

Use, utility and methods of telehealth for patients with COPD in England and Wales: a healthcare provider survey

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ABSTRACT

Introduction Although the effectiveness of domiciliary monitoring (telehealth) to improve outcomes in chronic obstructive pulmonary disease (COPD) is controversial, it is being used in the National Health Service (NHS).

Aim To explore the use of telehealth for COPD across England and Wales, to assess the perceptions of clinicians employing telehealth in COPD and to summarise the techniques that have been used by healthcare providers to personalise alarm limits for patients with COPD enrolled in telehealth programmes.

Methods A cross-sectional survey consisting of 14 questions was sent to 230 COPD community services in England and Wales. Questions were designed to cover five aspects of telehealth in COPD: purpose of use, equipment type, clinician perceptions, variables monitored and personalisation of alarm limits.

Results 65 participants completed the survey from 52 different NHS Trusts. 46% of Trusts had used telehealth for COPD, and currently, 31% still provided telehealth services to patients with COPD. Telehealth is most commonly used for baseline monitoring and to allow early detection of exacerbations, with 54% believing it to be effective. The three most commonly monitored variables were oxygen saturation, heart rate and breathlessness. A variety of methods were used to set alarm limits with the majority of respondents believing that at least 40% of alarms were false.

Conclusion Around one-third of responded community COPD services are using telehealth, believing it to be effective without robust evidence, with a variety of variables monitored, a variety of hardware and varying techniques to set alarm limits with high false alarm frequencies.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) imposes a global burden on individuals and healthcare systems. COPD is defined as ‘a common, preventable and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases.’¹ According to the British Lung Foundation, 1.2 million individuals are diagnosed with COPD in the

Key messages

- What is the extent of telehealth use in chronic obstructive pulmonary disease (COPD) across National Health Service England and Wales, and which techniques are used by healthcare providers when setting telehealth alarm limits?
- Around one-third of COPD services who responded to our survey were using telehealth, believing it to be effective despite the absence of robust evidence, and using a variety of methods to personalise telehealth alarm limits.
- This is the first study to report on methods used to specify telehealth alarm limits in patients with COPD across England and Wales, and to examine for what purposes the service was provided.

UK and there are many more undiagnosed—the ‘missing millions’.^{2,3} Snell *et al* reported that 29 776 patients died because of COPD in 2012, which makes it the fifth leading cause of death in the UK.^{2,3} The annual direct cost of COPD is reported to be nearly £1 billion with more than 1 million bed-days, and 140 000 hospital admissions annually.² Much of the morbidity, mortality and healthcare cost relates to exacerbations.

These aforementioned data make prompt intervention to reduce the burden of COPD imperative, particularly mitigation of exacerbations. Studies have shown that COPD outcomes can be improved with various interventions including smoking cessation, pulmonary rehabilitation, influenza vaccine, pharmacotherapy and lung volume reduction.^{1–6} Patients susceptible to frequent exacerbations experience poorer outcomes and excess healthcare cost.^{7–9}

For exacerbations that do occur, facilitating prompt access to therapy is important since there is some evidence to suggest that early therapy may be associated with more rapid resolution of symptoms and reduced risk of hospitalisation¹⁰—though this has never

been documented as a primary outcome in a rigorous randomised controlled study.

Supporting people living with COPD to maintain respiratory health, and to access care at the time of exacerbation remains a challenge. One approach that may facilitate the management of COPD is telehealth.^{11 12} Telehealth has been defined by the Telehealth Quality Group as ‘*the means by which technologies and related services concerned with health and well-being are accessed by people or provided for them irrespective of their location.*’¹³ Telehealth for COPD could be used for various purposes such as symptom monitoring, exacerbation detection, reinforcement of education and support for rehabilitation.^{14–16} While some studies have reported that the use of telehealth in COPD may improve outcomes,¹⁷ the evidence for cost-effectiveness remains limited.^{15 18} Telehealth cost per quality-adjusted life years (QALY) at £92 000/QALY on the ‘COPD value pyramid’ was the highest cost compared with other interventions, such as influenza vaccination (£1000/QALY) and pulmonary rehabilitation (£2000–£8000/QALY).¹⁹ According to a systematic review conducted by Polisena *et al* in 2010, examining four observational and six randomised studies, the use of telehealth with COPD appeared to be associated with a reduction of hospital admission rate, length of stay and emergency department visits ($p<0.05$).²⁰ More recent studies including a well-conducted randomised trial by Pinnock did not show improvement in outcomes including risk of hospitalisation and quality of life.²¹ Moreover, inappropriate use of telehealth could adversely affect care provided. In particular, an effective telehealth programme requires accurate and reliable setting of alarm limits to avoid unnecessary action or cost.

