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REVIEW

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Effects of self-management interventions with behavior-change support on long-term adherence in patients with chronic respiratory diseases: A systematic review

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Abstract: The aim of this systematic review is to determine the effects of self-management interventions with behavior-change support on medication adherence and smoking cessation in patients with chronic respiratory disease. We also describe the theories of health behavior change and behavior change techniques (BCTs) used to design these interventions and their mode of delivery. The PubMed/MEDLINE, Cochrane Library, CINAHL, and Pedro databases were systematically searched for relevant articles published up to November 2021. Randomized controlled trials (RCTs) that evaluated the effect of self-management interventions with behavior change support on medication adherence, correct inhaler use, and smoking cessation were included. Effect sizes (odds ratios) with 95% confidence intervals were calculated and pooled for random-effect meta-analysis. Of 5,223 articles identified, 15 were RCTs that met the inclusion criteria for the meta-analysis. Five of these RCTs were based on behavior change theory, including social cognitive theory and a transtheoretical model. Between one and eight components of BCTs in Behavior Change Technique (BCT) Taxonomy version1 were included in all interventions. The most frequent BCT components were social support (emotional) (n = 8), instruction on how to perform the behavior (n = 8), and goal setting (behavior) (n = 7). Meta-analysis showed that self-management interventions with behavior change support have positive effects on medication adherence, correct inhaler use, and smoking cessation for more than 6 months after their implementation. This indicates that individually tailored self-management interventions with behavior change support are effective in improving long-term medication adherence and smoking cessation in patients with chronic respiratory disease.

***Keywords*:** behavior change theory, health science, behavior change techniques, self-care

Introduction

Medication adherence and smoking cessation are essential components of managing patients with chronic respiratory disease. According to the World Health Organization, adherence to long-term therapy is defined as the extent to which a person's behavior – taking medication, following a diet, and/or executing lifestyles changes – corresponds to agreed recommendations from a health care provider (*1*). However, adherence is influenced by social and economic factors, the characteristics of the disease, and patient-related factors (*1*). Adherence to medication is less than 50% in many patients with chronic obstructive lung disease (COPD) because of patient-related factors, which include depression and beliefs and concerns about medication (*2*). Lack of confidence in inhaler use is also associated with lower adherence in these patients (*3*).

It has been suggested that interventions based on behavior change theory are more effective in improving adherence in people with chronic respiratory disease (*4,5*). Since the 1990s, studies in Japan and overseas have reported that approaches for enhancing self-efficacy are effective in changing patients' behavior, and the use of these approaches became more widespread in the 2000s (*6*). The respiratory rehabilitation statement published in Japan in 2018 stated that education on self-management for patients with respiratory disease should support behavior change to promote and maintain health and increase adherence (*7*). COPD was one of the major chronic respiratory diseases highlighted in Health Japan 21 (second term) (*8*), and there is an increasing focus on the importance of preventing exacerbations and disease progression. However, there is limited information on the long-term effects of behavior change interventions based on behavioral science on medication

adherence and smoking cessation from meta-analysis of randomized controlled trials (RCTs). Moreover, there are limited data on the components of behavior change intervention that are effective.

This systematic review aimed to determine the long-term effects of self-management interventions with behavior change support on medication adherence and smoking cessation in patients with chronic respiratory disease by meta-analysis of RCTs. We also aimed to identify the extent to which behavior change theory and BCTs have been implemented, the mode of delivery used for the interventions (how: place of delivery, provider, delivery format) and the components of interventions (what). We also investigated the effects of correct inhaler use, which is another important component of medication adherence by meta-analysis.

Method

Protocol and objective

This systematic review is reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 statement (*9*) but was not registered in advance.

Literature search and study inclusion process

Search strategy and databases

The PubMed/MEDLINE, Cochrane Library, Cumulative Index to Nursing & Allied Health Literature (CINAHL), and Pedro databases were searched to identify relevant articles published up to November 2021. The search strategy was adapted to each database, and the search terms are shown in Table 1.

Inclusion criteria

RCTs (including feasibility and pilot studies) that evaluated the effects of self-management interventions supporting behavior change on medication adherence, correct inhaler use, and smoking cessation were sought. Medication adherence was assessed by the number of participants who were adherent. Correct inhaler use was assessed based on the number of participants who followed the steps for inhaling medication from the inhalation device correctly. Studies that reported medication adherence and smoking cessation were included even if these were not the primary outcomes.

The eligibility criteria were as follows: intervention that can be implemented at home with self-management; study participants aged 18 years or older; chronic respiratory disease diagnosed by a physician; implementation of a psychological or behavioral self-management intervention or mention of the term "behavior change", "health behavior" or "behavioral intervention"; outcome assessment at more than 6 months the start of intervention; and a full-text version published in English.

Exclusion criteria

Studies that targeted a combination of respiratory and non-respiratory diseases were excluded, as were those published as quasi-randomized trials, systematic reviews, letters, editorials, cross-sectional studies, and case reports.

Outcome measurements

Eligible studies from the literature search could use self-report or objective measurements for medication adherence, and self-report or biochemical verification for smoking cessation.

Data extraction

Three reviewers (JN, AT, MF) independently screened titles and retrieved abstracts to identify studies that met the inclusion criteria. Full-text screening was performed for studies that could not be confidently excluded. The full texts of potentially eligible studies were retrieved and assessed for eligibility by one reviewer (MF). Disagreements and questions were resolved by consensus at discussion meetings attended by all reviewers.

The individual components of the behavior change intervention described in the included studies were extracted and classified in accordance with the BCT Taxonomy version 1 (BCTTv1) (*10,11*), which was developed to identify individual components of behavior change interventions and enable accurate reporting and replication of content.

