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Applying the treatable traits approach in bronchiectasis-A scoping review of traits, measurements and treatments implemented by allied health professionals and nurses

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ABSTRACT

Background: Using treatable traits as a management approach in bronchiectasis involves determining identifiable, clinically relevant, measurable and treatable problems to develop a management strategy in collaboration with the patient.
Objective: To identify new treatable traits not previously reported in the literature and treatment strategies for new and existing traits that could be implemented in an outpatient clinic or community setting by an allied health professional or nurse in adults with bronchiectasis.
Methods: A scoping review was conducted with searches of MEDLINE, CINAHL, AMED, Embase, Cochrane Central Register of Controlled Trials and PsycInfo. The search yielded 9963 articles with 255 articles proceeding to full text review and 114 articles included for data extraction.
Results: Sixteen new traits were identified, including fatigue (number of studies with new trait (n) = 13), physical inactivity (n = 13), reduced peripheral muscle power and/or strength (n = 12), respiratory muscle weakness (n = 9) and sedentarism (n = 6). The main treatment strategies for new and existing traits were airway clearance therapy (number of citations (n) = 86), pulmonary rehabilitation (n = 58), inspiratory muscle training (n = 20) and nebulised saline (n = 12).
Conclusion: This review identifies several new traits in bronchiectasis and highlights the common treatments for new and existing traits that can be implemented in a treatable traits approach in an outpatient clinic or community setting by an allied health professional or nurse.

1. Introduction

Bronchiectasis is characterised by permanent bronchial dilation, with chronic cough, sputum production and recurrent infection features of clinically significant disease [1–3]. While national and international guidelines in bronchiectasis management [4–6] outline the current evidence, these guidelines do not describe how to implement the different treatment strategies for this heterogenous disease in a personalised way. People with bronchiectasis have identified flexible personalised treatment strategies as a priority [7]. One treatment approach is to identify the 'treatable traits' [8] of each individual. Treatable traits are defined as individual patient problems that can be targeted by personalised management strategies [9]. Treatable traits are clinically relevant, identifiable, measurable, and treatable features of disease [9]. Descriptions of treatable traits in respiratory disease, including bronchiectasis, have previously been outlined [8,10–12] (Appendix A). In bronchiectasis, treatable traits are categorised as: 1) pulmonary traits (e.g. infection, mucus hypersecretion); 2) aetiological traits (e.g. immune deficiency); 3) extrapulmonary traits (comorbidities) (e.g. depression, gastroesophageal reflux disease); and 4) environment and lifestyle traits (e.g. lack of exercise) [8]. Since the initial description of treatable traits in bronchiectasis [8] the evidence has grown and the definition of some previously described terms have changed. For example, sedentarism is now realised to be distinctly different from lack of exercise both by

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definition and measurement [13]. It is recognised that treatable traits co-exist and evolve over time [11], along with an evolution in the treatable traits approach [14].

There are several methods that have been used to prioritise the traits targeted for management [9]. Firstly, traits can be prioritised based on their clinical impact [9]. Secondly, traits can be prioritised according to the impact on other traits [9], for example targeting exercise capacity to improve both dyspnoea and exercise tolerance. The third method is to prioritise traits that are of the highest priority/concern for the person living with bronchiectasis [9]. This final method aligns with the goal of personalising care to improve patient outcomes in conjunction with minimising any negative side effects [15].

The implementation of a treatable traits approach in bronchiectasis management requires a multidimensional plan [11]. While targeting aetiological conditions is primarily the role of the general practitioner (GP) or respiratory physician, pulmonary, extrapulmonary, environment and lifestyle traits require the expertise of a wider health professional team. The national and international guidelines in bronchiectasis recognise that a multidisciplinary team is required to manage the various clinical presentations and symptoms of the disease [4–6]. The identification of traits and the personalisation of care, according to the outcomes prioritised in collaboration with the patient, are the primary focus for management, for example reducing the number of infective exacerbations. Once the treatable traits have been identified and prioritised, strategies can be developed that target the particular trait/s. Treatment strategies that are supported by the national and international bronchiectasis guidelines and can be implemented by an allied health professional or nurse include: airway clearance therapy [4–6,16]; a self-management or action plan [5,6]; pulmonary rehabilitation or home exercise prescription [4–6,17]; physical activity (PA) and sedentary behaviour (SB) advice according to PA guidelines [6]; education relating to smoking cessation [6], avoidance of environmental airborne pollutants [6] and hydration; management of comorbidities (such as sinusitis and musculoskeletal pain) [5,6]; strategies for breathlessness; and infection control [5,6]. Treatment strategies may target single or multiple traits at the same time.

While there is a paucity of evidence implementing a treatable traits approach in bronchiectasis, this strategy, when applied in people with severe asthma was found to be feasible and resulted in significant improvements in quality of life and reduced primary care visits compared to usual care [18]. The success of a treatable traits approach for the management of severe asthma suggests there is also potential benefit for those with bronchiectasis. In a large international cohort of patients with COPD and asthma, an average of 5.1 (±2.7) treatable traits were identified, highlighting that multiple traits are often present and potentially interacting at any one time [19]. It was also demonstrated that the prevalence of some traits increased with disease severity, but others did not [19], suggesting that treatment approaches focused on disease severity may miss key treatment targets. This presents a complexity to management, particularly in non-specialist centers. As the treatable traits approach focuses on identifying traits, rather than a specific diagnostic label, it facilitates a more flexible and personalised approach that can adapt to individual presentations and potentially improve clinical outcomes [8,14]. There is also the potential that a focus on identifying treatable, measured aspects of disease could support a more targeted approach in primary care or non-specialist settings [14], recognising that rural and regional communities often have reduced access to specialist care [6,20].

As a management approach in adults with bronchiectasis, there is a need firstly to scope: 1) if new traits, along with measurements to identify and measure outcomes for the trait, have been reported in the published literature; and 2) the treatments that have been implemented for new and previously described traits. This scoping review will update the potential treatment targets and interventions in adults with bronchiectasis which is required if the treatable traits approach is to be tested in adults with bronchiectasis. A scoping review was chosen to enable the broad inclusion of studies on the topic regardless of study design or quality. The focus was limited to those traits, measurements and treatments that can be identified and implemented in the outpatient clinic or community setting by an allied health professional or nurse to enable a description of how a treatable traits approach can be used in the absence of ready access to specialist services or medical assistance.

2. Objectives

The scoping review aimed to answer the following questions:

1. Are there treatable traits (clinically relevant, identifiable, measurable and treatable) that are described in the published literature, but not yet identified as potential target traits (i.e. new traits) in adults with bronchiectasis?
2. What are the treatments that have been described for the new and previously identified (existing) treatable traits in adults with bronchiectasis that can be implemented and measured in an outpatient clinic or community setting by an allied health professional or nurse?

3. Methods

A preliminary search of MEDLINE, the Cochrane Database of Systematic Reviews and the Johanna Briggs Institute (JBI) Evidence Synthesis was conducted and no current or underway systematic review or scoping review on the topic was identified. This scoping review was conducted in accordance with the JBI method for scoping reviews [21], and adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [22] (Appendix B).

3.1. Eligibility criteria and information sources

There were no limitations on study design, publication date or geographic location for inclusion in the review to enable a wide scope for traits and treatments that have been identified in adults with bronchiectasis. We did not scope the literature to specifically identify measurements of traits, but have rather included only the measurements identified in the included studies. Published literature, including abstracts, letters to the editor and full text articles in English were considered for inclusion, as there was no support or funding for the translation of articles. All studies conducted in adults with bronchiectasis were included regardless of disease state (i.e. (a) stable disease; (b) during an infective exacerbation; or (c) immediately post-infective exacerbation). Stable disease was defined as the absence of an exacerbation. An infective exacerbation was defined as a deterioration in three or more of the following key symptoms for at least 48 h: cough; sputum volume and/or consistency; sputum purulence; breathlessness and/or exercise tolerance; fatigue and/or malaise; haemoptysis and a clinician determines that a change in bronchiectasis treatment is required [23]. Three methods were used to identify a new trait. The trait was either: (a) demonstrated in a study comparing adults with bronchiectasis against a healthy control group; and/or (b) demonstrated according to a published clinical cut-off value for the trait measure; and/or (c) described in an intervention study. A complete list of inclusion and exclusion criteria is described in Table 1. A trait, measurement or treatment was determined as implementable in the outpatient clinic or community setting if the study it was sourced from was conducted in this setting, or in contemporary practice, it is widely accepted that it could be delivered in such a setting, and the treatment/measurement was within the professional scope of an allied health professional or a nurse.