It is not clear how widespread the use of telehealth for COPD is in the National Health Service (NHS) England and Wales, or for what purposes it is being used. We set out to explore this. We hypothesised that different services would be using different methods to set telehealth alarms, with no clear guideline on how to personalise the alarm limits for each patient.

METHOD

A cross-sectional survey consisting of 14 questions (see online supplementary appendix 1) was sent to COPD community services in England and Wales. The organisations were those taking part in the Pulmonary Rehabilitation (PR) arm of the National COPD Audit Programme in September 2017. The organisations providing PR are frequently community health providers, and therefore those most likely to be using telehealth programmes. The survey was administered via SurveyMonkey in 2017. The questions were developed by the authors and tested for validity with local practitioners before being electronically distributed on email to the COPD community organisations. We assessed content and face validity. First, the first author developed the questions from his healthcare professional background and experience. Next, the

content was evaluated by two healthcare professional experts including one of the authors (JRH). Amendments to the questions were made in accordance with their comments and feedback. The face validity was checked by distributing the survey to a variety of healthcare professionals (doctors, nurses and physiotherapists). They provided feedback about the ease of completing the survey and whether it was measuring what we had intended to measure. The final version of the survey was then confirmed by all authors.

A cover statement explained the purpose of this survey. We additionally advertised availability of the survey by circulating the weblink electronically via email, Twitter and LinkedIn. Under the Research Governance Framework (2005), and Health Research Authority (HRA) review, this study was not considered as ‘research’ as this was a voluntary survey of healthcare professionals; therefore, no ethics, HRA, or Research and Development approvals were required.

Questions were designed to cover five different aspects of telehealth in COPD: purpose of use, equipment type, clinician perceptions, variables monitored and personalisation of alarm limits. Participants were asked to select which type of equipment was used in their service: (A) smartphone/tablet apps, (B) monitoring station (non-portable telehealth equipment fixed in the patient’s home), (C) fixed telephone, (D) video phone, and (E) other (please specify). For variables monitored, participants were asked to select all the variables that were monitored in their programme. We asked about heart rate, oxygen saturation, respiratory rate, blood pressure, temperature, peak flow, hours of continuous positive airway pressure use, hours of non-invasive ventilation (NIV) use, step count, physical activity, metabolic equivalent data, sleep quality, phlegm, cough, breathlessness, wheeze and use of rescue medication, and participants had the option to add any variables that were not listed in free text. For any variables being used, participants were then asked how the alarm limit for each variable was set from a drop-down list (arbitrary, international guidelines, national guidelines, personalised to the patient, don’t know or not applicable). Participants who indicated that the alarm limit was personalised were asked how this was done. Participants did not have to answer all the questions.

With regard to questions on clinician perception, responses were graded on a Likert scale between 1 (not at all) and 10 (very much so). Statistical Package for the Social Sciences (SPSS) V.24 was used to analyse the collected responses. $P\leq 0.05$ was accepted as the level of significance.

RESULTS

Two hundred and thirty organisations were invited to take part in this survey. Sixty-five participants completed the survey from 52 different organisations (50 in England and two in Wales). Twenty-four (46%) of organisations

had used telehealth for COPD, and currently, 16 (31%) still provided telehealth services to patients with COPD. Of the respondents, 36/65 (55%) were physiotherapists, 23% nurses, 12% miscellaneous, 8% doctors and 2% physiologists.

