerich J, Hernandez C, Alonso A, *et al*. Effects of an integrated care intervention on risk factors of COPD readmission. *Respir Med* 2007; **101(7):** 1462–1469.

23. Finkelstein SM, Speedie SM, Demiris G, *et al*. Telehomecare: quality, perception, satisfaction. *Telemed J E Health* 2004; **10(2):** 122–128.

24. Hajiro T, Nishimura K. Minimal clinically significant difference in health status: the thorny path of health status measures? *Eur Respir J* 2002; **19(3):** 390–391.

25. Puhan MA, Soesilo I, Guyatt GH, Schunemann HJ. Combining scores from different patient reported outcome measures in meta-analyses: when is it justified? *Health Qual Life Outcomes* 2006; **4:** 94.

26. Polisena J, Tran K, Cimon K, *et al*. Home telehealth for chronic obstructive pulmonary disease: a systematic review and meta-analysis. *J Telemed Telecare* 2010; **16(3):** 120–127.

27. Koff PB, Jones RH, Cashman JM, *et al*. Proactive integrated care improves quality of life in patients with COPD. *Eur Respir J* 2009; **33(5):** 1031–1038.

28. Department of Health. *Whole system demonstrator project*. London: DoH, 2008.

29. Bourbeau J, Bartlett S. Patient adherence in COPD. *Thorax* 2008; **63(9):** 831–838.