The search was conducted from inception to 16 December 2022. Study authors were not contacted for clarification of data or methods as an analysis of data and study quality was not the aim of the scoping review. Databases included in the search were: 1) Medical Literature Analysis and Retrieval System Online (MEDLINE); 2) Cumulative Index

Table 1
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Published in English	Absence of a new trait or a treatment of a trait
Participants are adults (≥ 18 years of age)	The study only described a new measurement for a trait, but not a new trait or a treatment of a trait
Included data in the bronchiectasis patient population	The trait could only be identified or measured in the hospital setting OR there was an absence of measurement
Studies reporting a possible new trait or a treatment for a new/existing trait	The treatment could only be implemented in the hospital setting OR by a medical professional
	Traits with only composite measures (e.g. quality of life measures)
	Conference abstracts where the full text was published OR duplicates of conference abstracts
	Systematic reviews, meta-analyses or editorials
	Insufficient data on the trait or treatment

to Nursing and Allied Health Literature (CINAHL); 3) Allied Health and Complementary Medicine Database (AMED); 4) Excerpta Medica Database (Embase); 5) Cochrane Central Register of Controlled Trials; and 6) PsychInfo.

3.2. Search strategy

The search strategy located abstracts, letters to the editor and published studies. An initial limited search of MEDLINE and CINAHL was undertaken to identify articles on treatable traits in chronic respiratory disease. The text words contained in the titles and abstracts of relevant articles, and the index terms used to describe the articles were used to develop a full search strategy in consultation with a medical librarian (Appendix C). The reference list of all included sources of evidence were screened for additional studies.

3.3. Study screening

Following the search, all identified citations were collated and uploaded into EndNote X9.3.3 (Clarivate Analytics, PA, USA) and imported to Covidence, where duplicates were removed. Titles and abstracts were screened in Covidence by two pairs of independent reviewers. Duplicates of conference abstracts were removed. Abstracts were assessed against the inclusion criteria (Table 1). If a reviewer had contributed or authored a source included for screening, this was allocated to an independent reviewer. Consensus regarding inclusion for full text review was reached through discussion. Potentially relevant sources were retrieved in full and uploaded to Covidence.

The full text of selected citations was assessed in detail against the inclusion and exclusion criteria (Table 1). The study screening process is demonstrated in the PRISMA flow diagram (Fig. 1).

3.4. Data extraction

For included articles, data was extracted by four independent reviewers. The first data extraction was to collate new traits reported in the literature. Traits were named according to the trait labels previously described in bronchiectasis [8] with some minor changes if it were determined to more accurately describe the trait based on current

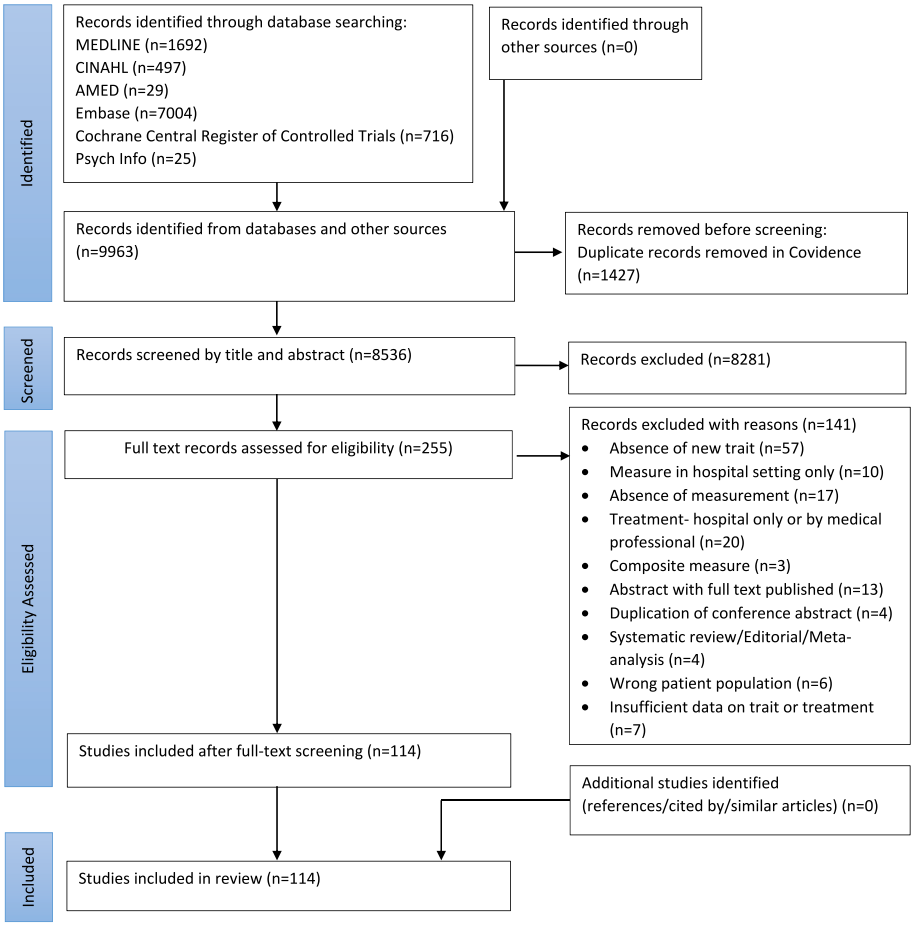

Fig. 1. PRISMA Flow Diagram for the scoping review process.

definitions and validated measurements (e.g. lack of exercise was changed/relabelled as reduced exercise capacity and considered distinct from sedentarism). The fields included in this data extraction were: 1) trait category according to previously defined treatable traits [8,10,11] (i.e. pulmonary, extrapulmonary, environment and lifestyle); 2) the new trait name; 3) the measurement specified to identify or quantify an outcome for the trait; 4) a summary of the evidence for the trait from the source; 5) the treatment implemented for the trait (only for intervention studies); 6) the study design and disease state (e.g. stable disease); and 7) authors. The second data extraction was to collate the treatments implemented for new and existing traits. Studies that described a new trait and implemented a treatment were included in both the new traits and the treatment of traits tables. If an intervention study described multiple outcome measures (e.g. pulmonary rehabilitation outcomes were measured with Forced Expiratory Volume in 1 s (FEV_1), Six Minute Walk Test (6MWT) and the number of infections in a year), each measure was determined to describe the assigned trait (e.g. FEV_1 is a measure of airflow obstruction). The fields included in this data extraction were: 1) trait name (new or existing); 2) measurement used to identify or quantify an outcome for the trait; 3) treatment implemented; 4) outcome data and significance; 5) study design and disease state; and 6) authors. The data extraction spreadsheet was piloted by KEW, and then adapted by ZJM, TJD and ALL. The data extraction completed by each reviewer was checked by a second independent reviewer for accuracy. The final data extraction spreadsheet was discussed and reviewed by all four reviewers to ensure consistency of approach and to resolve any conflicts.

4. Results

4.1. Study selection

The database search identified 9963 records. This resulted in 8536 records after duplicates were removed, with 255 records proceeding to full text review and 114 studies included in the scoping review from six databases (Fig. 1).

4.2. Study characteristics

All included studies were published between 1992 and 2022. Of the 114 included studies, the primary patient population studied was adults with stable bronchiectasis (n = 106). The remaining studies were conducted during inpatient rehabilitation (not stated if participants were stable or experiencing an infective exacerbation, n = 3), during an infective exacerbation (n = 4) and immediately post-infective exacerbation (n = 1). There were 82 full text articles, 30 abstracts and two letters to the editor included.

5. New traits

There were 72 included citations in 54 studies (supplementary file 1) which described 16 new traits that can be identified, measured and treated in an outpatient clinic or community setting in adults with bronchiectasis. Studies were cited more than once if they reported more than one new trait in the same study. Table 2 summarises the new traits described along with the measures used to identify the trait.