Perception

Fifty-two of 65 respondents completed the question about the usefulness of telehealth, where 0 represented 'not at all' and 10 represented 'very much so'. The median and IQR score was 5³⁻⁷ out of 10 on the Likert scale. In respondents who had used (n=28, median (IQR) 6 (3-7)) vs had not used (n=24, median (IQR) 5 (2-7)) telehealth, there was a difference in score of 1.0 which was not statistically significant (p=0.38). Participants thought that telehealth was useful in diverse aspects of COPD care, for example: 'stops unnecessary visits', 'clients know they can contact us rather than waiting to see the GP or going to hospital', 'symptom monitoring/alerting to exacerbations', 'we don't use it, but I suppose education/information'.

Purpose and equipment

Of those who still used telehealth, 88% used it for baseline monitoring, 82% for early detection of exacerbations, 41% for monitoring recovery from an exacerbation and 12% to assist patient adherence to management plan, which was reported by participants as exercise adherence, inhaler adherence and monitoring domiciliary NIV. Differential responses here may reflect the workload prioritisation of community teams. Some respondents used it for more than one indication. The equipment used (hardware) was a dedicated monitoring station (non-portable telehealth equipment that is fixed

in the patient's home) in 50%, a smartphone/tablet app in 46% and a fixed telephone in 36%.

The variables being monitored in more than 50% of services are illustrated in figure 1. This was most commonly oxygen saturation, heart rate and breathlessness.

Alarm limits

Table 1 shows how each respondent set the alarm limits for each variable they monitored. The majority selected either 'National guidelines' (although no such guidance exists) or 'personalised'. For personalisation techniques, the participants' answers could be categorised into four methods: observation taken at the time of set-up assessment, historical trends, calculation of a stable baseline, or a combination of set-up assessment and historical trend.

With regard to perceived sensitivity to detect exacerbation, 56% of 18 respondents thought their alarm technique was sensitive enough to identify exacerbation events. With regard to the efficiency of personalising alarm limits over arbitrary, the median (IQR) score on the Likert scale was 5⁴⁻⁸ in 17 participants, suggesting that there was no consensus on the utility of this approach.

Finally, we asked about the perceived proportion of 'false alarms'. These data are illustrated in figure 2. The majority of participants thought that at least 40% of alarms were false.

DISCUSSION

We have conducted a national survey to explore the use of telehealth in COPD across England and Wales, and to summarise the techniques used by healthcare providers to personalise alarm limits for patients with COPD enrolled in telehealth programmes. Our key findings are: Of the 52

