


Living with asthma and chronic obstructive airways disease: Using technology to support self-management – An overview

Chronic Respiratory Disease
2017, Vol. 14(4) 407–419
© The Author(s) 2016
Reprints and permission:
sagepub.co.uk/journalsPermissions.nav
DOI: 10.1177/1479972316660977
journals.sagepub.com/home/crd


Deborah Morrison¹, Frances S Mair¹, Lucy Yardley²,
Sarah Kirby² and Mike Thomas³

Abstract

Long-term respiratory conditions such as asthma and chronic obstructive pulmonary disease (COPD) are common, and cause high levels of morbidity and mortality. Supporting self-management is advocated for both asthma and increasingly so for COPD, and there is growing interest in the potential role of a range of new technologies, such as smartphone apps, the web or telehealth to facilitate and promote self-management in these conditions. Treatment goals for both asthma and COPD include aiming to control symptoms, maintain activities, achieve the best possible quality of life and minimize risks of exacerbation. To do this, health professionals should be (a) helping patients to recognize deteriorating symptoms and act appropriately; (b) promoting adherence to maintenance therapy; (c) promoting a regular review where triggers can be established, and strategies for managing such triggers discussed; and (d) promoting healthy lifestyles and positive self-management of symptoms. In particular, low uptake of asthma action plans is a modifiable contributor to morbidity and possibly also to mortality in those with asthma and should be addressed as a priority. Using technology to support self-management is an evolving strategy that shows promise. This review provides an overview of self-management support and discusses how newer technologies may help patients and health professionals to meet key treatment goals.

Keywords

Asthma, self-management, inhaled corticosteroid, telehealth, digital, COPD

Introduction

Long-term respiratory conditions such as asthma and chronic obstructive pulmonary disease (COPD) are common, with reported worldwide prevalence rates of almost 5% for both.¹ COPD is associated with high morbidity and high rates of hospital admissions, and is the third leading non-communicable disease cause of death worldwide.² Asthma is also associated with a significant symptom burden, and worldwide, the number of disability-adjusted life years lost due to asthma has been estimated at 15 million per year, similar to that for diabetes.³ Both asthma and COPD are diseases that remain life-long and are associated with considerable morbidity, mortality and health resource use, along with higher than expected levels of comorbidity.⁴ While asthma and COPD are controllable with pharmacological and

non-pharmacological treatment strategies, they are not curable; so many people live for many years with the consequences of these conditions and need to efficiently self-manage their illness in order to achieve optimal outcomes.

¹ General Practice and Primary Care, Institute of Health and Wellbeing, University of Glasgow, Glasgow, UK

² Department of Psychology, University of Southampton, Highfield, Southampton, UK

³ Primary Care Research, Aldermoor Health Centre, University of Southampton, Aldermoor Close, Southampton, UK

Corresponding author:

Frances S Mair, General Practice & Primary Care, Institute of Health & Wellbeing, 1 Horselethill Road University of Glasgow, Glasgow G12 9LX, UK.

Email: frances.mair@glasgow.ac.uk

There is good evidence for effectiveness of self-management in asthma,⁵ and increasingly so for COPD, in improving outcomes.^{6–8} However, the challenges of implementing self-management support into routine clinical practice are considerable,^{9,10} with many patients lacking adequate self-management training and support, and many professionals lacking time, skills or motivation to support self-management in patients. Newer technologies such as telehealth and digital interventions are increasingly seen as potential modalities for providing self-management support in a more acceptable, efficacious and cost-effective way. Telehealth refers to healthcare provided ‘at a distance’ via the use of technology while ‘digital intervention’ refers to any intervention delivered by digital technology which would include web-based interventions on PC or mobile devices, apps on smart phones and interventions delivered by text messages or interactive voice recognition.¹¹

This review provides an overview of self-management of these chronic respiratory conditions and discusses strategies to support behaviour change, considering the potential role for digital interventions to promote this.

What is the role of self-management in chronic respiratory diseases?

The evidence base supporting self-management is compelling for asthma,⁵ and recent studies are clarifying the effectiveness in COPD.^{6,8} As a result, supporting self-management is a crucial aspect of best care for those diagnosed with a chronic respiratory disease.^{7,12}

The treatment goals for asthma and COPD are broadly similar, aiming to control symptoms, maintain activities and minimize risks of exacerbation.^{12,13} Asthma is characterized by *reversible* airflow obstruction and variable symptoms, which are often underestimated by patients. Therefore optimizing symptom control is a key goal, with the aim that patients should lead a full, active and unimpeded lifestyle. COPD, however, is characterized by *irreversible* airflow obstruction and associated lung damage, so persistent symptoms are usual, although slightly variable in severity. The aims of management are optimization of symptoms and risk control and improving quality of life (QOL). These treatment goals are not currently achieved in either condition, and care of patients with asthma and COPD is often suboptimal.^{3,14–16}

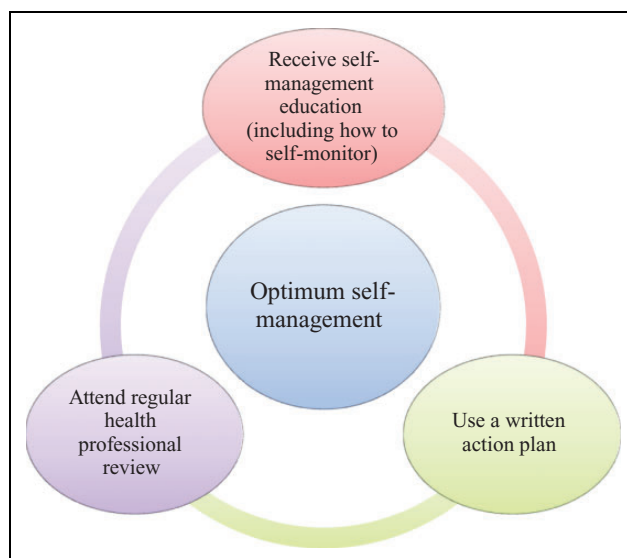


Figure 1. Components of optimum self-management in asthma.

