International perspectives on outcome measurement in pulmonary rehabilitation of people with COPD

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Original Research

International perspectives on outcome measurement in pulmonary rehabilitation of people with COPD: A qualitative study

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ABSTRACT

Background: There is high heterogeneity of outcomes and measures reported in the literature for pulmonary rehabilitation (PR), which might limit benchmarking and an effective evidence synthesis. A core outcome set (COS) can minimise this problem. It is however unclear which outcomes and measures are most important and suitable for different stakeholders.
Methods: A multicentre qualitative study with one-to-one semi-structured interviews with people with chronic obstructive pulmonary disease (COPD), healthcare professionals (HCPs), researchers and policy makers was conducted. Manifest content analysis was conducted to explore the frequency of outcomes viewed as crucial or not. Thematic analysis was performed to better understand stakeholders' views.
Results: 37 participants (17 people with COPD and 20 HCPs/researchers/policy makers) from 14 countries and 4 continents were included. Participants expressed that i) core outcomes need to be meaningful to people with COPD and show PR benefits; ii) there should be comprehensive assessment and similar outcomes across settings; iii) a balance between optimal and practical measures is needed; iv) the COS is needed to benchmark PR and advance knowledge; and v) reluctance to change outcomes/measures used by HCPs and using the COS as a maximum set of outcomes might be the pitfalls. 28 outcomes were identified as crucial, and 12 as not crucial.
Conclusions: This study provided important insights into outcome measurement in PR from the perspectives of different key international stakeholders and a list of outcomes that will inform a future consensus study.

1. Introduction

Pulmonary rehabilitation (PR) is a safe and effective intervention for the management of chronic obstructive pulmonary disease (COPD) [1]. Nevertheless, some patients still respond poorly to the intervention. This depends partially on the outcomes and measures selected, which commonly consider only the views of healthcare professionals (HCPs) or researchers [2–4].

A recent systematic review identified 163 outcomes and 217 measures reported in the literature, revealing high heterogeneity in outcome measurement during PR [5]. This is of most importance as measuring different outcomes and using different measures between centres and studies hinders benchmarking PR efficacy, an effective evidence synthesis, and effective marketing strategies to foster PR amongst payers, clinicians, and patients [6,7].

Heterogeneity can be minimised with a core outcome set (COS), defined as a standardised set of outcomes that is agreed by different stakeholders, and that should be measured and reported, as a minimum in PR trials and programmes [8,9]. A consensus in reporting outcomes of PR in patients with COPD has been advocated by international societies

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[10,11] and renowned researchers [12–15], and should include international perspectives to promote its worldwide applicability [8]. Although a Portuguese qualitative study has been previously conducted on perspectives of different stakeholders on outcomes of PR [16], international perspectives and views on the measures are unknown. Thus, this study aimed to explore international perspectives of people with COPD and HCPs, researchers and policy makers on outcomes and measures of PR.

2. Methods

A multicentre qualitative study with individual interviews was conducted. This study was approved by the Ethics Committee of the Research Unit of Health Sciences at the School of Nursing in Coimbra (UICISA), Portugal (P466-10/2017). All participants gave informed consent to participate in this study. The study is reported following the Consolidated Criteria for Reporting Qualitative Research (COREQ) [17]. This study is part of a COS that will include outcomes and measures to assess the effectiveness of PR programmes and is registered in the Core outcome measures in effectiveness trials (COMET) initiative database at https://www.comet-initiative.org/Studies/Details/1151.

2.1. Participant selection

People with COPD were recruited through HCPs using the snowballing technique, researchers' network, and a patient organisation (Respira) using purposive sampling.

HCPs, researchers, and policy makers (i.e., guideline developers) were invited through researchers' network and by disseminating the study via the European Respiratory Society group 1.02 (Rehabilitation and Chronic Care). A maximum variation strategy was used to recruit stakeholders from different countries with different backgrounds and gender [18].

Invitations occurred face-to-face or were sent by e-mail. A short explanation of the study and a short video "What are Core Outcome Sets" developed by COMET initiative, were provided to participants (https://youtu.be/g1MZi2mzK1U). Those interested to participate filled a sociodemographic and consent form (either online or face-to-face) and the interview with the researcher was scheduled according to participants' preferences.

People with COPD were included if they had a diagnosis of COPD and had participated or were participating in a PR programme.

HCPs, researchers, and policy makers were included if they had been involved in the design, assessment and/or implementation of PR programmes or data from them, and were able and comfortable speaking in English.

A total sample size of 10–20 interviews has been suggested for this type of study [18].

2.2. Data collection

An online or paper-based sociodemographic data form was completed by all stakeholders. The form was developed using Qualtrics (XM, Seattle, USA) and provided onsite or sent by email to participants. People with COPD provided information on sex, age, country of origin, occupation, time since diagnosis, and for how long they had been doing PR. HCPs, researchers, and policy makers provided information on sex, age, country of origin, professional group (e.g., HCP, researcher, guideline developer) and profession, and for how long they had been involved in PR.