The five most described new traits were fatigue (number of studies describing new trait (n) = 13), physical inactivity (n = 13), reduced peripheral muscle power and/or strength (n = 12), respiratory muscle weakness (n = 9), and sedentarism (n = 6). Each of these traits had at least one study conducted in bronchiectasis compared with a healthy control to demonstrate the presence of the trait. Three of the top five traits (fatigue, physical inactivity and sedentarism) also had studies demonstrating the trait's presence according to published clinical cut-off values for the suggested trait measurement. The remaining 11 new traits had fewer than five citations reporting the trait's presence (Table 2). Three of these traits (reduced self-efficacy, reduced ability to cope with illness and difficulty clearing sputum) were reported in treatment studies only.

6. Treatments implemented for new and existing traits

There were 14 treatment strategies in 86 studies (study contained treatment only = 60, study contained new trait and treatment = 26, supplementary file 1) investigated across 18 new and previously described traits that can be implemented and measured in a community setting by an allied health professional or nurse (Table 3). The treatment that was most frequently reported in the literature was airway clearance therapy (ACT) (number of citations (n) = 86), with 64/86 citations reporting a between groups difference for study outcomes. Pulmonary rehabilitation was the second most reported treatment in the literature (n = 58), with 26/58 citations reporting a between groups difference in outcomes and 32/58 citations reporting results from observational studies. Inspiratory muscle training (n = 20) and nebulised saline (n = 12) were the next most frequently reported treatments implemented. Education and action plans, high flow humidified air/oxygen and nutritional supplements were implemented across only two to three studies each (i.e. a treatment was reported for multiple traits within the one study, but from a small number of total studies). Other treatment strategies reported in the literature include pelvic floor retraining, breathing techniques, cognitive behavioural therapy, cold water nebulised humidification, cough control therapy, non-invasive ventilation, and whole-body vibration.

Of the new traits, the traits of fatigue, physical inactivity, reduced peripheral muscle power and/or strength, respiratory muscle weakness, stress urinary incontinence, reduced self-efficacy and difficulty clearing sputum all had treatment interventions that demonstrated a significant improvement in the trait. The new trait of reduced ability to cope with illness, had one intervention study demonstrating no impact on the trait. The remaining new traits did not have treatment studies identified. Pulmonary rehabilitation had the most citations reporting a significant improvement in the traits of fatigue (n = 3), physical inactivity (n = 2) and reduced peripheral muscle power and/or strength. Inspiratory muscle training had the most citations reporting a significant improvement in the trait of respiratory muscle weakness (n = 3).

6.1. Airway clearance therapy (ACT)

Airway clearance therapy was most frequently reported as a treatment for the trait of mucus hypersecretion (number of citations (n) = 26), followed by the trait of airflow obstruction (n = 24), dyspnoea (n = 14) and infection (n = 11). Most studies reported a significant improvement in the trait of mucus hypersecretion (19/26) and infection (9/11) when ACT was implemented as a treatment (Table 3). A minority of studies reported a significant improvement in the traits of airflow obstruction (5/24) and dyspnoea (3/14). The remaining traits treated with ACT had a small number of studies showing both significant and non-significant improvements in outcomes.

6.2. Pulmonary rehabilitation

Pulmonary rehabilitation was most frequently reported as a treatment for the trait of reduced exercise capacity (number of citations (n) = 18), with most studies (15/18) demonstrating a significant improvement in exercise capacity after pulmonary rehabilitation. Dyspnoea was the second most frequently reported trait, with most studies (8/10) reporting a significant improvement in outcomes. Airflow obstruction was the next most frequently reported trait, with a minority of studies (1/8) demonstrating a significant improvement in outcomes, followed by the trait of fatigue, with most studies demonstrating a significant improvement in outcomes (3/4).

Table 2
New traits that can be identified, measured and treated in an outpatient clinic or the community in adults with bronchiectasis.

New trait	Total no. of studies	Measurement of trait	No. of studies with a healthy control demonstrating trait presence ([t])	No. of studies demonstrating trait present by clinical cut-off value ([#])	First author, publication year
Fatigue	13	• FACIT- F < 34 • FSS • FIS >40 • CRDQ-Fatigue: 4 questions-clinical cut-off value ≥ 0.5 per question • Likert scale	1	4	Araujo, 2022 ^ Chan, 2016[#] Choi, 2020[a] Hester, 2012[#] Hester, 2020 ^ Lee, 2014 ^ Lim, 2016[#] Macfarlane, 2010[#] Ozalp, 2019 ^ Ozalp, 2012[t] Santos, 2020 ^ Thompson, 2002 ^ Walsh, 2020 ^
Physical inactivity	13	• Steps/day <6290/day • MVPA ≤150 mins/wk • LIPA • IPAQ • Five ADL tasks kcal/day	3	5	Alcaraz-Serrano, 2021[#] Bradley, 2015[#] Cakmak, 2020[t] Cedeno de Jesus, 2022 ^ Cordova-Rivera, 2021[t] Cordova-Rivera, 2019a[#] Cordova-Rivera, 2019b[#] De Camargo, 2018[t] Jose, 2021 ^ Jose, 2018 * O'Neill, 2017[#] Pehlivan, 2019 ^ Serrano, 2017[n]
Reduced peripheral muscle power and/or strength	12	• FTSTST • Isometric leg, shoulder, hand grip strength	3	0	Atalay, 2019 ^ Cakmak, 2020[t] Chapman, 2019 ^ Cordova-Rivera, 2019b[a] De Camargo, 2018[t] Jose, 2021 ^ Lim, 2016[a] Olveira, 2016 ^ Ozalp, 2012[t]*Patel, 2020 ^ Pehlivan, 2019 ^ Wang, 2020[a]
Respiratory Muscle weakness	9	• MIP • MEP • SMIP	1	0	Araujo, 2022 ^ Cakmak, 2020[t] Liaw, 2011 ^ Mandal, 2012 ^ McCreery, 2021 ^ Moran, 2007 ^ Newall, 2005 ^ Nicolini, 2022 ^ Ozalp, 2019 ^
Sedentarism	6	• Sedentary time (>7.8 h/day or < 1.5 METS) • IPAQ • Steps/day (<5000) • Sedentary behaviour questionnaire	1	4	Alcaraz-Serrano, 2021[#] Bradley, 2015[#] Cakmak, 2020[t] Cordova-Rivera, 2021 * McKeough, 2020[#] Serrano, 2017[#]
Stress urinary incontinence	4	• ICIQ-SF • Questions about bladder control or UI symptoms • Incontinence QoL questionnaire	0	1	Duignan, 2016 ^ Mooney, 2010[a] Prys-Picard, 2006[#] Rees, 2013 ^
Reduced sleep quality	3	• PSQI ≥5	1	2	Gao, 2014[t] Gao, 2018[#] Ferri, 2020[#]
Cough	2	• VAS • Cough symptom score	2	0	Spinou, 2017[t] Torrego, 2006[t]
Reduced self-efficacy	3	• SEMCD • CDSS	0	0	Brockwell, 2020 ^ Lavery, 2011 ^

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Table 2 (*continued*)

New trait	Total no. of studies	Measurement of trait	No. of studies with a healthy control demonstrating trait presence ([t])	No. of studies demonstrating trait present by clinical cut-off value ([#])	First author, publication year
					Sanchez-Ramirez, 2022 ^
Reduced ability to cope with illness	1	• IPQ-R	0	0	Lavery, 2011 ^
Reduced arm exercise capacity	1	• 6 min peg board and ring test	1	0	Cakmak, 2019[t]
Reduced cognition	1	• Wechsler Adult Intelligence Scale	1	0	Gulhan, 2015[t]
Reduced functional exercise capacity	1	• Five ADL tasks • VO_2 and VE max % in response to 5 ADLS	1	0	Nunes, 2015[t]
Reduced peripheral muscle endurance	1	• No of squats in 30 s	1	0	Ozalp, 2012[t]
Airway reflux	1	• Hulls airway reflux questionnaire >13/70	0	1	Mandal, 2013[#]
Difficulty clearing sputum	1	• VAS	0	0	Pyne, 2010 ^

N.B The measurements listed are summarised from the data sources. We have not assessed if they are valid and reliable measures for the trait. ADL: Activities of Daily Living; CDSS: Chronic Disease Self-Efficacy Scale; CRDQ: Chronic Respiratory Disease Questionnaire; FACIT- F: Functional Assessment of Chronic Illness Therapy-Fatigue; FIS: Fatigue Impact Scale; FSS: Fatigue Severity Scale; FTSTS: Five Times Sit to Stand; ICIQ-SF: International Consultation on Incontinence- Short Form; IPAQ: International Physical Activity Questionnaire; IPQ-R: Revised Illness Perception Questionnaire; LIPA: Light Intensity Physical Activity; MIP: Maximal Inspiratory Pressure; MEP: Maximal Expiratory Pressure; MVPA: Moderate to Vigorous Physical Activity; PSQI: Pittsburg Sleep Quality Index; SEMCD: Self-Efficacy to Manage Chronic Disease scale; SMIP: Sustained Maximal Inspiratory Pressure; VAS: Visual Analogue Score; $\dot{V}O_2$ max: maximum oxygen uptake; $\dot{V}_E$ max: maximum minute ventilation; ([a]) no healthy control, no clinical cut-off value reported; ([t]) trait present in study with a healthy control group; ([#]) trait present according to a clinical cut-off value (*) trait not present when compared with healthy controls; (^) treatment study: see Table 3 for significance; ([n]) trait not present by a clinical cut-off value.