Table 1. Search terms used in electronic database search

PICs component	Search terms
Patient	"chronic respiratory disease", "chronic respiratory failure", "Respiratory Tract Disease", "Respiratory Tract Disorder", "Respiratory Disease", "Lung Disease", "Chronic Lung Disease", "Pulmonary Disease"
Intervention	"behavior therap*", "behaviour therap*", "behavior change", "behaviour change", "behavior modification", "behaviour modification", "behavior intervention", "behaviour intervention", "behavioral intervention", "self manag*", self-management, self-care, self-car*, self-report*, home-based, home
Comparison	trial, randomized, RCT

*the wildcard character.

Quality assessment

The quality of the studies was assessed using the Cochrane Collaboration's tool for assessing the risk of bias (version 2.0). This tool includes five or six domains of bias depending on the method used for randomization. Five domains are used for parallel-group trials in which study participants are individually randomized: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported result. A sixth domain, namely, bias arising from the timing of identification and recruitment of participants, is added for cluster-randomized trials. The risk of bias was assessed by two authors (YT, MF) working independently. Any disagreements were resolved by discussion; if a decision could not be reached, a final decision was made at a consensus meeting attended by all the authors.

Statistical analysis

All statistical analyses were performed using Review Manager (RevMan) version 5.4. (*12*). Odds ratio (OR) were calculated along with their 95% confidence intervals (CIs). Assuming a degree of heterogeneity between the interventions, the data were pooled using a random-effects model. Statistical heterogeneity between study outcomes was assessed using the I^2 statistic according to the method outlined by Higgins *et al.* (*13*). I^2 values of 25%, 50%, and 75% are considered to indicate low, moderate, and high heterogeneity, respectively (*13*). In the case of high heterogeneity (I^2 > 75%), a subgroup analysis was performed to identify any valid causes. A sensitivity analysis was conducted if necessary.

Results

Study selection

The literature search up to November 2021 identified 9,528 records, 4,305 of which were found to be duplicates and were excluded. After screening of titles and abstracts, 5,031 studies were excluded, leaving 192 for full-text review. From the results of the review, 158 studies were excluded based on the eligibility criteria and 19 were excluded because their data were reported in an inappropriate format. Finally, data could be extracted from 15 studies that met the eligibility criteria. The outcome of the search process and study selection is shown in Figure 1.

Study characteristics

Overview of studies

The characteristics of the 15 studies are summarized in Table 2. All the studies were published between 2004 and 2021. Two studies each were performed in China (*14,15*), Israel (*16,17*), the Netherlands (*18,19*), and the UK (*20,21*); one study each was performed in Australia (*22*), Denmark (*23*), Iran (*24*), Jordan (*25*), Spain (*26*),

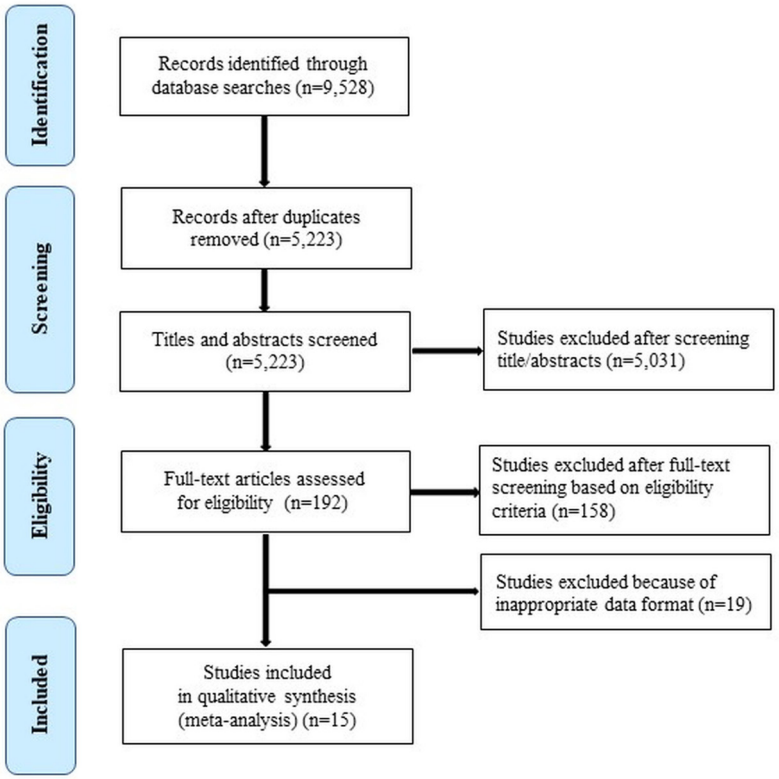

Figure 1. PRISMA flow-diagram of the study selection process.