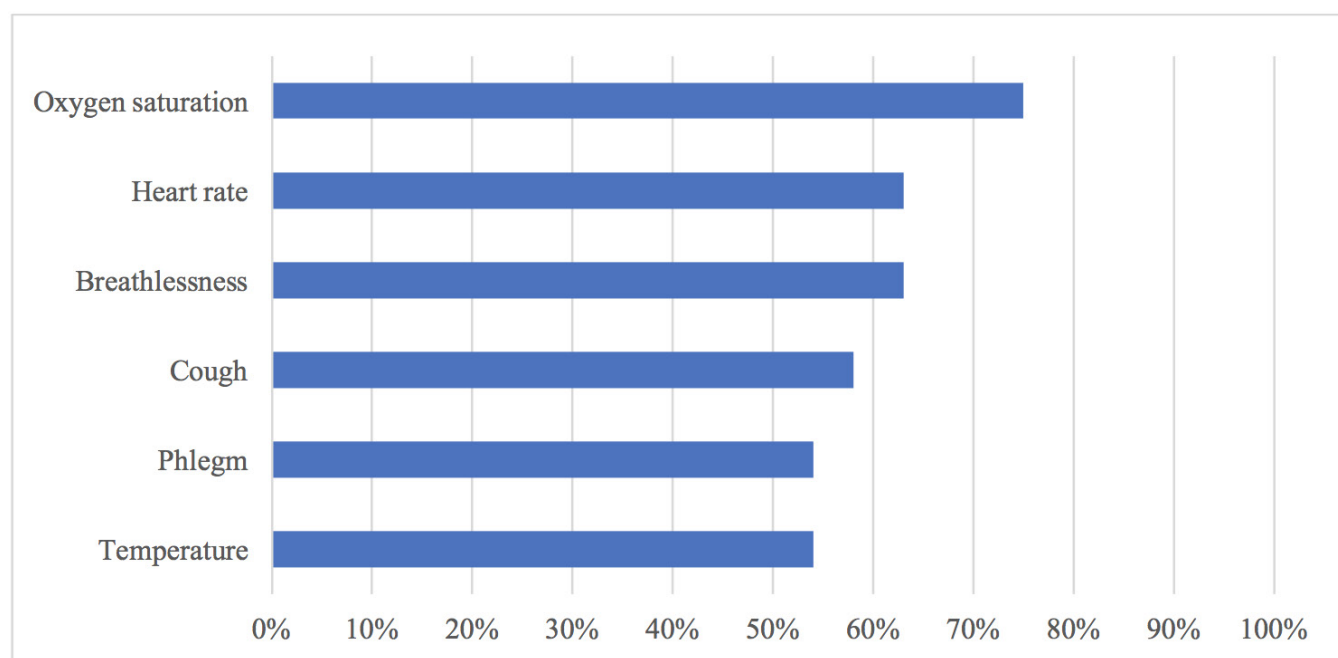


Figure 1 Variables monitored by telehealth providers.

Table 1 Participants' description of how alarm limits were set for each variable. Variables are ordered by frequency of use (see figure 1)

Variables	Arbitrary/what feels right	Local guideline	National guideline	Personalised (based on data from that patient)	Not applicable	Total
Oxygen saturation	0% 0	13% 2	27% 4	53% 8	7% 1	15
Heart rate	0% 1	17% 2	8% 1	67% 8	8% 1	13
Breathlessness	8% 1	17% 2	17% 2	42% 5	17% 2	12
Cough symptoms	8% 1	8% 1	17% 2	42% 5	25% 3	12
Phlegm symptoms	9% 1	18% 2	27% 3	18% 2	27% 3	11
Temperature	0% 0	27% 3	46% 5	18% 2	9% 1	11
Blood pressure	0% 0	18% 2	18% 2	55% 6	9% 1	11
Wheeze	13% 1	13% 1	25% 2	25% 2	25% 2	8
Physical activity	14% 1	0% 0	0% 0	43% 3	43% 3	7
Use of medication	0% 0	14% 1	29% 2	29% 2	29% 2	7
Hours of NIV use	0% 0	20% 1	0% 0	20% 1	60% 3	5
Sleep quality	0% 0	0% 0	0% 0	75% 3	25% 1	4
Step count	25% 1	0% 0	0% 0	25% 1	50% 2	4
Peak flow	0% 0	0% 0	0% 0	33% 1	67% 2	3

NIV, non-invasive ventilation.

organisations that responded, 16 (31%) currently use telehealth, 28/52 (54%) practitioners thought telehealth was useful in COPD (despite a high proportion of false alarms, and this did not vary by experience of use), telehealth is most commonly delivered from a fixed monitoring station (non-portable telehealth equipment that is fixed in the patient's home), and the most common variables monitored are oxygen saturation, heart rate and breathlessness score. Alarm limits for these variables were most commonly said to be personalised, using a variety of non-standardised techniques, or set using guidelines, which to the best of our knowledge do not exist.

It was not clear how widespread the use of telehealth for COPD was in NHS clinical practice. While around one-third of organisations currently used telehealth, there is not a single record of all organisations providing community COPD care, and therefore we cannot comment on the overall prevalence of use, and telehealth may in addition be provided by primary and secondary care organisations.