6.3. Inspiratory muscle training

Inspiratory muscle training was reported most frequently as a treatment for the traits of airflow obstruction (number of citations (n) = 4), reduced exercise capacity (n = 4), respiratory muscle weakness (n = 5) and mucus hypersecretion (n = 3). Except for the traits of respiratory muscle weakness (n = 3/5) and reduced exercise capacity (n = 1/4), the included citations reported no significant improvement in outcomes.

6.4. Nebulised saline

Nebulised hypertonic and/or isotonic saline was reported as a treatment for the traits of airflow obstruction (number of studies (n) = 5), mucus hypersecretion (n = 4) and infection (n = 2), with all traits having at least one citation reporting a significant difference in outcomes resulting from treatment.

7. Discussion

This is the first scoping review to explore new traits and associated measurements in adults with bronchiectasis, along with reported treatment interventions, that could be implemented in an outpatient clinic or community setting by an allied health professional or nurse. The top five new traits described in the literature were fatigue, physical inactivity, reduced peripheral muscle power and/or strength, respiratory muscle weakness and sedentarism. The treatments most frequently reported for new and previously reported traits were ACT, pulmonary rehabilitation, inspiratory muscle training and nebulised saline. Each of these treatments has the potential to target multiple traits simultaneously in adults with bronchiectasis.

In total, 16 new traits were described in the literature that had not been proposed previously in bronchiectasis or chronic airway diseases [8,10,11]. All of these traits were demonstrated as present against a healthy control group, or according to a defined clinical cut-off value, or were outcomes of a treatment study. We have provided the frequency with which each new trait was described in the literature, along with the outcome measures used to identify and measure each trait in the included studies. For example, five measures were identified for fatigue, all involving fatigue-specific questions that could be asked in any setting, three of which have a published clinical cut-off value for the interpretation of results. While we have documented the measures reported in each study, we have not assessed if these are the most appropriate measures for the trait. Sedentarism is defined as metabolic activity of <1.5 METS [24], but measures of physical activity such as step count and the International Physical Activity Questionnaire (IPAQ) were described as measuring sedentarism in some studies. It is important to distinguish the difference between physical activity and sedentarism to ensure it is correctly identified and measured into the future, which will support the identification of treatment options for sedentarism. It is interesting to observe that of the 16 new traits reported, eight traits currently have treatment interventions that have been explored and eight do not. While new traits have been proposed, not all of the new traits have evidence of treatments consistently available in this patient population. The evidence for treatable traits is growing, with the potential for both additional new traits and treatments to emerge [14]. A future research focus would be to test treatment interventions for each of the new traits.

The scoping review identified 14 treatment interventions reported in the literature for new and previously described traits. The most frequently reported treatment across all traits was ACT, consistent with treatment guideline recommendations in bronchiectasis [4–6]. From the scoping review, ACT most frequently demonstrated a significant improvement in mucus hypersecretion and infection, yet had no impact on airflow obstruction or dyspnoea. The remaining traits treated with ACT had only a small number of treatment studies demonstrating both significant and non-significant effects on these traits. Despite this, it is evident from the Australian Bronchiectasis Registry (ABR) and European Bronchiectasis Registry (EMBARC) data that the reported daily practice of ACT by patients and health professionals is less frequent (51 % ABR and EMBARC) [20,25] than the reported frequency of chronic productive cough (ABR 71 %) [20]. EMBARC data has highlighted the opinion of clinicians to be a key influence on the regular performance of ACT, with 68 % of patients reporting they do not regularly practice ACT [26].

There were many different ACTs implemented in the included

Table 3
Treatments and measures for new and existing traits in adults with bronchiectasis.

Treatment	New and existing traits	Total no. of studies	Outcome measures for trait	No. of citations with a Rx showing:	First author, Year Result type Significance
Airway Clearance Therapy (ACT)	Mucus hypersecretion	26	• Sputum wet/dry weight (g) • 24 h sputum volume (mls) • Subjective estimate of sputum expectorated	• Sign. improvement: 19 • No sign. improvement: 7	Between groups difference[1]: AbdelHalim, 2016 + Amit, 2012 + Conway, 1992 + de Souza Simoni, 2019 + Eaton, 2007 + Figueiredo, 2012 + Guimaraes, 2012 + Herrero-Cortina, 2016 + Livnat, 2021 + Munoz, 2018 + Murray, 2009 + Nicolini, 2013 + Patterson, 2004 + Patterson, 2005x Patterson, 2007x Polverino, 2012 + Santos, 2020 + Sari, 2016 + Semwal, 2015x Shukla, 2014 + Silva, 2017 + Syed, 2009x Thompson, 2002x Tsang, 2003x Within groups difference: Altiay, 2012 + Sangavi, 2022x
	Airflow obstruction	24	• FEV_1 • FVC • FEV_1/FVC • FEF (25-75) • PEFR	• Sign. improvement: 4 • No sign. improvement: 20 • Sign. negative response: 1	Between groups difference[1]: Altiay, 2012x AbdelHalim, 2016x Chandrasekar, 2022x Eaton, 2007x Guimaraes, 2012x Herrero-Cortina, 2016x Jao, 2010x Livnat, 2021x Munoz, 2018x Nicolini, 2022x Patterson, 2007x Santos, 2020 ˜ Semwal, 2015x Shukla, 2014x Syed, 2009x Thompson, 2002x Tsang, 2003x Uzmezoglu, 2018x Within groups difference: Patterson, 2004x Patterson, 2005x Sangavi, 2022 + Observational: Bentley, 2013 + Cacopardo, 2020 + Powner, 2019x
	Dyspnoea	14	• Modified Borg scale • MMRC dyspnoea score • Breathlessness score (undefined) • 15 s breathlessness score • CRDQ- dyspnoea subscale	• Sign. improvement: 4 • No sign. improvement: 11	Between groups difference[1:] AbdelHalim, 2016x Eaton, 2007x Jao, 2010x Munoz, 2018x Nicolini, 2013 + Santos, 2020 + Semwal, 2015x Thompson, 2002x Uzmezoglu, 2018# Within groups difference: Altiay, 2012 + Patterson, 2005x Patterson, 2007x Sangavi 2022x Sari, 2016x

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Table 3 (*continued*)