Table 2. Characteristics of studies included

Author, year (*Ref.*)	Participants (illness, lung function, sex, age)	Comparison	Intervention Component, delivery place, who delivered	Theory	Outcome/ measurement	End point
Borglykke *et al.*, 2008 (*23*)	COPD (admitted with acute exacerbation) FEV_1 %: - Male: Ex 35%, Con 36% Mean Age: Ex 65, Con 67	Control: Received standard information on the benefits of smoking	Smoking cessation groups (SCG): Weekly 2-h sessions over 5 weeks, three sessions after the quitting date, follow-up session after 3 months Hospitalized setting; nurses	Not described	Smoking cessation rate/ Self-report and carboxyhemoglobin	1Y
Garcia-Aymerich *et al.*, 2007 (*26*)	COPD FEV_1 1.2 ± 0.5L Male 86 %, Age 73 ± 8	Usual care: Pharmacological prescriptions and treatment followed the standard protocols of the center	Integrated care (IC): A 2-h educational session at discharge, individually tailored care plan (visit patient's home within 72 h after discharge, weekly phone calls during the first month after discharge, and one phone call at 3 and 9 months after discharge), access through an ICT[*2] platform Primary care setting and home; physician, nurse, social worker	Not described	Medication adherence scale, Inhaler Adherence Scale, observed skills for administration of inhaled drugs	12M
Hesselink *et al.*, 2004 (*18*)	Asthma, COPD or mixed Pre-FEV_1 % predicted: Ex 81.9 ± 22.6 Con 84.7 ± 23.4 Male: Ex 35%, Con 28% Age: Ex 49.9 ± 14.2, Con 44.7 ± 13.6	Usual care: Continued to receive usual-care from GPs	Education program: One to four 30-min semi-structured consultations (giving information, individual training regarding inhalation technique, discussion about barriers in coping with the disease, a supportive smoking cessation program, advice about when to consult a doctor, provide free booklets) Primary care setting; general practice assistants	Not described	Inhalation technique/ checklist developed by the Dutch Asthma Foundation, medication use/three-item checklist	2Y
Hilberink *et al.*, 2005 (*19*)	COPD FEV_1 %: - Male: Ex 46.3%, Con 55.4% Age: Ex 58.0 ± 12.1, Con 60.1 ± 11.5	Usual care: (Not described in detail)	Smoking Cessation in patients with COPD (SMOCC): A 4-h group training session, outreach visits and telephone calls depending on the motivational stage, delivering support materials General practices and home; GP and nurses	Trans theoretical model/	Point prevalence/ self-report and biochemical analysis	6M
Jarab *et al.*, 2012 (*25*)	COPD FEV_1 predicted (%) Ex 53.7 ± 15.9, Con 52.8 ± 17.8 Male: Ex 39.4%, Con 41.8% Age (median, IQR): Ex 61(14), Con 64(15)	Control group: (Not described in detail)	Pharmaceutical care program: Intensive education (no repeated process) making a medication table, discussion about the importance of exercise, symptom control and techniques for expectoration, providing a booklet Outpatient clinic; pharmacist	Not described	Medication adherence (Morisky Scale)/ self-report	6M
Jolly *et al.*, 2018 (*20*)	COPD meanFEV_1 predicted (%): 71.6% Male: EX 63%, Con 64% Mean Age: Ex 70.7 ± 8.8, Con 70.2 ± 7.8	Usual care: Received a standard information leaflet about self- management of COPD	Telephone health coaching intervention: Telephone coaching session for 35-60 min, 15-20 min telephone sessions at weeks 3, 7, and 11, providing standard written prompts or information at weeks 16 and 24 Home; Nurses	Social Cognitive Theory	Attempted to quit smoking in past 6 month/ self-report	12M

Abbreviations: Ex, experimental; Con, control; COPD, chronic obstructive pulmonary disease; ICT = information and communication technologies; NRT, nicotine replacement therapy; SPACE, Self-Management Program of Activity, Coping and Education; Y = years; M = months.

Table 2. Characteristics of studies included (continued)

Author, year (*Ref.*)	Participants (illness, lung function, sex, age)	Comparison	Intervention Component, delivery place, who delivered	Theory	Outcome/ measurement	End point
Kalter-Leibovici *et al.*, 2018 (*17*)	COPD FEV_1% predicted Ex 43.8 ± 10.8 Con 44.1 ± 10.0 Male: Ex 69.0%, Con 73.3% Age: Ex 66.7 ± 9.9 Con 68.3 ± 10.0	Recommended care alone: Received selfcare education, follow-up by pulmonologists, treatment with medication and oxygen, dietary advice, psychosocial support, smoking cessation group sessions and prescriptions for smoking cessation medications, physical exercise sessions	Recommended care plus disease management Disease management: Face-to-face sessions during patients' visits, remote contacts between visits, monitoring disease signs and symptoms, educational sessions for caregivers Community-based COPD centers; pulmonologists and nurses	Not described	Quit smoking/ patients' reports	3Y
Kessler *et al.*, 2018 (*28*)	COPD FEV_1% predicted Ex 37.8 ± 12.4, Con 36.4 ± 12.3 Male: Ex 69.4%, Con69.8% Age: Ex 67.3 ± 8.9, Con 66.6 ± 9.6	Received the usual or routine COPD care	Multicomponent home-based disease management intervention (COMET): Four individual home sessions over 5 weeks, monthly group or individual telephone sessions for 12-24 months, home monitoring at least once per week, an e-health telephone/web platform. Home; case managers and hospital physician	Not described	Smoking habits/ measurement: not described in detail	12M
Khdour *et al.*, 2020 (*16*)	Asthma FEV_1%: Ex 72.4 ± 15.2, Con 69.2 ± 14.4 Male: Ex 43.2%, Con 38.6% Age >60: Ex 25.2%, Con 21.6%	Usual care: Arranged by the hospital without any structured interventions	Pharmaceutical care in asthma management: Adherence assessment and education on an individual basis, inhaler techniques training, follow-up telephone calls, provide action plans, written medication lists and an asthma manual booklet Outpatient clinic and home; Pharmacist	Concern and beliefs	Medication adherence/ Morisky Scale, Inhaler technique/Standardized checklists	12M
Liang *et al.*, 2019 (*22*)	COPD FEV_1% predicted Ex 69.0 ± 20.5, Con 70.8 ± 19.3 Male: Ex 60.5%, Con 62.6% Age: Ex 66.6 ± 10.8 Con 61.7 ± 10.1	Usual care: Continued to provide routine care, given the Lung Foundation Australia booklet. Quitline referral was provided to smokers.	Interdisciplinary primary care: Individualized smoking cessation support consisted of brief counseling and "quitline" referral, prescription medications for smoking cessation, interview at home by pharmacist, education focusing on medication use, an 8-week home-based pulmonary rehabilitation consisting of one home visit and weekly follow-up telephone calls. General practitioners, clinic staff, pharmacist, physiotherapist	Not described	7-day point prevalence smoking abstinence/ biochemical analysis	6M
Lou *et al.*, 2013 (*14*)	COPD FEV_1%: - Male: Ex 48%, Con 48% Age: Ex 61.6 ± 10.2 Con 61.5 ± 10.1	Usual care: Treated in the usual manner	Behavioral intervention program: Brief smoking cessation advice and discussion for 5-8 min, home visits at least once a week, follow-up once a week during the first month and once a month until the end of the study, providing a booklet Healthcare centers and home; general practitioners	Not described	Continuous smoking abstinence rates/ Self-report and expired carbon monoxide level	4Y