The usefulness of telehealth in COPD remains controversial. Based on this survey, most participants thought that telehealth was useful for managing patients with COPD, despite an absence of robust clinical trial evidence and despite responses in this survey suggesting a high proportion of false alarms. This suggests that further qualitative work is required to understand why some clinicians' perceptions do not match the available evidence. Some studies have shown positive results when telehealth is used in patients with COPD, for example, a reduction in emergency department visits, need for NIV, hospital admissions and hospital length of stay,¹⁴ which will indirectly affect the cost of patient with COPD on healthcare. Other studies have not been positive. Ringbaek *et al* noted no significant benefit of telehealth on hospital admissions due to exacerbation or emergency department visits²² and the randomised trial by Pinnock did not improve admission rates of quality of life.²¹

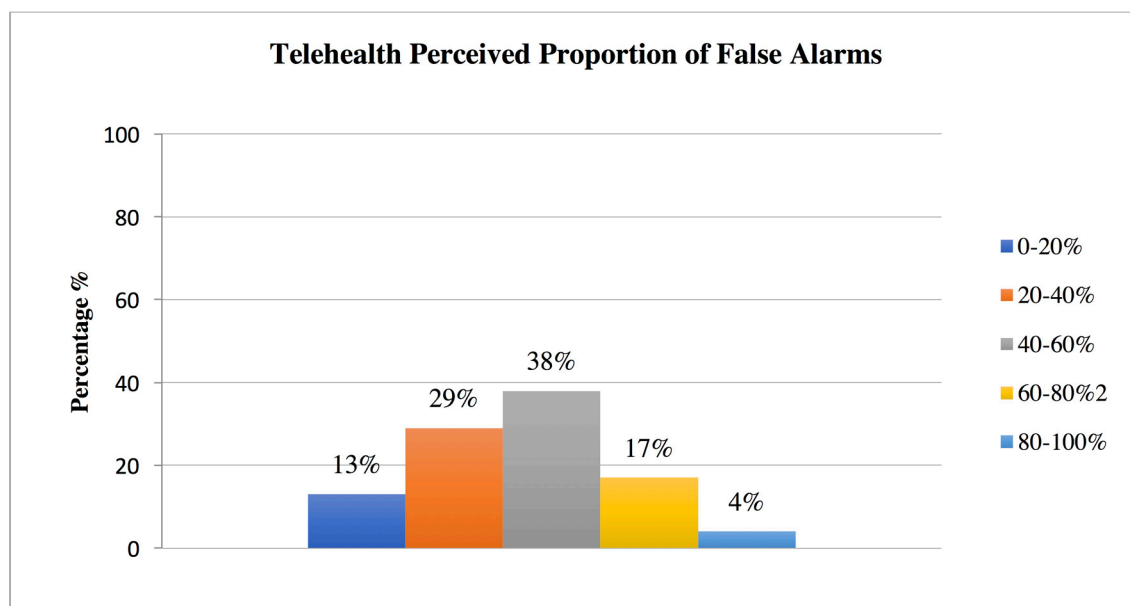


Figure 2 Perception of false alarms triggered from telehealth system.

The majority of participants who used telehealth in COPD used it for baseline monitoring and early detection of exacerbation. The variables monitored by providers included symptoms and physiological parameters. Heart rate, oxygen saturation and breathlessness were the most common variables monitored, each in >50% of services. In a pilot study in 2010, we demonstrated that daily physiological monitoring has the potential to provide early detection of COPD exacerbations.²³ Other more recent studies have also shown the possibility of predicting COPD exacerbation via close monitoring of patients' symptoms and physiological variables.^{24–26} However, in a recent systematic review, we concluded that there is currently insufficient information on how physiological parameters vary prior to exacerbation to support routine domiciliary monitoring solely for the prediction of exacerbations.²⁷ Moreover, the National Institute for Health and Care Excellence 2018 guideline has recommended not offering routine telehealth (physiological monitoring) for patients with stable COPD, as evidence remains controversial.²⁸ Regarding symptoms, in 2000 Seemungal *et al* noted a significant increase in respiratory symptoms (dyspnoea, cough and sore throat) prior to exacerbation with up to 64% of participants reporting increased dyspnoea on the day of onset of an exacerbation.²⁹ Thus, monitoring breathlessness in a telehealth programme might be valuable, but again there remains insufficient evidence to be able to recommend this routinely.