Cochrane reviews have shown that optimum self-management for individuals with asthma should include a combination of regular health professional review with provision of self-management education and an agreed written action plan (Figure 1), as this will improve outcomes for both patients (fewer symptoms, less limitation in activity, fewer days off school/work, improved QOL) and for health services (fewer contacts, less hospitalization).^{6,17,18}

Focusing on COPD, a recent Cochrane systematic review has demonstrated that self-management improves health-related QOL, reduces respiratory-related hospital admissions and improves levels of dyspnoea.⁸ However, due to heterogeneity, they were unable to be specific about what was the most effective form and content of self-management in COPD and it is clear that the evidence supporting self-management in COPD is more mixed than for asthma.¹⁹ At present, guidelines advise that optimum self-management in COPD focuses on the importance of smoking cessation, reducing exposure to indoor and outdoor pollution, promoting physical activity and healthy diet, adherence to pharmacological therapies and improving uptake of vaccinations. Pharmacological action plans are sometimes recommended in specific contexts such as supported discharge and exacerbation self-treatment with patient-held antibiotics and/or oral steroids, because evidence for their widespread use has not been established and there is no evidence that altering inhaled regimes in response to worsening symptoms can prevent exacerbations.^{8,12,20}

Implementing self-management – What is important?

Common to both asthma and COPD is a need to improve knowledge and understanding of the condition as part of the package of self-management education. Broadly, this involves promoting the following behaviours^{7,12,21}:

1. Recognizing a deterioration in symptoms (self-monitoring) and reacting appropriately.
2. Adhering to maintenance therapies.
3. Stopping smoking, avoiding triggers.
4. Health professional review.
5. Healthy lifestyle promotion (exercise, diet, stress reduction, relaxation, etc.).

As part of promoting these behaviours, health professionals should focus on empowering patients to take control of their illness and manage their symptoms, emphasizing that improved QOL can be the resultant outcome.

However, many people with chronic respiratory disease underplay their symptoms in order to avoid accepting their diagnosis, mistakenly attribute symptoms to other causes, adopt sedentary lifestyles or believe that their symptoms are normal for them or cannot be improved.^{22,23} It is therefore understandable that when people do not attribute their symptoms to an underlying disease process, they are more likely to consider that the advice provided to them is irrelevant. Facilitating a shared understanding of what symptoms a person is experiencing and what is realistic for them to achieve with regular therapy is an important place to start.

Recognizing deterioration in symptoms

Recognizing deterioration in symptoms is important as timely intervention can potentially avert progression to a severe exacerbation.^{6,24,25} The evidence for effectiveness of self-monitoring of symptoms is more evident for asthma patients than those with COPD.^{6,18,25–27} It is interesting to note that the latest UK BTS-SIGN Asthma guideline⁷ has moved away from the term ‘self-monitoring’, using the term ‘recognition of deteriorating symptoms’ instead. An analysis of exacerbations ($n = 425$) within a large randomized clinical trial (RCT) of asthma treatments found that participants displayed evidence of deteriorating asthma control (a decline in peak expiratory flow, increase in symptom scores or increase in

reliever use) occurring gradually and progressively for 5–7 days followed by a more rapid change over the 2–3 days before the exacerbation.²⁸ Other studies have found similar results, implying that there is a ‘window of opportunity’ to initiate treatment to prevent progression to a severe exacerbation.²⁹ Unfortunately, most patients lack action plans and an effective way of improving uptake of self-monitoring remains elusive.^{25,30,31} New technologies, such as smartphone and tablet computer apps could be used to address these issues, but the evidence for effectiveness remains unclear.³² Additionally, even when self-management occurs, the resulting behaviour is sometimes not appropriate or in accordance with the prior agreed action plan,³³ even in the context of asthma clinical trials when presumed exemplary education on self-monitoring is provided.²³

Provision of an asthma action plan can support patients to self-monitor by providing written advice about recognizing deteriorating symptoms and instructions on how to alter medications appropriately or when to seek help.^{27,34} Discussing and agreeing an action plan is a collaborative activity between a patient and a clinician and so takes time. Unfortunately the evidence is clear that they are not being used regularly, with the majority of patients lacking an action plan, which in some cases leads to potentially preventable deaths.³⁰ A systematic review focusing on barriers and facilitators of asthma plan use found that patients and carers often perceive that health professionals do not acknowledge the experience they have of managing their own condition already, and that the action plans provided were sometimes felt to be irrelevant to their own illness.³⁵ Additionally, health professionals may not offer action plans to all individuals with asthma, selecting those they believe capable of understanding an action plan, or those with milder asthma.³⁵

Self-monitoring by individuals with COPD is recommended, although less emphasized in guidelines, due to less evidence of effectiveness.¹² This is particularly true of action plans that are often only recommended in the immediate post-discharge situation as part of more extensive case management. However, they are also sometimes provided to patients at risk of exacerbations in conjunction with self-held antibiotic and oral steroid courses, despite the absence of a firm evidence base.¹² Self-monitoring in COPD, if used as an aid to self-management, should be symptom-based, as changes in physiological variables (i.e. lung function) do not allow differentiation between an

exacerbation and normal variability in the condition.^{24,26}

Technological advances have been employed in recent trials to promote self-monitoring in asthma. One example is using a sensor on a reliever inhaler to detect increasing use, communicating via Bluetooth to a smartphone to trigger alerts.³⁶ It seems plausible that this type of 'passive' monitoring may be acceptable to patients in the future and may lessen the treatment burden associated with self-management and self-monitoring, thus potentially increasing adherence.³⁷

Therefore although the evidence quoted earlier shows that asthma self-monitoring, in association with a written action plan, is best practice, it is clear that new strategies to increase uptake are needed. Several systematic reviews have highlighted that for such interventions to be effective they have to consider patient, professional and organizational issues, a feature that is not commonly found in published interventions to date.^{38–40}

Promoting adherence to maintenance therapies

Non-adherence with maintenance therapy is common in people with long-term conditions, including lung disease. When faced with patients with chronic respiratory diseases, it is important to consider whether they are taking medications as prescribed, and to try and assess levels of adherence and understand reasons for non-adherence in a non-judgemental way.⁴¹