Abbreviations: Ex, experimental; Con, control; COPD, chronic obstructive pulmonary disease; ICT = information and communication technologies; NRT, nicotine replacement therapy; SPACE, Self-Management Program of Activity, Coping and Education; Y = years; M = months.

Table 2. Characteristics of studies included (continued)

Author, year (*Ref.*)	Participants (illness, lung function, sex, age)	Comparison	Intervention Component, delivery place, who delivered	Theory	Outcome/ measurement	End point
Mitchell *et al.*, 2014 (*21*)	COPD FEV_1 % predicted Ex 56.04 ± 16.76, Con 59.60 ± 17.42 Male: Ex 60.6%, Con 49.4% Age: Ex 69 ± 8.0, Con 69 ± 10.1	Usual care: (Not described in detail)	SPACE for COPD: Work with SPACE for COPD manual over 6 weeks, a 30-45 min consultation, telephone calls at 2 and 4 weeks Primary care settings and home; physiotherapist	Readiness to change	Smoking status/ Self-report	6M
Sharifpour *et al.*, 2020 (*24*)	COPD FEV_1 act: Ex 1.91 ± 0.7, Con 1.94 ± 0.74 Male: 100% Age: Ex 54 ± 8, Con 56 ± 10	NRT	Guided self change + NRT: Five 1-h sessions over 5 weeks, including individual counseling, NRT, telephone follow ups Hospital and home; psychotherapist	Trans theoretical model	Smoking abstinence/ self-report	29W
Wang *et al.*, 2021 (*15*)	COPD FEV_1 % predicted Ex 43.7 ± 13.2, Con 45.4 ± 11.5 Male: Ex 66.7 %, Con 74.4% Age: Ex 63.2 ± 7.5, Con 64.4 ± 7.0	Control group: Received routine care, which included health education	Mobile health application program: Knowledge and information support, visual aids to teach participants skills to manage the disease, motivational support (Not described in detail)	Not described	Smoking abstinence/ self-report	12M
Willard-Grace *et al.*, 2020 (*27*)	COPD FEV_1 % predicted: 58 ± 20 Male: 65.5% Age: 61.3 ± 7.6	Usual care: Received resources provided by their clinic	Health coaching intervention: Accompanied to visits with clinicians, met individually in the community or at their home, telephone calls at least once every three weeks Primary care setting and home; health coaches, pulmonary specialists	Not described	Medication adherence/ patient-report, inhaler use/ observation and checklist	9M

Abbreviations: Ex, experimental; Con, control; COPD, chronic obstructive pulmonary disease; ICT = information and communication technologies; NRT, nicotine replacement therapy; SPACE, Self-Management Program of Activity, Coping and Education; Y = years; M = months.

and the US (*27*); and one study was a collaboration of European countries (France, Germany, Italy, and Spain) (*28*). The period between the start of the intervention and the final follow-up ranged from 6 to 48 months. The interventions were delivered by various health-related occupations.

Most commonly, in 12 studies, the intervention was conducted on an individual basis from the start of the intervention or was group-based with follow-up on an individual basis (*14,15,16,18-22,24,26-28*), and follow-up was carried out by telephone in 10 studies (*15,16,19,20-22,24,26-28*). One of these studies also used information and communications technology and a web platform (*28*).

Illness and severity

The most common respiratory disease was COPD (*14,15,17,19-28*) followed by asthma (*16,18*), and mixed COPD-asthma (*18*) (Table 2). Five of the 11 studies targeting patients with COPD (*17,20,21,27,28*) described the severity of COPD according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guideline (*29*), which was used as the basis for the Guideline for the Management of Chronic Obstructive Pulmonary Disease published by the Japanese Respiratory Society (*30*). The study by Jolly *et al.* (*20*) targeted patients with mild-to-moderate COPD. Mitchell *et al.* (*21*) included all stages of COPD, with the majority (60.3%) of patients classified as having moderate disease. Kalter-Leibovici *et al.* (*17*) and Kessler *et al.* (*28*) only included patients with severe COPD; severe exacerbations were also included in the study by Kessler *et al.* (*28*). The study by Willard-Grace *et al.* (*27*) targeted patients with moderate-to-severe COPD. The remaining seven studies (*14,19,22-26*) did not use the GOLD classification. Three of the studies, namely those by Garcia-Aymerich *et al.* (*26*), Borglykke *et al.* (*23*), and Wang *et al.* (*15*), included patients admitted with symptoms of acute exacerbation; the remaining four studies did not report the criteria used to determine severity.

Assessment of outcomes

The measurement methods used are summarized in Table 2.

Medication adherence was assessed by a questionnaire in three studies (*16,25,26*), a standardized checklist in one study (*18*), and by direct interview in another study (*27*). For the purposes of this review, the authors extracted the number of patients who were reported as adherent with medication from each study.

Correct inhaler use was evaluated by observation using a checklist in two studies *(16,27)* and by observation only in one study (*26*). Data for another study (*20*) that reported the number of participants who received an inhaler check followed by recommendations was also included in the meta-analysis.