Treatment	New and existing traits	Total no. of studies	Outcome measures for trait	No. of citations with a Rx showing:	First author, Year Result type Significance
	Infection	11	•Sputum bacteriology • Number of exacerbations/year • Number of hospitalisations/year • Oral antibiotic use/year • Time to exacerbation (days)	• Sign. improvement: 8 • No sign. improvement: 7 • Sign. negative response: 1	Between groups difference[1:] Antonello, 2019 [+] Chandrasekar, 2022[x] Munoz, 2018[#] Murray, 2009[x] Nicolini, 2022 [+] Tambascio, 2017[x] Observational: Barto, 2020 [+] Basavaraj, 2020[#] Basavaraj, 2021 [+] Powner 2019[#] Shah, 2021[#^]
	Oxygen desaturation	4	• SpO_2 • PaO_2	• Sign. improvement: 1 • No sign. improvement: 3	Between groups difference[1:] Sari, 2016 [+] Within groups difference: Patterson, 2004[x] Patterson, 2005[x] Patterson, 2007[x]
	Reduced exercise capacity	4	• 6MWT • ISWT • ESWT	• Sign. improvement: 2 • No sign. improvement: 2	Between groups difference[1:] Murray, 2009 [+] Munoz, 2018[x] Nicolini, 2022[x] Within groups difference: Sangavi, 2022 [+]
	Fatigue	2	• CRDQ- Fatigue: 4 questions- clinical cut-off value $\geq$ 0.5 per question • Likert scale 1-5	• Sign. improvement: 1 • No sign. improvement: 1	Between groups difference[1:] Santos, 2020 [+] Thompson, 2002[x]
	Respiratory muscle weakness	1	• MIP • MEP	• No sign. improvement: 1	Between groups difference[1:] Nicolini, 2022[x]
Pulmonary rehabilitation	Reduced exercise capacity	18	• ISWT • ESWT • CPET • 6MWT • MIST	• Sign. improvement: 15 • No sign. improvement: 3	Between groups difference[1:] Araujo, 2022 [+] Cedeno de Jesus, 2022 [+] Chalmers, 2019[x] Jose, 2021 [+] Kumar, 2017 [+] Lee, 2014 [+] Mandal, 2012 [+] Within groups difference: Balteanu, 2017 [+] Observational: Candemir, 2021 [+] Chapman, 2019 [+] Deniz, 2021 [+] Ong, 2011 [+] Patel, 2019 [+] Pehlivan, 2019[x] Sanchez-Ramirez, 2022 [+] Van Zeller, 2012[x] Walsh, 2020 [+] Zanini, 2015 [+]
	Dyspnoea	10	• MMRC dyspnoea score • Self-report scale • CRDQ- dyspnoea subscale • Baseline Dyspnoea Index	• Sign. improvement: 8 • No sign. improvement: 2	Between groups difference[1:] Lee, 2014 [+] Within groups difference: Araujo, 2022 [+] Cedeno de Jesus, 2022 [+] Observational: Candemir, 2021 [+] Chapman, 2019 [+] Deniz, 2021 [+] Pehlivan, 2019[x] Sanchez-Ramirez, 2022[x] Zanini, 2015 [+] Walsh, 2020 [+]
	Airflow obstruction	7	• FEV_1 • FVC • FEV_1/FVC • RV	• Sign. improvement: 1 • No sign. Improvement: 7	Between groups difference[1:] Chalmers, 2019 [&] Kumar, 2017[x] Lee, 2014[x] Mandal, 2012[x] Observational: Candemir, 2021[x] Deniz, 2021[x] Van Zeller, 2012[x]

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Table 3 (*continued*)

Treatment	New and existing traits	Total no. of studies	Outcome measures for trait	No. of citations with a Rx showing:	First author, Year Result type Significance
	Anxiety Depression	4	• HADS-A • HADS-D • DASS	• Sign. improvement: 2 • No sign. improvement: 2	Between groups difference[1]: Lee, 2014[x] Within groups difference: Kumar, 2017[x] Observational: Candemir, 2021 [+] Deniz, 2021 [+]
	Fatigue	4	• FSS • CRDQ- Fatigue: 4 questions- clinical cut-off value $\geq$ 0.5 per question • Self-rating	• Sign. improvement: 3 • No sign. improvement: 1	Between groups difference[1]: Araujo, 2022 [+] Lee, 2014 [+] Observational: Sanchez-Ramirez, 2022[x] Walsh, 2020 [+]
	Physical inactivity	3	• Steps/day <6290/day • Accelerometer $\leq$150min MVPA/wk • IPAQ • Total PA (kcal/day)	• Sign. improvement: 2 • No sign. improvement: 1	Between groups difference[1]: Jose, 2021[x] Within groups difference: Cedeno de Jesus, 2022 [+] Observational: Pehlivan, 2019 [+]
	Reduced peripheral muscle power/strength	4	• Hand grip strength • FTSTS	• Sign. improvement: 1 • No sign. improvement: 3	Between groups difference[1]: Jose, 2021[x] Observational: Chapman, 2019 [+] Patel, 2020[x] Pehlivan, 2019[x]
	Infection	2	• Time to exacerbation (days) • Number of exacerbations/year	• Sign. improvement: 1 • No sign. improvement: 1	Between groups difference[1]: Chalmers, 2019[x] Lee, 2014 [+]
	Oxygen desaturation	2	• SpO_2	• No sign. improvement: 2	Observational: Deniz, 2021[x] Van Zeller, 2012[x]
	Respiratory muscle weakness	2	• MIP • MEP	• Sign. improvement: 1 • No sign. improvement: 1	Between groups difference[1]: Araujo, 2022 [+] Mandal, 2012[x]
	Reduced self-efficacy	1	• SEMCD6	• No sign. improvement: 1	Observational: Sanchez-Ramirez, 2022[x]
	Sarcopenia	1	• Fat free muscle index	• No sign. improvement: 1	Observational: Chapman, 2019[x]
Inspiratory muscle training	Airflow obstruction	5	• FEV_1 • FVC • FEV_1/FVC • PEFR	• No sign. improvement: 5	Between groups difference[1]: Liaw, 2011[x] Newall, 2005[x] Ozalp, 2019[x] Within groups difference: Patterson, 2004[x] Observational: McCreery, 2021[x]
	Reduced exercise capacity	4	• 6MWT • CPET • ISWT	• Sign. improvement: 1 • No sign. improvement: 3	Between groups difference[1]: Liaw, 2011[x] Ozalp, 2019 [+] Newall, 2005[x] Observational: McCreery, 2021[x]
	Mucus hypersecretion	3	• 24 h sputum volume (mls) • Sputum weight (g)	• No sign. improvement: 3	Between groups difference[1]: Naraparaju, 2010[x] Patterson, 2004[x] Within groups difference: Newall, 2005[x]
	Respiratory muscle weakness	4	• MIP • MEP • SMIP	• Sign. improvement: 3 • No sign. improvement: 2	Between groups difference[1]: Liaw, 2011 [+] Newall, 2005[x] Ozalp, 2019 [+] Observational: McCreery, 2021 [&#]
	Dyspnoea	2	• MMRC dyspnoea score • Borg scale during 6MWT	• No sign. improvement: 2	Between groups difference[1]: Liaw, 2011[x] Ozalp, 2019[x]
	Fatigue	1	• FSS	• No sign. improvement: 1	Between groups difference[1]: Ozalp, 2019[x]
	Oxygen desaturation	1	• SpO_2	• No sign. improvement: 1	Between groups difference[1]: Liaw, 2011[x]
Nebulised saline	Airflow obstruction	5	• FEV_1 • FVC • FEF 25-75 %	• Sign. improvement: 3 • No sign. improvement: 3	Between groups difference[1]: Kellett, 2011 [+] Nicolson, 2012[x] Sutton, 1988[x]

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Table 3 (*continued*)