Taking medicines as prescribed in asthma and COPD is crucial to avoid exacerbations, improve day-to-day control and reduce the risk of hospitalizations and death.^{42,43} For example, in asthma, falling levels of adherence to inhaled corticosteroids (ICS) is associated with progressively poorer outcomes, with evidence that for every 25% increase in time without ICS, the rate of asthma-related hospitalization doubles.⁴⁴ Population mean adherence rates to ICS are low, usually reported at 30–50%, with marked variability between patients.⁴⁵

Not taking medications as prescribed can be intentional or unintentional. Common reasons for unintentional non-adherence are poor inhaler technique and forgetting to take medication.⁴¹ Electronic reminder systems show promise in the case of unintentional non-adherence due to forgetfulness, but seem unlikely to be effective in those intentionally non-adherent and as yet there is no robust evidence relating to their benefits, in terms of long-term adherence or

improvements in clinical outcomes.^{46–48} Inhaler technique problems are compounded by an ever-increasing array of inhalers,^{49,50} with evidence that health professionals can be as confused as patients.⁵⁰ Checking inhaler technique is an essential part of any review. Instructional videos have been shown to be an effective way of improving correct inhaler use, particularly in those with limited health literacy,⁵¹ and may be a useful option particularly where placebo inhalers are unavailable.

A qualitative synthesis by Pound et al.⁵² provides a detailed exploration of 'why' people do not take medicines as prescribed. Many prefer not to take medicines at all where possible, with contributory factors being: (1) doubts about the need for the medications in the first place (in asthma specifically, this is compounded by a reluctance to accept the diagnosis) and (2) concerns about potential side effects of treatments. Actively establishing underlying concerns during a review is essential to address adherence issues.

Lifestyle advice and triggers

Typical triggers for inducing symptoms in those with asthma or COPD are cigarette smoke, other environmental irritants such as air pollution, allergens, infections, exercise and certain medications (e.g. non-steroidal anti-inflammatory drugs, beta-blockers and aspirin).

The benefits of stopping smoking and achieving a smoke-free environment are clear in both asthma and COPD, and for those with COPD, smoking cessation influences the natural history of the disease.^{53–55} Despite this, one-third or more of patients with COPD continue to smoke, and smoking rates in people with asthma are similar to those of the general population. Documentation of smoking status and provision of smoking cessation support is a vital component of clinical care in asthma and COPD. Going forward, technology-supported interventions such as txt2Stop may be increasingly considered.⁵⁶ Infections are a well-recognized trigger for both asthma and COPD, and promoting uptake of vaccinations is considered the best practice. While handwashing to reduce spread of infection has always been advocated, there is now firm evidence that this does reduce spread of respiratory infections.⁵⁷ Advice on avoidance of other triggers is less clear-cut.⁷ For example, UK asthma guidelines discuss the potentially paradoxical effects of removing a pet from the home: it may improve symptoms; however, removal of the allergen source

also reduces the opportunity for tolerance developing, which itself may reduce symptoms.⁷ House dust mites are a trigger for some individuals; however, both chemical and physical methods of reducing house dust mites have been shown to be ineffectual, and therefore advice to these individuals may revolve more around promoting adherence to ICS. Regarding exercise, appropriate pharmacological therapy, in particular, using beta agonists before exertion, should allow most of those with asthma to continue to exercise. While exercise training has not been shown to specifically improve asthma outcomes, it does improve cardiovascular fitness, and should be advocated as part of general healthy lifestyle measures.⁷ New technologies that promote physical activity monitoring such as 'Fitbit' and 'JawboneUP', may prove useful as a means to promote activity, but this remains an evolving area.⁵⁸ For those with COPD there is good evidence that pulmonary rehabilitation classes relieve symptoms such as dyspnoea and fatigue, and improve emotional functioning and their uptake should be promoted at every opportunity⁵⁹ and, in recent times, pulmonary rehabilitation via telecare has been increasingly advocated as a potential way to deliver such services.⁶⁰ With asthma, stress and anxiety can be a trigger for some individuals and there is higher prevalence of psychological problems in those with asthma.^{4,61} Those with anxiety and depression tend to have poorer outcomes, so establishing the presence of these comorbidities and discussing management strategies is an important aspect of asthma care.⁶¹ A similar link between depression and COPD is well recognized and worth exploring during consultations.^{4,62} As web-based cognitive behavioural therapy or apps become increasingly available, this provides another therapeutic option to offer, which might be particularly useful for those for whom lack of time is a significant barrier to accessing such services.^{63,64}

Establishing triggers with patients with asthma or COPD at a review, and discussing person-specific strategies for reducing their impact is an important part of self-management education, but must be tailored to the individual.

Health professional review

Self-management support should be provided by clinicians in addition to regular clinical review, and self-management advice reviewed and reinforced at regular (e.g. annual) checks. In asthma, provision of an

action plan is only shown to be effective in conjunction with a regular health professional review.^{6,65} At present, regular professional review often means a face-to-face, prearranged appointment. However, not all patients are willing or able to attend, particularly given most people perceive themselves as being well, so attendance is variable. In the UK National Review of Asthma Deaths published in 2014, only 57% of those who died had evidence of a routine asthma review in the preceding year. As well as patient barriers to the asthma review, professional barriers also exist. Healthcare professionals report only providing asthma action plans to select groups of patients, for example, those who are well educated, or already well controlled, potentially missing the majority with potential to benefit.³⁵ Lack of time and confidence in own ability to discuss action plans and self-management education have been identified as important issues for health professionals.⁴⁰

One aspect of the health professional review, which is difficult to quantify is the impact of the quality of the clinician–patient relationship on outcomes. Improving the patient–professional relationship may be a modifiable factor influencing whether a person self-manages effectively or not. A recent qualitative study of adults with asthma in the United States⁶⁶ reported widespread over-reliance on reliever inhalers across those with uncontrolled and controlled asthma. However, those who were uncontrolled described a poorer relationship with their healthcare providers, feeling that their provider did not listen to them and this patient group rejected self-management advice. This group was also more likely to attribute effects such as weight gain to a side effect of ICS. In contrast, the controlled group reported feeling engaged with their health provider. The importance of this relationship is a strong theme generated from a comprehensive systematic review on barriers to self-management in asthma, which also demonstrated that patients with positive relationships with healthcare providers have less Emergency Department (ED) attendances, and are more likely to adhere to self-management advice in general.⁴⁰

Can technology improve self-management?