One major challenge with the use of telehealth is the question of how best to set alarm limits. Too sensitive and there will be excess false alarms, not sensitive enough and exacerbations will be missed. The majority of participants (59%) in this survey thought that >40% of alarms received from telehealth systems were false, which is perhaps why some participants did not agree that personalising alarm limits made telehealth services more efficient, as a high

number of false alarms could lead to alarm fatigue, unnecessary actions and unnecessary clinical workload. This is consistent with published evidence which has shown that more than 72% of alarms are not clinically related.³⁰ Triggered alarms could be due to technical issues, sensor malposition, changes in therapy and poor clinical judgement. Even though there is no robust evidence to either agree or disagree with some of the techniques of how alarm limits were personalised, techniques were similar to those reported in our systematic review.²⁷ This survey emphasises the need for testing, optimising and establishing a protocol for personalisation of alarm limits. Many participants reported using national guidance to personalise limits, even though no such guidance exists. We have previously reported our experience of setting alarm limits based on calculating baseline variation in monitored variables, and using Z scores to distinguish normal from abnormal variation.²³ Further work is required to understand how to best establish patients on telehealth programmes.

Strengths and limitations

Our survey has some limitations. We cannot be sure we reached a representative sample of all organisations providing telehealth. The survey was distributed electronically and no reminder was sent to fill and submit the survey, which may have contributed to the low response rate. Responders who completed this survey were from a wide range of providers, such as doctors, nurses and physiotherapists, but we did not set out to survey the opinions of healthcare commissioners. Findings from this study should be interpreted with a caution, as some questions were answered from a smaller number of participants. Furthermore, the responders to this survey in 52/230 organisations could be biased towards either a positive or negative view of telehealth in COPD depending on their previous

experience, and we have no way to assess this. The strength of our survey is that, to our knowledge, there is no previous survey assessing the use and purpose of telehealth for COPD in the NHS, or the techniques of personalisation of alarm limits. Further studies could consider, in particular, how telehealth has changed practice, and how patients are selected for telehealth programmes.

CONCLUSION

Around one-third of responding community COPD services are using telehealth, believing it to be somewhat effective without robust evidence, monitoring a variety of variables and using a variety of hardware and techniques to set alarm limits with resultant high false alarm frequency. This potentially increases clinical workload and actions; therefore, further robust research is needed to evaluate the utility of telehealth, and specifically the efficacy of personalising alarm limits and the validity of this approach in clinical practice prior to wider implementation in the NHS UK and more widely.

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Contributors AAR and JRH conceived and designed the study. Study questions were edited and revised by YA, AA, EP and SQ, while MCS facilitated the distribution of the survey. AAR and JRH performed the initial analysis, interpretation and evaluation of data. AAR wrote the first manuscript draft and all authors revised it for important intellectual content. All authors read and approved the final manuscript.

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Data sharing statement We will consider requests for data sharing via email to the corresponding author.