Treatment	New and existing traits	Total no. of studies	Outcome measures for trait	No. of citations with a Rx showing:	First author, Year Result type Significance
					Observational: Perez-Urria, 2021[#] Pyne, 2010 [+]
	Mucus hypersecretion	4	• Sputum weight (g)	• Sign. improvement: 4 • No sign. improvement: 1	Between groups difference[1]: Herrero-Cortina, 2018 [&] Kellett, 2005 [+] Serrano, 2016 [+] Observational: Perez-Urria, 2021 [+]
	Infection	2	• Number of antibiotics/year • Number of exacerbations/year • Number of exacerbations requiring antibiotics/year • Exacerbation days/year • Exacerbation days requiring antibiotics/year	• Sign. improvement: 1 • No sign. improvement: 1	Between groups difference[1]: Kellett, 2011 [+] Nicholson, 2012[x]
	Difficulty clearing sputum	1	• VAS (0-10)	• Sign. improvement: 1	Observational: Pyne, 2010 [+]
Education and action plans	Infection	2	• Number of exacerbations/year • Number of antibiotics/year	• No sign. improvement: 2	Between groups difference[1]: Brockwell, 2020[x] Lavery, 2011[x]
	Airflow obstruction	1	• FEV_1	• No sign. improvement: 1	Between groups difference[1]: Hester, 2020[x]
	Anxiety Depression	1	• HADS-A • HADS-D	• No sign. improvement: 1	Between groups difference[1]: Hester, 2020[x]
	Fatigue	1	• FIS >40	• No sign. improvement: 1	Between groups difference[1]: Hester, 2020[x]
	Reduced ability to cope with illness	1	• IPQ-R	• No sign. improvement: 1	Between groups difference[1]: Lavery, 2011[x]
	Reduced self-efficacy	1	• SECD • CDSS	• Sign. improvement: 1 • No sign. improvement: 1	Between groups difference[1]: Brockwell, 2020[x] Lavery, 2011 [+]
High flow humidified air/O2	Airflow obstruction	2	• FEV_1 • FVC	• Sign. improvement: 1 • No sign. improvement: 1	Between groups difference[1]: Good, 2021[x] Observational: Annunziata, 2019 [+]
	Infection	2	• Number of exacerbations/year	• Sign. improvement: 2	Between groups difference[1]: Good, 2021 [+] Observational: Annunziata, 2019 [+]
	Reduced exercise capacity	2	• 6MWT	• Sign. improvement: 1 • No sign. improvement: 1	Between groups difference[1]: Good, 2021[x] Observational: Annunziata, 2019 [+]
	Dyspnoea	1	• MRC dyspnoea score	• Sign. improvement: 1	Observational: Annunziata, 2019 [+]
Nutritional supplements	Airflow obstruction	1	• FEV_1 • FVC • FEV_1/FVC	• No sign. improvement: 1	Between groups difference[1]: Dona, 2018[x]
	Depression	1	• HADS-D	• No sign. improvement: 1	Between groups difference[1]: Dona, 2018[x]
	Dyspnoea	1	• MMRC dyspnoea score	• No sign. improvement: 1	Between groups difference[1]: Dona, 2018[x]
	Infection	1	• Number of exacerbations/year	• No sign. improvement: 1	Between groups difference[1]: Dona, 2018[x]
	Reduced bone density	1	• Bone density (g/cm2)	• Sign. improvement: 1	Within groups difference: Olveira, 2016 [+]
	Reduced exercise capacity	1	• CPET	• No sign. improvement: 1	Between groups difference[1]: Dona, 2018[x]
	Reduced peripheral muscle strength	1	• Hand grip strength	• No sign. improvement: 1	Within groups difference: Olviera, 2016[x]
Pelvic floor retraining	Urinary incontinence	2	• International consultation on incontinence-short form • Urinary symptoms	• Sign. improvement: 2	Observational: Duignan, 2016 [+] Rees, 2009 [+]
Breathing techniques	Airflow obstruction	1	• PEFR • FEV_1	• Sign. improvement: 1 • No sign. improvement: 1	Within groups difference: Salman, 2022[#]
Cognitive behavioural therapy	Anxiety Depression	1	• HADS-A • HADS-D	• No sign. improvement: 1	Between groups difference[1]: Parkin, 2006[x]
	Reduced exercise capacity	1	• ISWT	• Sign. improvement: 1	Between groups difference[1]: Parkin, 2006 [+]
Cold water nebulised humidification	Mucus hypersecretion	1	• Sputum wet weight (g)	• Sign. improvement: 1	Between groups difference[1]: Conway, 1992 [+]

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Table 3 (*continued*)

Treatment	New and existing traits	Total no. of studies	Outcome measures for trait	No. of citations with a Rx showing:	First author, Year Result type Significance
Cough control therapy	Cough hypersensitivity	1	• LHQ	• Sign. improvement: 1	Observational: Mohammed, 2020 $^{+}$
Non invasive ventilation	Airflow obstruction	1	• FEV_1	• No sign. improvement: 1	Between groups difference$^{1:}$ Moran, 2007^{x}
	Dyspnoea	1	• Breathlessness score (not defined)	• No sign. improvement: 1	Between groups difference$^{1:}$ Moran, 2007^{x}
	Mucus hypersecretion	1	• Wet and dry sputum weight (g)	• No sign. improvement: 1	Between groups difference$^{1:}$ Moran, 2007^{x}
	Respiratory muscle weakness	1	• MIP • MEP	• Sign. improvement: 1	Between groups difference$^{1:}$ Moran, 2007 $^{+}$
Whole body vibration	Dyspnoea	1	• MMRC dyspnoea score	• No sign. improvement: 1	Between groups difference$^{1:}$ Atalay, 2019^{x}
	Reduced exercise capacity	1	• 6MWT	• No sign. improvement: 1	Between groups difference$^{1:}$ Atalay, 2019^{x}
	Reduced peripheral muscle power	1	• FTSTS	• No sign. improvement: 1	Between groups difference$^{1:}$ Atalay, 2019^{x}

N.B The measurements listed are summarised from the data sources. We have not assessed if they are valid and reliable measures for the trait. (^{1}) A between groups difference is either between: (a) two active treatments, or (b) a treatment and a control group; (Sign.): significant; ($^{+}$) a significant positive response to treatment; (^{x}) no significant response to treatment; ($^{-}$) a significant negative response to treatment; ($^{\&}$) both significant and non-significant results reported in the same study at different time points of evaluation; ($^{\#}$) different outcome measures for the same trait demonstrating both a significant and non-significant response to treatment depending on the measure used; ($\hat{}$) different outcome measures for the same trait demonstrating both a significant positive and negative response to treatment depending on the measure used; CDSS: Chronic Disease Self-efficacy Scale; CPET: Cardiopulmonary Exercise Testing; CRDQ: Chronic Respiratory Disease Questionnaire; DASS: Depression Anxiety Stress Scale; ESWT: Endurance Shuttle Walk Test; FIS: Fatigue Impact Score; FSS: Fatigue Severity Scale; FTSTS: Five Times Sit to Stand; HADS-A: Hospital Anxiety and Depression Scale-Anxiety; HADS-D: Hospital Anxiety and Depression Scale- Depression; IPAQ: International Physical Activity Questionnaire; IPQ-R: Revised Illness Perception Questionnaire; ISWT: Incremental Shuttle Walk Test; LHQ: Newcastle Laryngeal Hypersensitivity Questionnaire; MEP: Maximal Expiratory Pressure; MIP: Maximal Inspiratory Pressure; MIST: Modified Incremental Step Test; MMRC; Modified Medical Research Council; MRC: Medical Research Council; SEMCD6: Self-Efficacy for Managing Chronic Disease 6-item Scale; 6MWT: Six Minute Walk Test; SMIP: Sustained Maximal Inspiratory Pressure.
N.B when not specified and a p value was reported, assumption made that study tested between groups difference.

studies, including manual techniques (percussion and vibration), postural drainage, breathing techniques (including the active cycle of breathing techniques), oscillating and non-oscillating positive expiratory pressure (PEP) therapy, high flow chest wall oscillation (HFCWO), and expiration with an open glottis in the lateral posture (ELTGOL). Included studies compared ACT to no ACT, to a different form of ACT, or between two different types of devices which use the same technique (e.g. Acapella® versus Flutter®). The heterogeneity in study designs and clinical practice has made it challenging to determine which is the most effective ACT technique to implement in an individual clinical presentation [16,27]. The European Respiratory Society (ERS) has recently provided guidance on the various considerations when choosing ACTs [16], with no single ACT technique consistently more effective than another [28,29].

The second most frequently reported treatment was pulmonary rehabilitation. Pulmonary rehabilitation for bronchiectasis is recommended internationally in pulmonary rehabilitation clinical practice guidelines [17,30,31], along with national and international guidelines in bronchiectasis management [4–6]. Reduced exercise capacity and dyspnoea most frequently demonstrated significant improvements following pulmonary rehabilitation, and airflow obstruction most frequently demonstrated no significant improvement in this scoping review. The scoping review identified only a small number of studies in the remaining traits treated with pulmonary rehabilitation. The pulmonary rehabilitation programs implemented varied in design, including program location (hospital, outpatient clinic, home), program length, exercise types, exercise frequency, supervision model, education provided, follow-up and motivation provided, and additional components such as training in ACT or inspiratory muscle training. The heterogeneity in programs has been previously described [32], with evidence that the only trait consistently addressed in pulmonary rehabilitation is reduced exercise capacity or deconditioning [33]. Essential components of pulmonary rehabilitation programs have been outlined [30], but there is yet to be a recommendation on the most relevant traits for treatment in programs [33]. It is also acknowledged that rates of program access, uptake and completion are low in people with chronic respiratory disease, including bronchiectasis [20,30,34]. Pulmonary rehabilitation has the potential to impact traits that contribute significantly to quality of life [34,35] and disease severity [36] in bronchiectasis. It remains to be examined whether improved clinical outcomes and long-term maintenance of improvements can be achieved for people with bronchiectasis through a treatable traits focus in pulmonary rehabilitation.