Self-management in chronic respiratory diseases improves outcomes but how best to improve uptake on a day-to-day basis remains unclear. The traditional method of self-management support and education

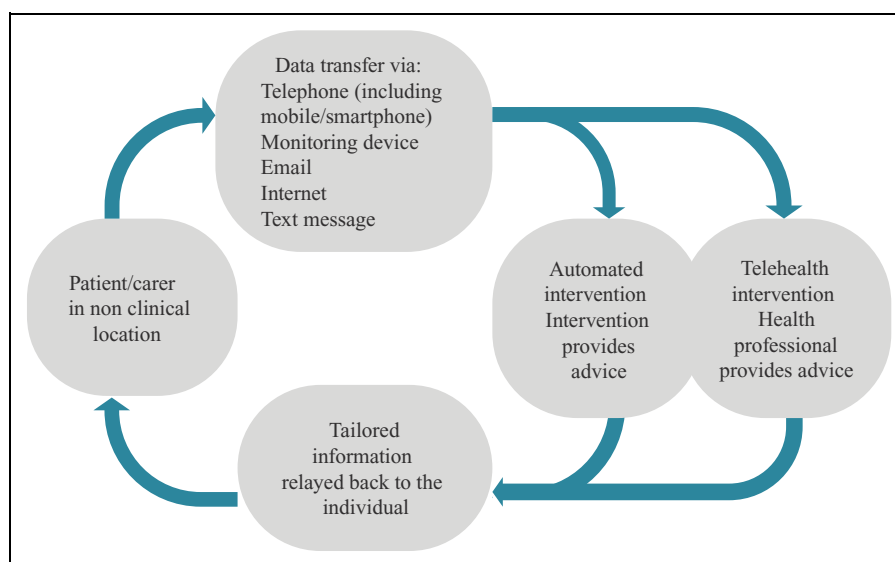


Figure 2. Difference between digital interventions that provide automated tailored advice and telehealth interventions.

during face-to-face reviews only works in a proportion of individuals and the lack of support between reviews may be a barrier to sustained engagement with self-management.²¹ There is increasing interest in using technology to improve uptake of self-management behaviours. This might work by facilitating alternatives to face-to-face reviews (such as via telephone),⁶⁷ or as a way of providing ongoing tailored information and support between reviews, such as with digital interventions, as illustrated in Figure 2. Digital interventions to promote self-management behaviours may work completely independently from health professionals through the provision of automated tailored advice generated by the intervention based on information provided by the patient.⁶⁸ More commonly, digital interventions are used as telehealth interventions, where patients provide clinical data to a health professional in a different location, who reviews it and provides tailored advice back (via the intervention), for example, based on oxygen saturation levels or peak flows.^{25,69} The majority of digital interventions published to date include a telehealth component, with completely stand-alone digital interventions in the minority.^{68–70}

There appears to be a divergence in the use of technology when investigating its role in supporting self-management of chronic respiratory diseases, with telehealth being the most popular modality for COPD, but with asthma digital interventions generally including automated advice, often supplemented with additional health professional input.⁶⁸ This is possibly

driven by the increased evidence and experience of using action plans in asthma, which lend themselves well to algorithm-based digitally generated advice.

There is also burgeoning literature for digital interventions supporting lifestyle and behaviour change as part of optimum self-management, for example, interventions supporting stopping smoking and increasing physical activity.^{71–74}

Technology and COPD

In 2011, McLean et al. provided a clinical overview of telehealthcare for long-term conditions (COPD, heart failure and diabetes), noting that telehealthcare interventions were proliferating rapidly, although underpinned by variable quality of evidence.⁷⁵ They reported some isolated examples of success, particularly in those with severe chronic diseases such as problematic asthma and diabetes that it could reduce hospital admissions, without increasing mortality, and suggesting that less complex interventions may be more cost-effective. They also detailed potential pitfalls associated with introducing telehealthcare such as enduring technical difficulties, safety concerns (data loss, confidentiality), potential adverse effects on workload and negative effects on patient–professional relationships. A Cochrane review focusing on COPD reported more convincing findings,⁶⁹ with evidence of improvements in QOL and ED attendances, although noting that these telehealth interventions were often part of a larger complex intervention so that teasing out which elements were effective was

not possible. These findings mirror that of the UK government-funded Whole Systems Demonstrator (WSD) project that investigated the role of telehealth and telecare technologies in chronic disease management and included the world's largest RCT of telehealth involving 6191 patients with diabetes, COPD or heart failure. Across the three chronic diseases (disease-specific data is not available for these outcomes), it showed some reductions in emergency admission rates, length of admission, markedly reduced mortality rates (4.6% vs 8.3%, $p < 0.001$),⁷⁶ but overall was not found to be cost-effective.⁷⁷ While across the WSD study there was no improvement in QOL and psychological outcomes,⁷⁸ published COPD-specific sub-group data reports disease-specific QOL and psychological outcomes showing that for those in the intervention arm there was a consistent trend to improved health-related QOL, along with better emotional functioning and mastery, which improved over time.⁷⁹ This partly matches the earlier Cochrane review, which while showing no benefit in mortality, did demonstrate improved QOL and reduced ED attendances.⁶⁹

Pinnock et al.⁸⁰ evaluated integrating a COPD telehealth intervention into existing clinical services with both control and intervention groups having care from the same clinical provider. They found no difference in their primary outcome, time to first admission, or in any secondary outcomes (including disease-specific QOL and length of admission). As well as the mixed results regarding effectiveness, the review by McLean et al.⁷⁵ highlighted potential negative implications on the patient-provider relationship, including reinforcement of historical power relationships with 'passive patients being monitored by a now distant medical professional'. However, qualitative studies report that patients are mostly positive about their experiences, reporting that they felt safer and that they had learned more about their condition, and staff felt that the improved knowledge could be a useful long-term benefit.⁸¹ Earlier qualitative work had also suggested that interacting with a telehealth intervention and receiving feedback from the health professional can increase satisfaction in relation to factors such as continuity of care, understanding of symptom variability and encouragement of self-management behaviour.⁸² While participants were mostly positive about their role in telemonitoring, several were glad to hand their devices back at the end of this short (3–6 month) study, stating that they were getting bored using it everyday. This raises the question about long-term

sustainability of such interventions requiring regular work by the patients that increase their overall treatment burden.³⁷

Qualitative studies suggest that COPD telehealth interventions should complement rather than replace current clinical care, supporting and encouraging self-management and that interventions that are specifically developed to be intuitive and easy to use can overcome perceived barriers to using technology by those with little experience of it.⁸²

The uncertainties over telehealth in COPD are such that it is not clear how it would work in real-life settings, and future research needs to be clear about the aims and structure of the telehealth interventions, and to consider implementation issues from the outset.⁸³ If telehealth is to be effective, then it must not add to the burden of treatment that patients already endure.⁸⁴ There are suggestions from qualitative, but not quantitative studies, that there may be a group of patients for whom telehealth reduces the burden of disease and increases confidence.^{81,82,85} Strategies for establishing who is most likely to benefit from telehealth interventions is another important gap in the available evidence.

