Telehealthcare for chronic obstructive pulmonary disease: a Cochrane Review and meta-analysis

INTRODUCTION
At present, there are only a limited number of effective pharmacological interventions for chronic obstructive pulmonary disease (COPD). It is against this background that interest in telehealthcare models of care, which involve care for patients at 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, often by incorporating a degree of service redesign.

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.

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.

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’. 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 by information and communication technologies.

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 included. 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 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 and hospitalisation, but not significantly reduce the risk of emergency department attendance and hospitalisation, but not significantly reduce the risk of hospitalisation, and mortality. This report is a synopsis of the recently published Cochrane Review.

S McLean, MSc, MBBS, MRCP, PhD student; U Nurmatov, MD, PhD, research fellow; A Sheikh, FRCP, 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, FRCP, 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 Submitted: 3 February 2012; Editor’s response: 8 March 2012; final acceptance: 1 May 2012. ©British Journal of General Practice

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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 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 included. 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 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 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 1.73).

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

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

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How this fits in

Chronic obstructive pulmonary disease (COPD) is increasingly common and now poses a substantial health problem in many parts of the world. Governments and industry are optimistic that telehealthcare will help manage the care burden of these people. This study found consistent evidence that telehealthcare helps people with COPD stay out of emergency departments and hospitals. Telehealthcare did not appear to affect the death rate or patients’ quality of life.

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

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.](image-url)
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,
Table 1. Description of characteristics of included studies

<table>
<thead>
<tr>
<th>Study, year</th>
<th>Number of participants, country, setting</th>
<th>Intervention studied</th>
<th>Main outcomes of interest</th>
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<tbody>
<tr>
<td>Bourbeau 2003</td>
<td>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</td>
<td>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 were made for the first month following discharge.</td>
<td>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</td>
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<tr>
<td>Casas 2006</td>
<td>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.</td>
<td>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.</td>
<td>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</td>
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<tr>
<td>Chandler 1990</td>
<td>13 adult patients in Kentucky, US with COPD, asthma, or both who were receiving theophylline from pulmonary medicine outpatient</td>
<td>The intervention group measured their theophylline level at home using a blood spot test, then phoned the clinic for advice on drug dosage.</td>
<td>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</td>
</tr>
<tr>
<td>de Toledo 2006</td>
<td>157 participants, in Spain all recruited during their tertiary hospital admission for an exacerbation of COPD</td>
<td>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.</td>
<td>Number of readmissions, number of visits to emergency department, mortality, acceptability to professionals, patterns of use, equipment, and communication costs</td>
</tr>
<tr>
<td>Finkelstein 2004, 2006</td>
<td>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.</td>
<td>Two intervention groups: 1) standard care plus videoconferencing. 2) standard care plus videoconferencing plus physiological monitoring; for example, spirometry for COPD.</td>
<td>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</td>
</tr>
<tr>
<td>Johnston 2000</td>
<td>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.</td>
<td>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.</td>
<td>Use of services, costs for inpatient and outpatient services, visits to emergency departments, costs for pharmacy services, clinic care, 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</td>
</tr>
<tr>
<td>Nguyen 2008</td>
<td>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.</td>
<td>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.</td>
<td>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</td>
</tr>
</tbody>
</table>

... continued
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, 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 studies13,14,17,20 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 studies12,13 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
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\textsuperscript{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.

After 6 months of this study\textsuperscript{18} the difference across the control and intervention group in CRQ scores was not significant.

Emergency department visits

Three studies\textsuperscript{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\textsuperscript{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\textsuperscript{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\textsuperscript{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 \textit{et al} study\textsuperscript{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\textsuperscript{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\textsuperscript{16} which included deaths reported no statistically significant difference in mortality between the groups; however, raw data were not available for British Journal of General Practice, November 2012 e742
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.26 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.26 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.9 concentrated on telemonitoring in COPD and included interventions without the same degree of healthcare professional

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Table 2. Cochrane risk of bias rating

<table>
<thead>
<tr>
<th>Study, year</th>
<th>Adequate sequence generation</th>
<th>Allocation concealment</th>
<th>Blinding</th>
<th>Incomplete outcome data addressed?</th>
<th>All outcomes Free of selective reporting</th>
<th>Free of other bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bourbeau 200312</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Casas 200613,29</td>
<td>0</td>
<td>0</td>
<td>–</td>
<td>+</td>
<td>0</td>
<td>–</td>
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<tr>
<td>Garcia-Aymerich 200722</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Chandler 199015</td>
<td>+</td>
<td>O</td>
<td>+</td>
<td></td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>de Toledo 200416</td>
<td>0</td>
<td>0</td>
<td>–</td>
<td>0</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Finkelstein 2004,23,200616</td>
<td>0</td>
<td>0</td>
<td>–</td>
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<tr>
<td>Johnston 200017</td>
<td>0</td>
<td>0</td>
<td>–</td>
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<td>–</td>
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<tr>
<td>Nguyen 200818</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Vitacca 200919</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
<td>Whitten 200720</td>
<td>0</td>
<td>0</td>
<td>O</td>
<td></td>
<td>+</td>
<td>–</td>
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<tr>
<td>Wong 200521</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>+</td>
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</tbody>
</table>

+ = criterion fulfilled. – = criterion not fulfilled. O = insufficient information.
### Table 3. Results from the 10 included trials