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REFERENCES

- Global Initiative for Chronic Obstructive Lung Disease. The global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease. Gold report 2018.
- Snell N, Strachan D, Hubbard R, et al. S32 Epidemiology of chronic obstructive pulmonary disease (COPD) in the UK: findings from the British Lung Foundation's 'respiratory health of the nation' project. *Thorax* 2016;71(Suppl 3).
- British Lung Foundation. Chronic obstructive pulmonary disease (COPD) statistics. Available: <https://statistics.blf.org.uk/copd>
- Ni W, Shao X, Cai X, et al. Prophylactic use of macrolide antibiotics for the prevention of chronic obstructive pulmonary disease exacerbation: a meta-analysis. *PLoS One* 2015;10:e0121257.
- Wilkinson T, Wedzicha JA. Strategies for improving outcomes of COPD exacerbations. *Int J Chron Obstruct Pulmon Dis* 2006;1:335–42.
- Garner J, Kemp SV, Toma TP, et al. Survival after endobronchial valve placement for emphysema: a 10-year follow-up study. *Am J Respir Crit Care Med* 2016;194:519–21.
- Xu W, Collet JP, Shapiro S, et al. Negative impacts of unreported COPD exacerbations on health-related quality of life at 1 year. *Eur Respir J* 2010;35:1022–30.
- Donaldson GC, Law M, Kowlessar B, et al. Impact of prolonged exacerbation recovery in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2015;192:943–50.
- Foo J, Landis SH, Maskell J, et al. Continuing to Confront COPD international patient survey: economic impact of COPD in 12 countries. *PLoS One* 2016;11:e0152618.
- Wilkinson TM, Donaldson GC, Hurst JR, et al. Early therapy improves outcomes of exacerbations of chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2004;169:1298–303.
- Jensen MH, Cichosz SL, Hejlesen OK, et al. Clinical impact of home telemonitoring on patients with chronic obstructive pulmonary disease. *Telemed J E Health* 2012;18:674–8.
- Ekeland AG, Bowes A, Flottorp S. Effectiveness of telemedicine: a systematic review of reviews. *Int J Med Inform* 2010;79:736–71.
- Telehealth Quality Group EEIG. International Code of practice for telehealth services 2018/19 V2. *Telehealth Global* 2017;2.
- Segrelles Calvo G, Gómez-Suárez C, Soriano JB, et al. A home telehealth program for patients with severe COPD: the PROMETE study. *Respir Med* 2014;108:453–62.
- Dinesen B, Haesum LK, Soerensen N, et al. Using preventive home monitoring to reduce hospital admission rates and reduce costs: a case study of telehealth among chronic obstructive pulmonary disease patients. *J Telemed Telecare* 2012;18:221–5.
- Kamei T, Yamamoto Y, Kajii F, et al. Systematic review and meta-analysis of studies involving telephone monitoring-based telenursing for patients with chronic obstructive pulmonary disease. *Jpn J Nurs Sci* 2013;10:180–92.
- Yang F, Wang Y, Yang C, et al. Mobile health applications in self-management of patients with chronic obstructive pulmonary disease: a systematic review and meta-analysis of their efficacy. *BMC Pulm Med* 2018;18.
- Sorknaes AD, Madsen H, Hallas J, et al. Nurse tele-consultations with discharged COPD patients reduce early readmissions—an interventional study. *Clin Respir J* 2011;5:26–34.
- Society BT. IMPRESS guide to the relative value of COPD interventions. *British Thoracic Society Reports* 2012;4.
- 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;16:120–7.
- Pinnock H, Hanley J, McCloughan L, et al. Effectiveness of telemonitoring integrated into existing clinical services on hospital admission for exacerbation of chronic obstructive pulmonary disease: researcher blind, multicentre, randomised controlled trial. *BMJ* 2013;347:f6070.
- Ringbaek T, Green A, Chr Laursen L, et al. Effect of telehealthcare on exacerbations and hospital admissions in COPD: a randomised controlled trial 2015;(10):1801–8.
- Hurst JR, Donaldson GC, Quint JK, et al. Domiciliary pulse-oximetry at exacerbation of chronic obstructive pulmonary disease: prospective pilot study. *BMC Pulm Med* 2010;10.
- Martín-Lesende I, Orruño E, Bilbao A, et al. Impact of telemonitoring home care patients with heart failure or chronic lung disease from primary care on healthcare resource use (the TELBIL study randomised controlled trial). *BMC Health Serv Res* 2013;13.
- Trkovnik M, Kuleš M, Tabaković I, et al. Thin-layer chromatography of some coumarin derivatives. *Journal of Chromatography A* 1976;128:227–30.
- Hamad GA, Crooks M, Morice AH. The value of telehealth in the early detection of chronic obstructive pulmonary disease exacerbations: a prospective observational study. *Health Informatics J* 2016;22:406–13.
- Al Rajeh A, Hurst J. Monitoring of physiological parameters to predict exacerbations of chronic obstructive pulmonary disease (COPD): a systematic review. *J Clin Med* 2016;5.
- National Institute for Health and Care Excellence. Chronic obstructive pulmonary disease in over 16s: diagnosis and management. NICE guideline 2018.
- Seemungal TA, Donaldson GC, Bhowmik A, et al. Time course and recovery of exacerbations in patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2000;161:1608–13.
- Chambrin MC, Ravau P, Calvelo-Aros D, et al. Multicentric study of monitoring alarms in the adult intensive care unit (ICU): a descriptive analysis. *Intensive Care Med* 1999;25:1360–6.