Other uses of technology in COPD include the provision of information or support online, for example, via social media. Many disease-based charities such as the British Lung Foundation or American Lung Association have a linked Facebook page or website, with forums where users can ask questions and hear about experiences of others with similar problems. These may be useful for practical queries that users may have, for example, recommendations for a suitable backpack for carrying home oxygen. However, a quick review of such sites shows evidence of potentially harmful advice being posted by other users. For example, one user requesting advice due to experiencing increased shortness of breath and cough, was advised to drink plenty of water to 'thin the phlegm down'. Following such advice would have detrimental effects if heart failure was the underlying pathology.

'YouTube' is another commonly used source of information and COPD is one of the few disease areas where the quality of information provided on YouTube has been formally evaluated.⁸⁶ Unsurprisingly they report the quality as mixed: 70% of the 223 patient education videos they evaluated demonstrated high scores providing quality and trustworthy health information, but 20% were very poor. This suggests that clinicians may want to find videos they have

looked at themselves to ensure they are suitable, and be specific in recommendations. Regardless of the quality of these videos, the authors note that there was very little evidence of user engagement with them in the form of 'likes', marking as a 'favourite' or saving to their own accounts. This is not evidence that there is no demand, as further work by these authors provide evidence of unmet need in this area.⁸⁷ Importantly, it should be noted that 'engagement' is unlikely to be accurately assessed by counting clicks on a 'like' button and so it is clear that more research is needed in this area.

Technology and asthma

A Cochrane review focusing on telehealth in asthma concluded that the likelihood of clinically meaningful benefits in those with mild-to-moderate asthma was low, with more potential demonstrated in those with severe disease.²⁵ As alluded to above, there is more interest in the role of digital interactive interventions for supporting self-management in asthma, which are inexpensive to produce in comparison with professional care and so have the potential to be cost-effective. The literature on asthma interventions is broader, with interventions assessed including not only telehealth but also other digital interventions including apps, simple reminders and interactive voice-response interventions, to name a few. A systematic review of automated digital interventions to support self-management for adults with asthma concluded that there was some evidence of effectiveness, but that understanding of the active ingredients of such interventions was not possible due to lack of detail in the descriptions, particularly as there was little evidence that intervention development had been theory informed.⁶⁸ A later systematic review also found that the majority of interventions did not use any theoretical frameworks or guidelines to inform their design.⁸⁸ With increasing emphasis on the importance of theory-informed development,⁹ it may be that the evidence picture becomes clearer over the next decade.

In 2012, Huckvale et al. reviewed 72 freely available smart phone applications 'apps' looking at three domains: comprehensiveness of asthma information, consistency of advice with evidence and compliance with health information best practice principles.⁸⁹ Disappointingly, no apps were found to contain comprehensive evidence-based advice, and in 32 of 72, advice provided was not supported by evidence,

concluding that improvement was required before clinicians could recommend such apps. A recent update to that review has reinforced the message that questions about clinical quality and safety persist.⁹⁰ A Cochrane review focusing on the effectiveness of smartphone and tablet apps for asthma self-management in comparison to traditional methods of delivery found only two RCTs and inconclusive results.³² The disparity between the number of available apps (72) and the published evaluations (2) is an issue when discussing using such tools with patients. As with advice about websites or YouTube videos, clinicians would need to explore them individually to ensure they are safe until such time as there are available apps that have been rigorously developed and formally evaluated.

Other studies have investigated specifically the role of electronic medication reminders, which would seem to have particular utility when unintentional non-adherence is the issue. Tao et al. included four asthma studies; three used text messages and one used a pager-like device with audiovisual reminder (green light and beep).⁹¹ Pooled results from these four asthma studies demonstrated a small but statistically significant positive effect on patient adherence to medication with the use of reminders. Overall, they also noted that trials with smaller sample sizes had larger effect sizes, and that given three of the four asthma trials were small (<100 participants) this effect needs to be interpreted with caution. Additionally, the asthma studies also used additional self-management tools (information, advice, tailoring), so it is impossible to separate out the active ingredient. Their main conclusion was a call for more adequately powered good-quality trials, which is the conclusion of most other systematic reviews in the field.^{32,92}

There is little evidence of effectiveness or information about user experiences from asthma or COPD-related social media use, although the number of Facebook pages suggests that they are well used. The UK patient charity, Asthma UK, has an active and well-visited Facebook page, with the option of responding to clinical queries posted online by advising users to phone their helpline for advice.

Future directions

Support for self-management aims to improve outcomes in a number of ways: improved recognition of deteriorating symptoms, more appropriate responses

to exacerbations, improving adherence (intentional and non-intentional) to medication and empowering patients to take control of their illness.^{8,79,93,94}

As a treatment strategy, self-management support is not offered enough by health professionals or utilized enough by those with the potential to benefit.^{30,35} Health professionals need to develop a more patient-centred approach, recognizing the importance of a positive patient–provider relationship if outcomes are to improve.^{35,39,40,65,94,95}

Technology has potential to facilitate effective self-management, particularly around ways of reducing the burden of self-management such as with passive monitoring, improving the delivery of self-management education and the development of more sophisticated interactive interventions that can provide safe and clinically appropriate advice directly to the user 24 hours a day. Research into digital interventions to support self-management is still in its infancy, and previously evaluated interventions have not always been developed using best practice. The key will be ensuring that future interventions are developed using best available evidence, are ‘person-based’ (i.e. developed with adequate attention to user experience), robustly evaluated and with implementation issues considered from the beginning including at patient, professional and organizational levels.^{39,40,96,97}