Inspiratory muscle training was the next most frequently reported treatment of new and existing traits, followed by nebulised saline (hypertonic and/or isotonic). Only respiratory muscle weakness had a small number of studies demonstrating a significant improvement following inspiratory muscle training. Inspiratory muscle training is currently recommended as a treatment for respiratory muscle weakness in the ERS bronchiectasis guidelines [4], but is not included as a recommendation for pulmonary rehabilitation programs [30]. Further research is required to inform the broader implementation of inspiratory muscle training as a treatment technique. Nebulised saline is recommended in the management guidelines for bronchiectasis in accordance with stepwise management [5]. The trait of mucus hypersecretion had the most citations reporting a significant improvement following treatment. Current evidence regarding the use of nebulised saline as an adjunct to ACT supports the use of isotonic saline [37], with uncertainty regarding additional benefits with the use of hypertonic saline [38]. In clinical practice, nebulised saline is recommended when sputum is viscous and recurrent infections continue despite optimising ACT [5], and medical guidance is often sought prior to suggesting the nebulisation of hypertonic saline.

The remaining treatments had a small number of intervention studies describing their implementation in adults with bronchiectasis in an outpatient clinic or community setting. Not all treatments had an intervention study demonstrating a significant improvement in measured outcomes. Education, self-management strategies and action plans, while recommended in some treatment guidelines [6], have limited evidence to support their use [39]. Education and self-management strategies are often incorporated as a feature of pulmonary rehabilitation programs [30] or clinic reviews, and it may be

difficult to ascertain the efficacy in isolation. For example, a physiotherapist teaching ACT will provide education on why ACT is important and individualise the technique to allow self-management in different clinical states of disease. Research does demonstrate that these treatments are important to patients [7,40]. Future research could further test the treatments reported in different settings and clinical states (i.e. during stable disease or infective exacerbations).

This scoping review supports providing access to ACT and pulmonary rehabilitation as a minimum standard in adults with bronchiectasis. These treatments have the largest potential to improve multiple traits simultaneously. ACT is recommended to be implemented by a respiratory physiotherapist [4,5]. The delivery of pulmonary rehabilitation requires allied health professionals with experience in exercise prescription [30]. Both treatments can be implemented in different community settings with little or no access to equipment such as airway clearance devices or exercise equipment. While previous reviews of interventions for bronchiectasis found there is limited evidence for individual treatment techniques [34,41,42], the potential of these treatments to target multiple patient traits suggests that implementation of these key strategies may improve outcomes for adults with bronchiectasis. There is a need for implementation research to determine if a treatable traits management strategy will improve clinical outcomes, is easily translatable in resource limited settings and is preferred by adults with bronchiectasis.

Consistent with scoping review methods [43], the quality of the included studies was not assessed. It was also outside the scope of the review to identify new traits and treatments for traits that are identified, measured and treated by a medical professional. Our intent was to demonstrate the range of traits and treatments that could be identified and treated in outpatient clinics and community settings where there is access to allied health and nursing. Strengths of this scoping review include the extensive number of studies reviewed, which has enabled a very broad review of the traits and treatments currently reported in adults with bronchiectasis in an outpatient clinic or community setting.

8. Conclusion

New traits and treatments of new and existing traits were identified that can be implemented by an allied health professional or nurse in an outpatient clinic or community setting. There is the potential for treatable traits to improve clinical outcomes in adults with bronchiectasis. Future research is needed to explore the effect on health outcomes of translating the treatable traits approach.

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CRediT authorship contribution statement

Kirsty E. Watson: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft. **Annemarie L. Lee:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing. **Tiffany J. Dwyer:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing. **Zoe J. McKeough:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing.

Declaration of competing interest

There is no conflict of interest.

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Appendix D. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.rmed.2023.107503.

Appendix A. Current treatable traits in bronchiectasis and chronic respiratory disease

	Current trait	Measurement of trait- identification and outcomes	Treatment for trait	Expected benefits of treatment [8]
Pulmonary	**Infection** [8] Frequent chest infection [11]	Clinical features Sputum characteristics Inflammatory markers Sputum culture ≥2 courses of antibiotics for an exacerbation of chest symptoms [11]	Airway clearance Prompt treatment of exacerbations	Reduce exacerbations Improve quality of life
	Chronic Pseudomonas infection [8] Airway bacterial colonisation [11]	Two or more culture isolates at least 3 months apart in 1 year	Airway clearance	Reduce exacerbations Improve quality of life Slow lung function decline Prevent chronic infection
	Mucus hypersecretion [8] Chronic sputum production/Chronic bronchitis [11]	Colour of sputum Volume ≥25 ml of mucus produced daily for the past week in the absence of ongoing infection [10] Cough and sputum 3 months × 2 years (no eosinophilic airway inflammation)	Airway clearance Airway adjunct devices Smoking cessation [11]	Reduce sputum volume Reduce viscosity/increase ease if expectoration
	Mucus plugging	Clinical features CT scan	Airway clearance Nebulised saline	Reduce sputum volume Reduce viscosity/increase ease if expectoration

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	Current trait	Measurement of trait- identification and outcomes	Treatment for trait	Expected benefits of treatment [8]
	Airflow obstruction Airflow limitation [11] Airway smooth muscle contraction Emphysema Airway mucosal oedema	FEV1/FVC < LLN Fixed ratio spirometry GLI equations (A) FEV1/FVC <70 % and FEV1<80 % predicted Bronchodilator reversibility CT, DLCO, compliance CT, spirometry induced bronchoconstriction	Smoking cessation Exercise	Improved exercise capacity and functional status
	Cough hypersensitivity	Clinical features Search other potential extrapulmonary causes Capsaicin cough challenge	Chest physiotherapy Speech pathology intervention [11]	Improve QoL
	Oxygen desaturation [10]	Oxygen saturation levels of <90 % in 6MWT [10]		
	Dyspnoea [10]	Dyspnoea score ≥2 MMRC scale		
Extrapulmonary	**Depression/anxiety**	Questionnaires Psychologist/liaison HADS (≥8 on depression subscale) [10] HADS (≥8 on anxiety subscale) [10]	Anxiety management Breathing retraining Cognitive behavioural therapy Support groups	Improve QoL
	Obesity/underweight	BMI≥30 kg/m$^{2\ (M)}$	Nutritional evaluation Regular physical activity [8,10]	Improve QoL and outcome
	GORD GORD [11]	Clinical features		Improve QoL
	Rhinosinusitis [11]	Clinical features Imaging Same (A)		Improve QoL
	Dysfunctional breathing [10]	Nijmegen score ≥23 (M)		
	Deconditioning [11]	Rehabilitation [11] Exercise		
	Cachexia [11] (weight loss and muscle loss)	BMI [11]	Diet [11] Physical activity	
	Vocal cord dysfunction	Flow-volume curve Vocal cord dysfunction questionnaire: total score ≥5 positive for laryngeal dysfunction [10]	Speech pathology therapy	
	Obstructive sleep apnoea [10]	Questionnaires [10] Sleep study	CPAP Weight loss	
	Daytime sleepiness [10]	Epworth sleep score >8		
	Other significant medical history [10]	Patient self-reported other medical conditions [10]		
Behavioural/ Lifestyle Factors	**Smoking** Same	Patient reported Exhaled carbon monoxide	(B,M,A) Tobacco cessation support [11] Nicotine replacement Avoid environmental exposures [11]	Improve QoL, lung function, exercise capacity, response to treatment
	Lack of exercise/ sedentarism Exercise tolerance [10]	Cardiopulmonary exercise testing 6-min walk test Distance of <350 m on 6MWT [10]	Exercise regularly Pulmonary rehabilitation Prescribed exercise programs	Improve QoL and outcome
	Adherence Same (M)	Prescription refill rate Patient feedback Subjective report- use of <80 % of prescribed treatment [10]	Education Written instructions Self-management	Improve outcome
	Exposure to air pollution Exposure to sensitizing agents [11]	PM10 and NO2 concentrations	Reduce exposure Desensitisation [11] Protective equipment [11]	Reduce exacerbations
	Poor inhalation technique [10]	Observation of technique [10]	Education	
	Sarcopenia [10]- loss of muscle mass and strength	Appendicular skeletal muscle mass index <7.26 kg/m^2 males <5.45 kg/m^2 females		
	Side effects of treatment Family and social support [11]	Record of side effects and patient impact	Treatment optimisation Family therapy education Self-management support	
	Absence of written action plan [10]	Patient does not possess written action plan or does not use the prescribed plan during exacerbations		
	Bone density [10]	Osteopenia T-score: −1.0 to −2.5 Osteoporosis T -score: ≤ −2.5		

The current treatable traits in bronchiectasis and chronic respiratory disease as previously summarised by first authors Agusti [11], Boaventura [8] and McDonald [10]. Traits that have been published in bronchiectasis specifically [8] are in **bold text**. Aetiological trait category, traits, measurements and treatments that can only be implemented by a medical professional have been excluded. QoL: Quality of Life.