Smoking status and abstinence rates were measured by self-report in nine studies, four of which also included biochemical verification (*14,19,22,23*). Only two of these studies defined smoking cessation (*i.e.*, abstinence from cigarettes during the previous 7 days) *(19,22)*.

Quality assessment

The results of the quality assessment using the Cochrane risk of bias tool are shown in Figure 2. An individually parallel randomized tool was used in 12 studies and a cluster parallel randomized tool was used in three studies. The most common types of bias identified were

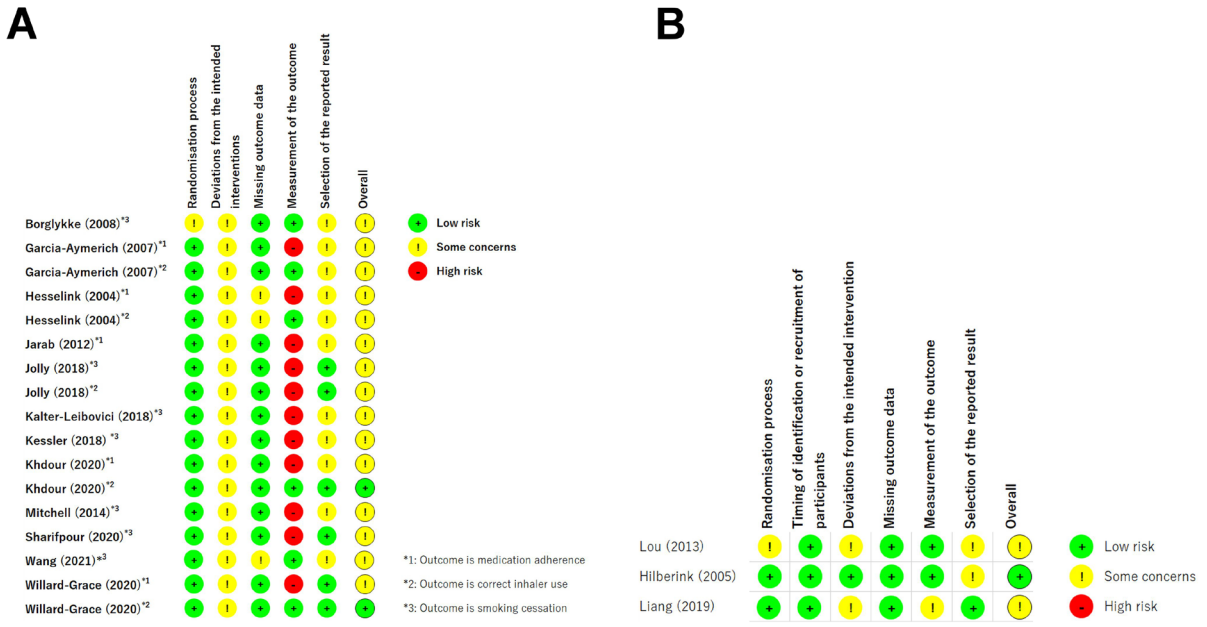

Figure 2. Risk of bias of individual domains across included randomized trials. (A) Individually randomized trials; (B) Cluster-randomized trials.

bias due to deviations from intended interventions, bias in measurement of the outcome, and bias in selection of the reported result. All methods used to measure medication adherence and most of those used to measure smoking cessation adherence were based on self-reported questionnaires. This is one of the limitations of this review. However, bias arising from deviations from intended interventions was unavoidable because all study participants would have been aware of their assigned intervention during the trial. Bias in terms of selection of the reported result reflects the fact that most of the details concerning the research protocols used were not available.

Behavior change theories or techniques used in self-management interventions

One study used social cognitive theory (*20*), three used a transtheoretical model that included readiness to change (*19,21,24*), and one mentioned consideration of participants' concerns and beliefs but did not report application of a specific theory (*16*) (Table 2). Ten studies did not mention behavior change theory.

Between one and eight BCTs categorized with reference to BCTTv1 were included in all interventions (Table 3). Overall, the most frequent BCT components were social support (emotional) (n = 8), instruction on how to perform the behavior (n = 8), and goal setting (behavior) (n = 7).

The most frequent components for promoting behavior change and adherence with medication were instruction on how to perform the behavior (n = 5) (*16,18,20,26,27*), followed by goal setting (behavior) (n = 3) (*16,20,27*) and problem solving (n = 3) (*18,20,27*).

For smoking cessation, social support (emotional) (n = 6) (*14,15,17,21,22,24*) was used most frequently, followed by goal setting (behavior) (n = 5) (*14,19,20,23,24*) and pharmacological support (n = 5) (*17,19,22-24*). Of the five studies that used pharmacological support, two also included this component for the purposes of comparison between groups (*17,24*).

Effects of self-management based on behavior change interventions to promote adherence

i) Smoking cessation

Ten studies were included in a random-effects meta-analysis (*14,15,17,19-24,28*). These studies included 5,406 patients with COPD (intervention groups, n = 2,838; control groups, n = 2,568). In four studies (*14,19,23,24*), all participants were smokers at baseline and received self-management intervention specifically for smoking cessation. In the other six studies (*15,17,20-22,28*), not all participants were smokers; in these studies, smoking cessation was included as part of a multicomponent intervention and the only data provided for smoking cessation was for patients who were smokers at baseline. Meta-analysis revealed that the number of participants who quit smoking was significantly higher in the intervention group than in the control group (OR: 2.91, 95% CI: 1.20-7.06, p = 0.02; Figure 3).