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: D Morrison was undertaking a fellowship funded by the Chief Scientist Office Scotland at the time of writing this review (Ref CAF 11/08). This research received no other specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. Vos T, Flaxman AD, Naghavi M, et al. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the global burden of disease study 2010. *Lancet* 2012; 380: 2163–2196.
2. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012; 380: 2095–2128.
3. Masoli M, Fabian D, Holt S, et al. The global burden of asthma: executive summary of the GINA Dissemination Committee report. *Allergy* 2004; 59: 469–478.
4. Agur K, Morrison D, Mercer SW, et al. Managing multimorbidity in primary care in patients with chronic respiratory conditions *NPJ Prim Care Respir Med* 2016; in press.
5. Taylor SJC, Pinnock H, Epiphaniou E, et al. A rapid synthesis of the evidence on interventions supporting self-management for people with long-term conditions: PRISMS - practical systematic review of self-management support for long-term conditions. *HS&DR* 2014; 2. doi:10.3310/hsdr02530.
6. Gibson PG, Powell H, Wilson A, et al. Self-management education and regular practitioner review for adults with asthma. *Cochrane Database Syst Rev* 2003; 1: CD001117.
7. BTS SIGN. *British guideline on the management of asthma*. SIGN Publication no. 141. Edinburgh: British Thoracic Society Scottish Intercollegiate Guidelines Network, 2014.
8. Zwerink M, Brusse-Keizer M, van der Valk PD, et al. Self management for patients with chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2014; 3: CD002990.
9. Medical Research Council. *Developing and evaluating complex interventions: new guidance*. London: MRC, 2008.
10. Pinnock H, Epiphaniou E and Taylor SJ. Phase IV implementation studies. The forgotten finale to the complex intervention methodology framework. *Ann Am Thorac Soc* 2014; 11(Suppl 2): S118–S122.
11. McLean G, Band R, Saunderson K, et al. Digital interventions to promote self-management in adults with hypertension systematic review and meta-analysis. *J Hypertens* 2016; 34: 600–612.
12. Global Initiative for Chronic Obstructive Lung Disease (GOLD). *Global strategy for diagnosis, management, and prevention of COPD*, 2015. <http://www.atsjournals.org/doi/pdf/10.1164/rccm.201204-0596PP>.
13. Global Initiative for Asthma. *Global strategy for asthma management and prevention 2014*, 2014. www.ginaasthma.com (accessed 09 April 2016).
14. Rabe KF, Vermeire PA, Soriano JB, et al. Clinical management of asthma in 1999: the asthma insights and reality in Europe (AIRE) study. *Eur Respir J* 2000; 16: 802–807.

15. Partridge MR, Dal Negro RW and Olivieri D. Understanding patients with asthma and COPD: insights from a European study. *Prim Care Respir J* 2011; 20: 315–323, 17 p following 23.
16. Boulet LP, Hernandez P, Devlin H, et al. Asthma and chronic obstructive pulmonary disease guideline implementation: lessons learned on recruitment of primary care physicians to a knowledge translation study. *Can Respir J* 2013; 20: 275–280.
17. Gibson PG, Coughlan J, Wilson AJ, et al. Limited (information only) patient education programs for adults with asthma. *Cochrane Database Syst Rev* 2000; 2: CD001005.
18. Powell H and Gibson PG. Options for self-management education for adults with asthma. *Cochrane Database Syst Rev* 2003; 1: CD004107.
19. Bucknall CE, Miller G, Lloyd SM, et al. Glasgow supported self-management trial (GSuST) for patients with moderate to severe COPD: randomised controlled trial. *BMJ* 2012; 344: e1060.
20. Walters JA, Turnock AC, Walters EH, et al. Action plans with limited patient education only for exacerbations of chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2010; 12(5): CD005074.
21. Morrison D, Mair FS, Chaudhuri R, et al. Details of development of the resource for adults with asthma in the RAISIN (randomized trial of an asthma internet self-management intervention) study. *BMC Med Inform Decis Mak* 2015; 15: 57.
22. Rabe KF, Adachi M, Lai CK, et al. Worldwide severity and control of asthma in children and adults: the global asthma insights and reality surveys. *J Allergy Clin Immunol* 2004; 114: 40–47.
23. Thomas M and Bateman E. Asthma attacks: how can we reduce the risks? *NPJ Prim Care Respir Med* 2015; 25: 14105.
24. 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: 1608–1613.
25. McLean S, Chandler D, Nurmatov U, et al. Telehealthcare for asthma. [Review]. *Cochrane Database Syst Rev* 2010; 10: CD007717.
26. Burton C, Pinnock H and McKinstry B. Changes in telemonitored physiological variables and symptoms prior to exacerbations of chronic obstructive pulmonary disease. *J Telemed Telecare* 2015; 21: 29–36.
27. Gibson PG and Powell H. Written action plans for asthma: an evidence-based review of the key components. *Thorax* 2004; 59: 94–99.
28. Tattersfield AE, Postma DS, Barnes PJ, et al. Exacerbations of asthma: a descriptive study of 425 severe exacerbations. The FACET International Study Group. *Am J Respir Crit Care Med* 1999; 160: 594–599.
29. Partridge MR, Latouche D, Trako E, et al. A national census of those attending UK accident and emergency departments with asthma. The UK National Asthma Task Force. *J Accid Emerg Med* 1997; 14: 16–20.
30. Royal College of Physicians. *Why asthma still kills: the national review of asthma deaths (NRAD) confidential enquiry report*. London: Royal College of Physicians, 2014.
31. Anhoj J and Nielsen L. Quantitative and qualitative usage data of an Internet-based asthma monitoring tool. *J Med Internet Res* 2004; 6: e23.
32. Marcano Belisario JS, Huckvale K, Greenfield G, et al. Smartphone and tablet self management apps for asthma. *Cochrane Database Syst Rev* 2013; 11: CD010013.
33. Partridge MR, van der Molen T, Myrseth SE, et al. Attitudes and actions of asthma patients on regular maintenance therapy: the INSPIRE study. *BMC Pulm Med* 2006; 6: 13.
34. Gibson PG. Asthma action plans: use it or lose it. *Prim Care Respir J* 2004; 13: 17–18.
35. Ring N, Jepson R, Hoskins G, et al. Understanding what helps or hinders asthma action plan use: a systematic review and synthesis of the qualitative literature. *Patient Educ Couns* 2011; 85: e131–e143.
36. Merchant R, Inamdar R, Quade R, et al. Interim results from a randomized, controlled trial of remote monitoring of inhaled bronchodilator use on asthma control and management. *Ann Allergy Asthma Immun* 2013; 1: A6.
37. Mair FS and May CR. Thinking about the burden of treatment. *BMJ* 2014; 349: g6680.
38. Ring N, Malcolm C, Wyke S, et al. Promoting the use of personal asthma action plans: a systematic review. *Prim Care Respir J* 2007; 16: 271–283.
39. Pinnock H, Epiphaniou E, Pearce G, et al. Implementing supported self-management for asthma: a systematic review and suggested hierarchy of evidence of implementation studies. *BMC Med* 2015; 13: 127.
40. Miles C, Arden-Close E, Thomas DM, et al. *Barriers and facilitators of effective self-management in adults with asthma: systematic review and thematic synthesis of patient and healthcare professional views*. (Manuscript submitted) 2016.
41. Horne R, Chapman SC, Parham R, et al. Understanding patients' adherence-related beliefs about medicines