<table>
<thead>
<tr>
<th>Study, year</th>
<th>Quality of life</th>
<th>Emergency department visits</th>
<th>Hospitalisations</th>
<th>Deaths</th>
<th>Dropouts</th>
<th>Patient satisfaction</th>
<th>Costs</th>
<th>Other outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bourbeau 2003&lt;sup&gt;12&lt;/sup&gt;</td>
<td>On the SGRQ, QoL life improved with mean difference, –4.00 (95% CI = –8.31 to 0.31) where negative change is improving</td>
<td>There were fewer emergency department visits for the intervention group with an OR of 0.40 in comparison with the control group</td>
<td>There were fewer hospitalisations for the intervention group with an OR of 0.67 in comparison with the control group</td>
<td>There were 5 deaths out of 95 patients in the control group, OR 0.53 (95% CI = 0.17 to 1.63)</td>
<td>26 patients dropped out after randomisation, 1 was lost to follow up, and 11 found the burden of evaluation to be too great</td>
<td>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</td>
<td>The differences from baseline lung function across the groups were not significantly different for either of the measures of FEV1 or FVC</td>
<td></td>
</tr>
<tr>
<td>Casas 2006&lt;sup&gt;13,22&lt;/sup&gt; (Garcia-Aymerich 2007)&lt;sup&gt;21&lt;/sup&gt;</td>
<td>On SGRQ, QoL improved with mean difference –11.60 (95% CI = –21.11 to –2.09)</td>
<td>There were fewer hospitalisations for the intervention group with an OR of 0.40 in comparison with the control group</td>
<td>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 (0.66 to 1.75)</td>
<td>Differences from baseline lung function increased more in the usual care group but not significantly (P&lt;0.05)</td>
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<tr>
<td>Chandler 1990&lt;sup&gt;15&lt;/sup&gt;</td>
<td>No hospitalisations</td>
<td>No comparisons</td>
<td>2 patients due to moving and financial reasons</td>
<td>No comparisons were statistically significant between the groups</td>
<td>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-up visits and long-distance telephone calls</td>
<td>Differences from baseline lung function increased more in the usual care group but not significantly (P&lt;0.05)</td>
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<tr>
<td>de Toledo 2006&lt;sup&gt;14&lt;/sup&gt;</td>
<td>Significant reduction in emergency department attendance OR 0.47 (95% CI = 0.24 to 0.89)</td>
<td>Significant reduction in hospitalisations OR 0.50 (0.29 to 0.85)</td>
<td>No significant difference in deaths. 14 patients died in the intervention group of 67 and 15 patients died in the control group of 90</td>
<td>Cost of the equipment: €36,649, 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</td>
<td>Discharge to a higher level of care (nursing home or hospital); 42% of control participants, 21.4% of video care participants and 19% of telemonitoring participants</td>
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<tr>
<td>Finkelstein 2004&lt;sup&gt;23&lt;/sup&gt; 2006&lt;sup&gt;24&lt;/sup&gt;</td>
<td>No statistically significant difference in mortality across the groups</td>
<td>No statistically significant difference in mortality across the groups</td>
<td>No significant difference in hospitalisations</td>
<td>No significant difference 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</td>
<td>Home care client satisfaction instrument scores were significantly higher for patients who had experienced virtual visits</td>
<td>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</td>
<td>Discharge to a higher level of care (nursing home or hospital); 42% of control participants, 21.4% of video care participants and 19% of telemonitoring participants</td>
<td></td>
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<tr>
<td>Study, year</td>
<td>Quality of life</td>
<td>Emergency</td>
<td>Hospitalisations department visits</td>
<td>Deaths</td>
<td>Drop outs</td>
<td>Patient satisfaction</td>
<td>Costs</td>
<td>Other outcomes</td>
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<tr>
<td>Johnston 2000&lt;sup&gt;17&lt;/sup&gt;</td>
<td></td>
<td></td>
<td>Reported that mean number of visits per patient was 1.79 for intervention patients and control patients 1.53</td>
<td>Results are not given separately for different conditions</td>
<td>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</td>
<td></td>
<td>Total mean cost of patients in the control group was US$1948 (SD 3681), note large SDs</td>
<td></td>
</tr>
<tr>
<td>Nguyen 2008&lt;sup&gt;18&lt;/sup&gt;</td>
<td>Groups were compared using the Chronic Respiratory Questionnaire</td>
<td></td>
<td>Only one patient attended the emergency department</td>
<td></td>
<td>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</td>
<td>Satisfaction scores for both arms were similar: 2.7 and 2.6.</td>
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<tr>
<td>Vitacca 2009&lt;sup&gt;19&lt;/sup&gt;</td>
<td>Marked reduction in emergency department visit in intervention arm OR 0.07 (95% CI = 0.02 to 0.21)</td>
<td>Reduction in hospitalisations, however CIs cross the line of no-effect OR 0.61 (95% CI = 0.24 to 1.53)</td>
<td>No significant difference for deaths (COPD deaths are not reported separately)</td>
<td>111 patients were excluded because of reduced cognitive status, insufficient family cultural requisites or refusal</td>
<td>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</td>
<td></td>
<td>COPD patients and tracheostomised patients requested the most assistance for ventilation. Fewer exacerbations were experienced by patients using teleassistance</td>
<td></td>
</tr>
<tr>
<td>Whitten 2007&lt;sup&gt;20&lt;/sup&gt;</td>
<td>There was a greater mean number of visits per patient in the control group: OR 0.17</td>
<td>There was no significant difference between the telephone and the control group in hospitalisation rates at 3 months (P = 0.182)</td>
<td></td>
<td></td>
<td>Interviews were conducted with 49 patients who were overall very satisfied with the telehealthcare programme.</td>
<td></td>
<td>Data of patients with COPD and CHF were analysed together</td>
<td></td>
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<tr>
<td>Wong 2005&lt;sup&gt;21&lt;/sup&gt;</td>
<td></td>
<td></td>
<td>4 patients refused to answer the second wave of questions and had their answers replaced by the group mean</td>
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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 study17 and the other trialled a self-management intervention27 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.

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