The statistical heterogeneity was high (I^2 = 92%) and was explored by sensitivity and subgroup analyses. The sensitivity analysis was performed by removing each study one by one and confirmed that the result was not markedly affected by any single study. Subgroup analyses were conducted to separate studies according to severity of illness, differences in components of the intervention, outcome measurements, and duration of follow-up. When the studies were grouped by severity of illness, there was a distinction between studies that included patients with severe or exacerbated COPD (15,17,23,28) and those that included all stages of COPD (14,19-22,24). The sub-group analyses showed that the intervention improved adherence to smoking cessation among only participants with severe or exacerbated COPD (OR: 2.57, 95% CI: 1.54-4.28, p = 0.0003; Figure 4). Other subgroup analyses did not significantly change the heterogeneity.

ii) Medication adherence

Five studies were subjected to random-effects meta-analysis (*16,18,26,27*). These studies included 725 participants (intervention groups, n = 353; control groups, n = 372).

Pharmacological support was the only intervention in three studies (*16,25,27*) and part of a multicomponent intervention in two studies (*18,26*).

Meta-analysis showed that the number of adherent participants was higher in the intervention group than in the control group (OR: 2.27, 95% CI: 1.57-3.27, p < 0.0001; Figure 5). The statistical heterogeneity was low (I^2 = 0%).

iii) Correct inhaler use

Five studies were included in a random-effects meta-analysis (*16,18,20,26,27*). These studies included 1,104 participants (intervention groups, n = 533; control groups, n = 571). The meta-analysis showed that the number of participants who used their inhalers correctly was higher in the intervention group than in the control group (OR: 4.07, 95% CI: 1.66-9.96, p = 0.002; Figure 6). The statistical heterogeneity was high (I^2 = 88%) and explored by sensitivity and subgroup analyses. A sensitivity analysis, which was conducted by removing a study one by one showed that the result was not markedly affected by any single study. Subgroup analysis according to type and severity of disease did not change the I^2 value.

Discussion

Previous systematic reviews in patients with chronic respiratory diseases have shown that behavior change support is effective in improving adherence (*4,31*). However, the present systematic review is the first

Table 3. Frequency of behavior change techniques identified in trials

Author, year (*Ref.*)	1. Goals and planning	2. Feedback and monitoring	3. Social support	4. Shaping knowledge	5. Natural consequences	11. Regulation	12. Antecedents
Borglykke *et al.*, 2008 (*23*)	1.1. Goal setting (behavior)		3.1. Social support (unspecified)			11.1. Pharmacological support	
Garcia-Aymerich *et al.*, 2007 (*26*)	1.4. Action planning			4.1. Instruction on how to perform the behavior			
Hesselink *et al.*, 2004 (*18*)	1.2. Problem solving	2.5. Monitoring of outcomes of behavior without feedback		4.1. Instruction on how to perform the behavior			
Hilberink *et al.*, 2005 (*19*)	1.1. Goal setting (behavior) 1.2. Problem solving				5.1. Information about health consequences	11.1. Pharmacological support	
Jarab *et al.*, 2012 (*25*)			3.3. Social support (emotional)				
Jolly *et al.*, 2018 (*20*)	1.1. Goal setting (behavior) 1.2. Problem solving 1.5. review behavior goal	2.2. Feedback on behavior 2.3. Self-monitoring of behavior		4.1. Instruction on how to perform the behavior			
Kalter-Leibovici *et al.*, 2018 (*17*)	1.4. Action planning	2.1. Monitoring of behavior by others without feedback 2.7. Feedback on outcomes of behavior	3.3. social support (emotional)			11.1. Pharmacological support	
Kessler *et al.*, 2018 (*28*)	1.3. Goal setting (outcome) 1.4. Action planning	2.6. Biofeedback					
Khdour *et al.*, 2020 (*16*)	1.1. Goal setting (behavior) 1.4. Action planning		3.3. Social support (emotional)	4.1. Instruction on how to perform the behavior			
Liang *et al.*, 2019 (*22*)			3.3. Social support (emotional)	4.1. Instruction on how to perform the behavior		11.1. Pharmacological support	
Lou *et al.*, 2013 (*14*)	1.1. Goal setting (behavior)	2.1. Monitoring of behavior by others without feedback 2.6. Bio feedback	3.1. Social support (unspecified) 3.3. Social support (emotional)		5.1. Information about health consequences 5.2. Salience of consequences		12.4. Distraction
Mitchell *et al.*, 2014 (*21*)	1.4. Action planning	2.3. Self-monitoring of behavior	3.3. Social support (emotional)	4.1. Instruction on how to perform the behavior			
Sharifpour *et al.*, 2020 (*24*)	1.1. Goal setting (behavior) 1.2. Problem solving	2.2. Feedback on behavior 2.3. Self-monitoring of behavior	3.3. Social support (emotional)		5.4. Monitoring of emotional consequences	11.1. Pharmacological support	
Wang *et al.*, 2021 (*15*)			3.3. Social support (emotional)	4.1. Instruction on how to perform the behavior			
Willard-Grace *et al.*, 2020 (*27*)	1.1. Goal setting (behavior) 1.2. Problem solving	2.2. Feedback on behavior		4.1. Instruction on how to perform the behavior			

The numbers are classification numbers of BcTTv1.