- prescribed for long-term conditions: a meta-analytic review of the Necessity-Concerns Framework. *PLoS One* 2013; 8: e80633.
42. Sims EJ, Price D, Haughney J, et al. Current control and future risk in asthma management. *Allergy Asthma Immunol Res* 2011; 3: 217–225.
 43. Toy EL, Beaulieu NU, McHale JM, et al. Treatment of COPD: relationships between daily dosing frequency, adherence, resource use, and costs. *Respir Med* 2011; 105: 435–441.
 44. Williams LK, Peterson EL, Wells K, et al. Quantifying the proportion of severe asthma exacerbations attributable to inhaled corticosteroid nonadherence. *J Allergy Clin Immunol* 2011; 128: 1185–1191.e2.
 45. Bender B, Milgrom H and Rand C. Nonadherence in asthmatic patients: is there a solution to the problem? *Ann Allergy Asthma Immunol* 1997; 79: 177–185.
 46. Strandbygaard U, Thomsen SF and Backer V. A daily SMS reminder increases adherence to asthma treatment: a three-month follow-up study. *Respir Med* 2010; 104: 166–171.
 47. Vervloet M, Linn AJ, van Weert JC, et al. The effectiveness of interventions using electronic reminders to improve adherence to chronic medication: a systematic review of the literature. *J Am Med Inform Assoc* 2012; 19: 696–704.
 48. Tran N, Coffman JM, Sumino K, et al. Patient reminder systems and asthma medication adherence: a systematic review. *J Asthma* 2014; 51: 536–543.
 49. Harnett CM, Hunt EB, Bowen BR, et al. A study to assess inhaler technique and its potential impact on asthma control in patients attending an asthma clinic. *J Asthma* 2014; 51: 440–445.
 50. Broeders ME, Sanchis J, Levy ML, et al. The ADMIT series—issues in inhalation therapy. 2. Improving technique and clinical effectiveness. *Prim Care Respir J* 2009; 18: 76–82.
 51. Wilson EA, Park DC, Curtis LM, et al. Media and memory: the efficacy of video and print materials for promoting patient education about asthma. *Patient Educ Couns* 2010; 80: 393–398.
 52. Pound P, Britten N, Morgan M, et al. Resisting medicines: a synthesis of qualitative studies of medicine taking. *Soc Sci Med* 2005; 61: 133–155.
 53. Baena-Cagnani CE, Gomez RM, Baena-Cagnani R, et al. Impact of environmental tobacco smoke and active tobacco smoking on the development and outcomes of asthma and rhinitis. *Curr Opin Allergy Clin Immunol* 2009; 9: 136–140.
 54. Mackay D, Haw S, Ayres JG, et al. Smoke-free legislation and hospitalizations for childhood asthma. *N Engl J Med* 2010; 363: 1139–1145.
 55. Menzies D, Nair A, Williamson PA, et al. Respiratory symptoms, pulmonary function, and markers of inflammation among bar workers before and after a legislative ban on smoking in public places. *JAMA* 2006; 296: 1742–1748.
 56. Free C, Knight R, Robertson S, et al. Smoking cessation support delivered via mobile phone text messaging (txt2stop): a single-blind, randomised trial. *Lancet* 2011; 378: 49–55.
 57. Little P, Stuart B, Hobbs FD, et al. An internet-delivered handwashing intervention to modify influenza-like illness and respiratory infection transmission (PRIMIT): a primary care randomised trial. *Lancet* 2015; 386: 1631–1639.
 58. Chiauzzi E, Rodarte C and DasMahapatra P. Patient-centered activity monitoring in the self-management of chronic health conditions. *BMC Med* 2015; 13: 77.
 59. McCarthy B, Casey D, Devane D, et al. Pulmonary rehabilitation for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2015; 2: CD003793.
 60. Paneroni M, Colombo F, Papalia A, et al. Is telerehabilitation a safe and viable option for patients with COPD? A feasibility study. *COPD* 2015; 12: 217–225.
 61. Thomas M, Bruton A, Moffat M, et al. Asthma and psychological dysfunction. *Prim Care Respir J* 2011; 20: 250–256.
 62. Hanania NA, Mullerova H, Locantore NW, et al. Determinants of depression in the ECLIPSE chronic obstructive pulmonary disease cohort. *Am J Respir Crit Care Med* 2011; 183: 604–611.
 63. Andersson G and Cuijpers P. Pros and cons of online cognitive-behavioural therapy. *Br J Psychiatry* 2008; 193: 270–271.
 64. Espie CA, Kyle SD, Williams C, et al. A randomized, placebo-controlled trial of online cognitive behavioral therapy for chronic insomnia disorder delivered via an automated media-rich web application. *Sleep* 2012; 35: 769–781.
 65. Pinnock H and Thomas M. Does self-management prevent severe exacerbations? *Curr Opin Pulm Med* 2015; 21: 95–102.
 66. George M, Keddem S, Barg FK, et al. Urban adults' perceptions of factors influencing asthma control. *J Asthma* 2015; 52: 98–104.
 67. Pinnock H, Adlem L, Gaskin S, et al. Accessibility, clinical effectiveness, and practice costs of providing