Appendix B. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA- ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	pg. 2
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	pg. 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	1. Introduction pg. 2-4
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	2. Objectives pg. 4
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Protocol not published
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	3.1 Eligibility and information sources pg. 4-5
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	3.1 Eligibility and information sources pg. 4-5
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Appendix C pg. 35
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	3.3 Study screening pg. 5
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	3.4 Data extraction pg. 6
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	3.4 Data extraction pg. 6
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	3.4 Data extraction pg. 6
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	4.1 Study selection pg. 6-7
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Table 2 pg. 8-11 Table 3 pg. 13-25
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	4.3 New traits pg. 7-10 4.4 Treatments implemented for new and existing traits pg. 10-23
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Sections 4.2-4.4.4 pg. 8-25
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	5. Discussion pg. 26-28
Limitations	20	Discuss the limitations of the scoping review process.	5. Discussion pg. 28
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	6. Conclusion pg. 28
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Funding source pg. 28

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley [6] and Levac and colleagues [7] and the JBI guidance [4,5] refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018; 169:467–473. https://doi.org/10.7326/M18-0850.

Appendix C. Search Strategy

(a) Search strategy for MEDLINE, EMBASE, AMED, PsycInfo, Cochrane Central Register of Controlled Trials

1. Outpatient Clinics, Hospital/
2. Hospital outpatient clinic*.mp.
3. community outpatient clinic*.mp.
4. exp Primary Health Care/
5. Primary health care.mp.
6. (Family clinic* or GP clinic* or General practitioner clinic*).mp. [mp = title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
7. Nurse Practitioners/
8. Nurse practitioner*.mp.
9. Nurse Specialists/
10. nurse specialist*.mp.
11. Interdisciplinary clinic*.mp.
12. Multidisciplinary clinic*.mp.
13. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14. exp Bronchiectasis/
15. Bronchiectasis.mp.
16. Self-Management/
17. Self manag*.mp.
18. Self Care/
19. self care*.mp.
20. 16 or 17 or 18 or 19
21. exp Respiratory Therapy/
22. Respiratory therap*.mp.
23. Physical Therapy Modalities/
24. Airway clearanc*.mp.
25. sputum clearanc*.mp.
26. pulmonary rehab*.mp.
27. Exercise/
28. Exercis*.mp.
29. Physical activit*.mp.
30. Dyspnea.mp. or exp Dyspnea/
31. “shortness of breath".mp.
32. breathless*.mp.
33. “Quality of Life"/
34. “Quality of Life".mp.
35. life qualit*.mp.
36. 33 or 34 or 35
37. Depression/
38. Depress*.mp.
39. Anxiety/
40. Anxiet*.mp.
41. 37 or 38 or 39 or 40
42. Air Pollution/
43. Air pollut*.mp.
44. Smoking Cessation/
45. Smok*.mp.
46. 44 or 45
47. “Nebulizers and Vaporizers"/
48. Sinusitis/
49. sinus*.mp.
50. Saline Solution, Hypertonic/
51. hypertonic saline.mp.
52. “Treatment Adherence and Compliance"/
53. treatment adherence.mp.
54. action plan.mp.
55. Patient Education as Topic/
56. patient education.mp.
57. Health Knowledge, Attitudes, Practice/
58. health knowledge.mp.
59. Urinary Incontinence/
60. urinary incontinence.mp.
61. 59 or 60
62. exp Nutrition Therapy/
63. nutrition.mp.
64. 62 or 63
65. Pain/
66. pain.mp.
67. 65 or 66
68. 47 or 48 or 49 or 50 or 51
69. 52 or 53 or 54 or 55 or 56 or 57 or 58
70. 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32
71. 20 or 36 or 41 or 46 or 61 or 64 or 67 or 68 or 69 or 70
72. Treatable trait*.mp.
73. Precision Medicine/

(*continued on next page*)

(*continued*)

(a) Search strategy for MEDLINE, EMBASE, AMED, PsycInfo, Cochrane Central Register of Controlled Trials	
74.	Precision medicine*.mp.
75.	Individualised treatment*.mp.
76.	personalised treatment*.mp.
77.	72 or 73 or 74 or 75 or 76
78.	ambulatory care facilities/or community health centers/or outpatient clinics, hospital/
79.	13 or 78
80.	71 or 77
81.	14 or 15
82.	79 and 81
83.	80 and 81
84.	82 or 83
85.	limit 84 to “all adult (19 plus years)"
(b) Search strategy for CINAHL	
S76	S74 OR S75
S75	S71 AND S72
S74	S72 AND S73
S73	S7 OR S22 OR S27 OR S31 OR S36 OR S37 OR S38 OR S41 OR S47 OR S54 OR S59 OR S62
S72	S1 OR S2
S71	S64 OR S65 OR S66 OR S67 OR S68 OR S69 OR S70
S70	“nurse specialist”
S69	(MH “Nurse Practitioners+") OR “nurse practitioners"
S68	(MH “Primary Health Care") OR “primary health care” OR (MH “Health Care Delivery, Integrated”) OR (MH “Secondary Health Care")
S67	“community outpatient clinic*.mp."
S66	“multidisciplinary clinic*.mp."
S65	(MH “Multidisciplinary Care Team+") OR “interdisciplinary clinic*.mp."
S64	(MH “Ambulatory Care Facilities+") OR (MH “Outpatient Service”) OR “Outpatient Clinics, Hospital/" OR (MH “Outpatients”) OR (MH “Nurse-Managed Centers”) OR (MH “Community Health Centers+") OR (MH “Clinical Nurse Specialists”) OR (MH “National Association of Clinical Nurse Specialists")
S63	S61 OR S62
S62	“pain”
S61	(MH “Pain")
S60	S56 OR S57 OR S58 OR 59
S59	“nutrition”
S58	(MH “Diet Therapy+")
S57	“urinary incontinence"
S56	(MH “Urinary Incontinence")
S55	S49 OR S50 OR S51 OR S52 OR S53 OR S54
S54	“health knowledge"
S53	(MH “Health Knowledge")
S52	“patient education"
S51	(MH “Patient Education")
S50	“action plan”
S49	“treatment adherence"
S48	S43 OR S44 OR S45 OR S46 OR S47
S47	“hypertonic saline"
S46	(MH “Saline Solution, Hypertonic")
S45	“sinus”
S44	(MH “Sinusitis")
S43	(MH “Nebulizers and Vaporizers")
S42	S40 OR S41
S41	“smok*"
S40	(MH “SmokingCessation")
S39	“Air pollut*"
S38	(MH “Air Pollution")
S37	S33 OR S34 OR S35 OR S36
S36	“Anxiet*"
S35	(MH “Anxiety")
S34	“depress*"
S33	(MH “Depression")
S32	S29 OR S30 OR S31
S31	“life qualit*"
S30	“"Quality of Life""
S29	(MH “Quality of Life")
S28	S24 OR S25 OR S26 OR S27
S27	“breathless*"
S26	“shortness of breath"
S25	“dyspnea"
S24	(MH “Dyspnea+")
S23	S9 OR S10 ORS11 OR S12 OR S13 ORS14 OR S15 OR S16 ORS17 OR S18 OR S19 ORS20 OR S21 OR S22
S22	“Physical activit*"
S21	“Exercis*"
S20	(MH “Exercise")
S19	“pulmonary rehab*"
S18	(MH “Rehabilitation, Pulmonary+")
S17	“Sputum clearanc*"

(*continued on next page*)

(*continued*)

(b) Search strategy for CINAHL	
S76	S74 OR S75
S16	"Airway clearanc*"
S15	(MH "Physical Therapy")
S14	"Respiratory therap*"
S13	(MH "RespiratoryTherapy+")
S12	""personalised treatment"*"
S11	"Individualised treatment*"
S10	""precision medicine""
S9	"treatable trait*"
S8	S4 OR S5 OR S6 OR S7
S7	"self care*"
S6	(MH "Self Care")
S5	"self manag*"
S4	(MH "Self-Management")
S3	"bronchiectasis"
S2	(MH "Bronchiectasis+")

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