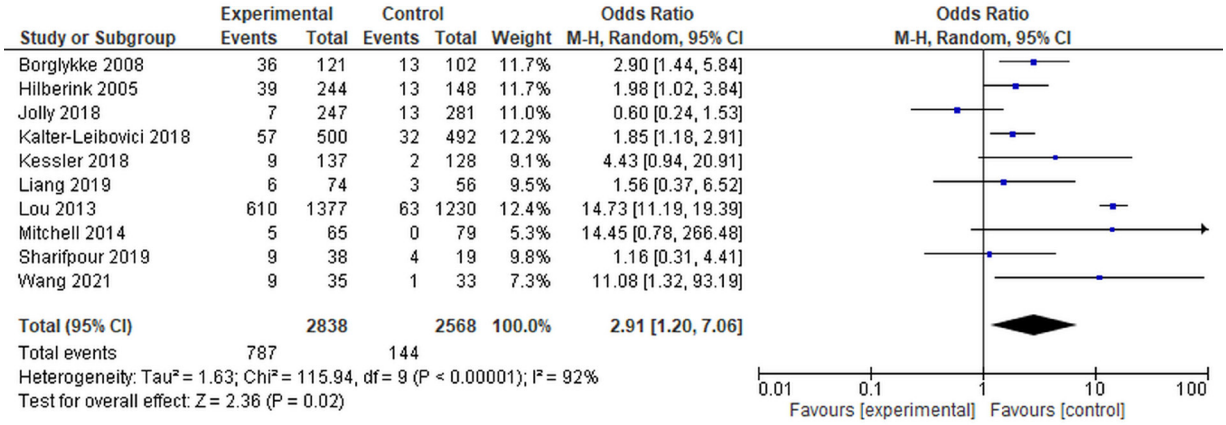

Figure 3. Meta-analysis to estimate the effect of self-management interventions with behavior support on smoking cessation.

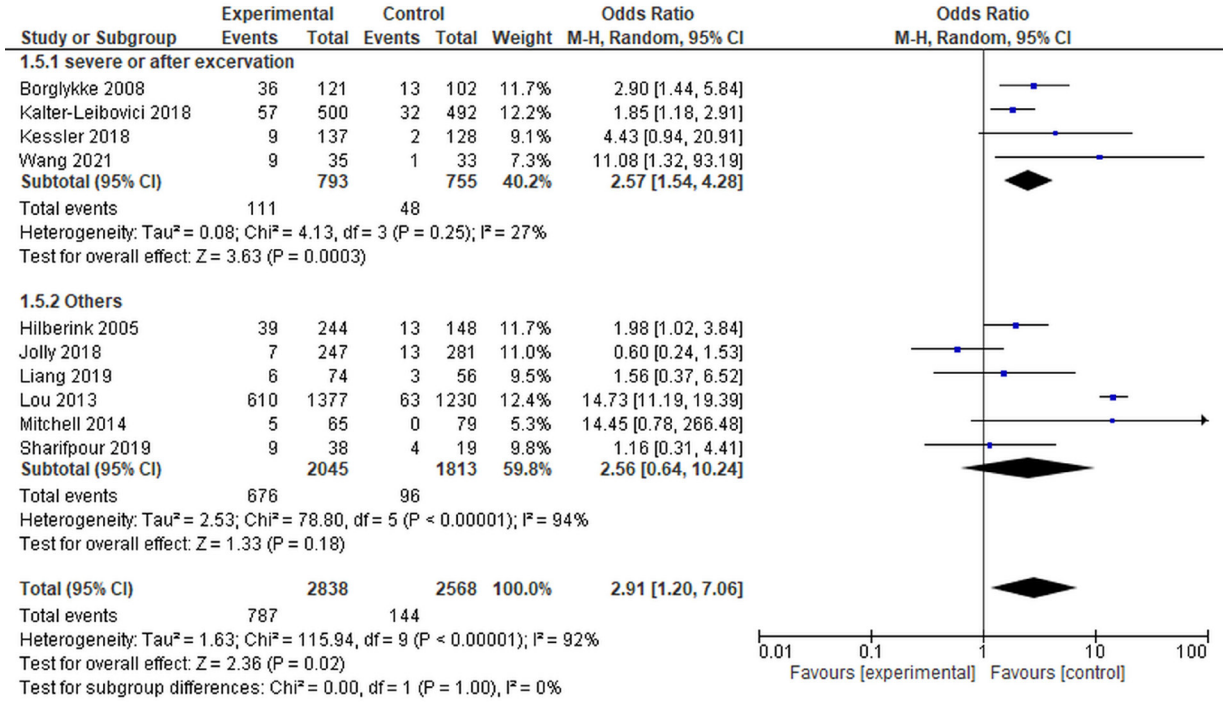

Figure 4. Sub-group analysis of smoking cessation grouped by severity of illness.

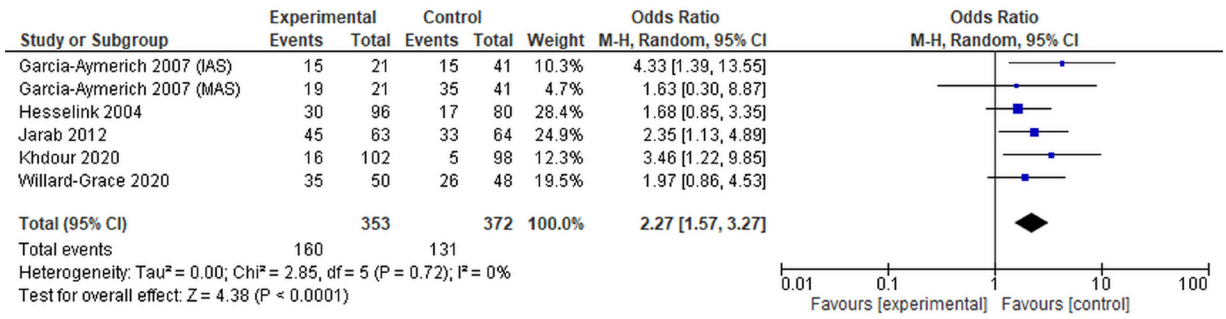

Figure 5. Meta-analysis to estimate the effect of self-management interventions with behavior support on medication adherence.