- a telephone option for routine asthma reviews: phase IV controlled implementation study. *Br J Gen Pract* 2007; 57: 714–722.
68. Morrison D, Wyke S, Agur K, et al. Digital asthma self-management interventions: a systematic review. *J Med Internet Res* 2014; 16: e51.
 69. McLean S, Nurmatov U, Liu JL, et al. Telehealthcare for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2011; 7: CD007718.
 70. Panagioti M, Richardson G, Murray E, et al. Reducing Care Utilisation through Self-management Interventions (RECURSIVE): a systematic review and meta-analysis. *Health Serv Deliv Res* 2011; 2(54).
 71. Brown J, Michie S, Geraghty AW, et al. A pilot study of StopAdvisor: a theory-based interactive internet-based smoking cessation intervention aimed across the social spectrum. *Addict Behav* 2012; 37: 1365–1370.
 72. Michie S, Brown J, Geraghty AW, et al. Development of StopAdvisor: a theory-based interactive internet-based smoking cessation intervention. *Transl Behav Med* 2012; 2: 263–275.
 73. Brown J, Michie S, Geraghty AW, et al. Internet-based intervention for smoking cessation (StopAdvisor) in people with low and high socioeconomic status: a randomised controlled trial. *Lancet Respir Med* 2014; 2: 997–1006.
 74. Yardley L, Ware LJ, Smith ER, et al. Randomised controlled feasibility trial of a web-based weight management intervention with nurse support for obese patients in primary care. *Int J Behav Nutr Phys Act* 2014; 11: 67.
 75. McLean S, Protti D and Sheikh A. Telehealthcare for long term conditions. *BMJ* 2011; 342: d120.
 76. Steventon A, Bardsley M, Billings J, et al. Effect of telehealth on use of secondary care and mortality: findings from the Whole System Demonstrator cluster randomised trial. *BMJ* 2012; 344: e3874.
 77. Henderson C, Knapp M, Fernandez JL, et al. Cost effectiveness of telehealth for patients with long term conditions (Whole Systems Demonstrator telehealth questionnaire study): nested economic evaluation in a pragmatic, cluster randomised controlled trial. *BMJ* 2013; 346: f1035.
 78. Cartwright M, Hirani SP, Rixon L, et al. Effect of telehealth on quality of life and psychological outcomes over 12 months (Whole Systems Demonstrator telehealth questionnaire study): nested study of patient reported outcomes in a pragmatic, cluster randomised controlled trial. *BMJ* 2013; 346: f653.
 79. Rixon L, Hirani SP, Cartwright M, et al. A RCT of telehealth for COPD patient's quality of life: the whole system demonstrator evaluation. *Clin Respir J* 2015. doi: 10.1111/crj.12359.
 80. 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.
 81. Kenealy TW, Parsons MJG, Rouse APB, et al. Telecare for Diabetes, CHF or COPD: Effect on Quality of Life, Hospital Use and Costs. A Randomised Controlled Trial and Qualitative Evaluation. *PLoS ONE* 2015; 10(3): e0116188. doi:10.1371/journal.pone.0116188.
 82. Williams V, Price J, Hardinge M, et al. Using a mobile health application to support self-management in COPD: a qualitative study. *Brit J Gen Pract* 2014; 64: e392–e400.
 83. Elwyn G, Hardisty AR, Peirce SC, et al. Detecting deterioration in patients with chronic disease using telemonitoring: navigating the 'trough of disillusionment'. *J Eval Clin Pract* 2012; 18: 896–903.
 84. May C, Montori VM and Mair FS. We need minimally disruptive medicine. *Brit Med J* 2009; 339: 485–487.
 85. Kerr C, Murray E, Stevenson F, et al. Interactive health communication applications for chronic disease: patient and carer perspectives. *J Telemed Telecare* 2005; 11: 32–34.
 86. Stelfox M, Chaney B, Ochipka K, et al. YouTube as a source of chronic obstructive pulmonary disease patient education: a social media content analysis. *Chron Respir Dis* 2014; 11: 61–71.
 87. Stelfox M, Chaney B, Chaney D, Paige S, et al. Engaging community stakeholders to evaluate the design, usability, and acceptability of a chronic obstructive pulmonary disease social media resource center. *JMIR Res Protoc* 2015; 4: e17.
 88. Al-Durra M, Torio MB and Cafazzo JA. The use of behavior change theory in internet-based asthma self-management interventions: a systematic review. *J Med Internet Res* 2015; 17: e89.
 89. Huckvale K, Car M, Morrison C, et al. Apps for asthma self-management: a systematic assessment of content and tools. *BMC Med* 2012; 10: 144.
 90. Huckvale K, Morrison C, Ouyang J, et al. The evolution of mobile apps for asthma: an updated systematic assessment of content and tools. *BMC Med* 2015; 13: 58.

91. Tao D, Xie LY, Wang TY, et al. A meta-analysis of the use of electronic reminders for patient adherence to medication in chronic disease care. *J Telemed Telecare* 2015; 21: 3–13.
92. Nieuwlaat R, Wilczynski N, Navarro T, et al. Interventions for enhancing medication adherence. *Cochrane Database Syst Rev* 2014; 11: CD000011.
93. Aarne L. Guided self management of asthma – how to do it. *BMJ* 1999; 319: 759–760.
94. Thomas M. Why aren't we doing better in asthma: time for personalised medicine? *NPJ Prim Care Respir Med* 2015; 25: 15004.
95. Kirby S, Donovan-Hall M and Yardley L. Measuring barriers to adherence: validation of the problematic experiences of therapy scale. *Disabil Rehabil* 2014; 36: 1924–1929.
96. Murray E, Treweek S, Pope C, et al. Normalisation process theory: a framework for developing, evaluating and implementing complex interventions. *BMC Med* 2010; 8: 63.
97. Yardley L, Morrison L, Bradbury K, et al. The person-based approach to intervention development: application to digital health-related behavior change interventions. *J Med Internet Res* 2015; 17: e30.