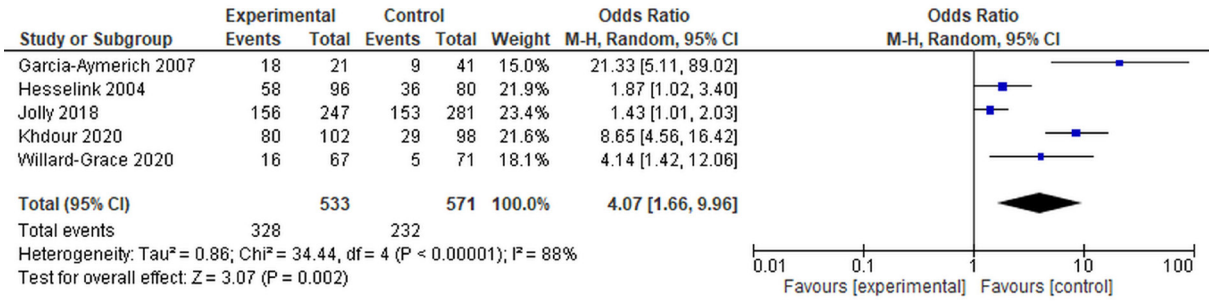

Figure 6. Meta-analysis to estimate the effect of self-management interventions with behavior support on correct inhaler use.

to examine the long-term effects of self-management interventions with behavior change support to improve medication adherence, smoking cessation, and correct inhaler use in patients with chronic respiratory disease. It is also the first aiming to classify the contents of interventions by behavior change technique (BcTTv1). All three components are essential for these patients to be able to manage their disease. Our findings suggest that interventions with behavior change support achieve better rates of medication adherence and smoking cessation than interventions without behavior support and that these effects can persist for at least 6 months after implementation. According to the transtheoretical model of health behavior change, the maintenance stage is estimated to last from 6 months to about 5 years (*32*), which suggests the importance of supporting the transition to the maintenance stage in patients with chronic disease.

As reported elsewhere (*4*), many of the studies included in our meta-analysis were not based on behavior change theories for the development of the interventions and none of the interventions were developed based on BCTs. Several BCTs included in intervention strategies were extracted by referring to the BCTTv1 (Table 3).

For smoking cessation, social support (emotional) (n = 6) (*14,15,17,21,22,24*) was used most frequently, followed by goal setting (behavior) (n = 5) (*14,19,20,23,24*) and pharmacological support (n = 5) (*17,19,22-24*). Emotional support such as motivational interviews may be important when self-efficacy is diminished by chronic illness. There have been reports of code classifications being devised for effective BCTs that suggest behavioral support accompanied by BCTs contributes to smoking cessation (*33,34*). Goal setting (behavior), pharmacological support, and information about health consequences have been reported to be the most promising BCTs for maintaining smoking cessation after leaving a smoking cessation facility (*34*), which is in line with our findings.

When subgroup analysis was performed, heterogeneity (I^2) was reduced when studies were divided according to severity of COPD (degree of airflow obstruction and acute exacerbation). Therefore, behavior change interventions may be more effective in patients with more severe airflow obstruction and in those who have experienced acute exacerbation of COPD. However, some reports suggest an association between the FEV_1/FVC and the likelihood of successful smoking cessation in patients with COPD (*35*), while other researchers have found no association between the severity of airflow obstruction and the effect of pharmacological treatment on smoking cessation (*5*). However, given the small number of studies included in this review, further investigations are needed.

Interventions with behavior support were more likely to achieve optimal long-term medication adherence and correct inhaler use than those that did not include behavior support. Subgroup analysis did not alter the high heterogeneity (I^2) of the results for correct inhaler use. This can be attributed to the small number of studies and the different measurement methods used in the studies. However, all studies found differences in outcomes between the intervention and control groups, suggesting that the intervention improved adherence. Although there has been limited research on supporting medication adherence with BCTs, there has been a study in which 11 theory-based BCTs was selected to improve medication adherence in older adults (*36*), and the importance of taking into account each patient's individual needs and adopting a tailored approach to delivery of BCTs has been noted (*37*).

With the exception of one study, all interventions adopted repeated processes and patients in the intervention groups were followed up remotely by telephone or *via* a website platform. The components of the interventions were tailored individually according to each patient's specific needs. The previous study reported that person-centered support *via* telephone can mitigate worsening self-efficacy in patients with COPD by supporting and strengthening their ability and self-esteem (*38*). Our analysis suggests that individually tailored self-management interventions with health behavior change support were effective in improving medication adherence and smoking cessation. However, our review may contain a degree of bias toward BCTs that are easier to provide remotely. Various remote devices have been developed in recent years, so further research is needed to confirm the elements of an

intervention that support self-management of patients with chronic respiratory disease.

This review has several limitations. First, none of the intervention strategies was developed in accordance with the BCTTv1. We did not contact any authors to obtain unpublished data, so we could not extract information on behavior change theories that were not explicitly stated but may have been used, and it was also difficult to code and classify the components of BCTs according to the authors' intentions. Furthermore, it was not possible to classify the BCTs used in the control groups because too little detail was provided. Second, medication adherence and smoking cessation were assessed by self-report, which may have introduced a degree of reporting bias. Only one study provided a definition of smoking cessation and not all studies reported the duration of abstinence from smoking. Moreover, although we included the number of participants reported to be adherent with medication in each study in our meta-analysis, the assessment criteria varied from study to study and may have influenced our results. Third, we included studies with a duration of at least 6 months from the implementation of interventions and analyzed the data measured at the final follow-up, so the measurement timing may have affected adherence. Fourth, although this review did not impose limits on the types of respiratory disease that could be included, most of the studies targeted patients with COPD. Therefore, our findings may be biased towards the characteristics of this patient population.

Conclusion

This review and meta-analysis demonstrated that self-management interventions with behavior change support improve adherence to smoking cessation, medication, and correct inhaler use and that the improvements can be maintained for at least 6 months in patients with chronic respiratory disease.

When tailored to the patient's specific needs, behavior change support is suggested to promote patient's self-management and improve long-term adherence.

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