Interviews with HCPs/researchers/policy makers were conducted online, through Zoom (California, USA), in English, by one English-proficient speaker and were recorded with the system's recorder. Interviews with people with COPD occurred in 2 formats: 1) online for people that were able to speak in English or Portuguese or 2) face-to-face in PR facilities of different countries with a local HCP in their native language.

One-to-one interviews were conducted by four researchers and followed a semi-structured guide (**Appendix A**) with open-ended questions about outcomes essential to be measured, preferences on the measures, perspectives on outcome measurement in different settings and different phenotypes, and of having a COS for pulmonary rehabilitation.

A rapport was established with participants, by keeping an informal environment and allowing short non-related conversations to the topics during the interviews.

After the interviews, audio files were saved to a computer with access restricted only to the researchers. Names of participants were replaced with pseudonyms to ensure confidentiality. Field notes were taken during and after each interview with reflections about the data collection process and ideas for analysis.

Orthographic transcription of audios was performed and followed a notation system previously proposed [18]. Interviews that were not conducted in English were first transcribed and then translated to English before the analysis by English proficient researchers.

2.3. Data analysis

The sample characteristics were analysed using Excel (Microsoft, Washington, USA).

Qualitative data were managed and analysed in Atlas.ti (v9, Berlin, Germany). Firstly, manifest content analysis was conducted to identify the frequency of outcomes reported as crucial or not for the COS, and the most commonnly reported outcome measures for each outcome [19]. No list of outcomes or measures was provided to participants. Outcomes were defined as crucial if they were spontaneously mentioned by participants after the question "Of all the outcomes mentioned [by you], can you share which ones are more important/crucial to you?". Similarly, they were categorized as non-crucial if participants mentioned that they should not be part of the COS. Outcomes were defined in clinical concepts through the interpretation of participants' own words.

Then, data were analysed by one author with thematic analysis with a primary inductive approach in 6 phases: transcription, generating initial codes, searching for themes, reviewing themes and defining and naming themes and producing the report [20]. S.S-M generated the initial codes using organic coding and the codes were then merged and interpreted as themes, when there were common patterns within the data [18]. During the analysis, memos were used to register decisions and other meaningful notes. Themes were discussed with the research team until consensus was reached. A negative case analysis was performed to ensure that there were no views of participants contradicting the overall interpretation of data.

Validation of results was performed with member checking, by one HCP and one person with COPD who revised the results to ensure they did not misrepresent their perspectives.

Trustworthiness was ensured through procedures of credibility, transferability, dependability and confirmability as recommended (Table A3) [21]. The research team reflexivity can be found in **Appendix A.**

3. Results

A total of 37 participants were interviewed. People with COPD (n = 17) were 53% males, on average 66 years old, diagnosed for about 14 years, mostly retired (74%) and from six countries and 2 continents. The other stakeholder group (n = 20) was composed of HCPs (95%), researchers (75%), and policy makers (20%). They were mostly females (55%), on average 43 years old, with 14 years of experience with PR on average, from six professional backgrounds of 11 countries and 3 continents. A total of 14 countries from 4 continents were covered. Interviews lasted 41 [17–82] minutes. Details of participants' characteristics are presented in Table 1.

A total of 28 outcomes were identified by both stakeholder groups as

Table 1
Characteristics of participants (n = 37).

	People with COPD (n = 17)	Healthcare professionals/ Researchers/Policy makers (n = 20)
Sex, n (%)		
Male	9 (53)	9 (45)
Female	8 (47)	11 (55)
Age, mean ± SD	65.9 ± 7.3	43.9 ± 9.6
Country, n (%)		
Portugal	4 (24)	–
Netherlands	4 (24)	3 (15)
UK	1 (6)	3 (15)
Norway	3 (18)	2 (10)
Germany	3 (18)	–
Sweden	–	2 (10)
Belgium	–	3 (15)
Switzerland	–	1 (5)
Italy	–	1 (5)
France	–	1 (5)
Denmark	–	1 (5)
Brazil	2 (12)	–
Australia	–	2 (10)
Canada	–	1 (5)
Occupation, n (%)		
Retired	12 (71)	N.A.
Self-employed	1 (6)	N.A.
Retired due to incapacity	3 (18)	N.A.
Employed	1 (6)	20 (100)
Healthcare professionals	N.A.	19 (95)
Physiotherapists	N.A.	7 (35)
Medical doctors	N.A.	3 (15)
Psychologists	N.A.	2 (10)
Nurses	N.A.	2 (10)
Occupational therapists	N.A.	3 (15)
Dietitians	N.A.	2 (10)
Researchers	N.A.	15 (75)
Policy makers	N.A.	4 (20)
Experience with pulmonary rehabilitation, months	40.4 ± 48.1	164.1 ± 99.6

N.A.: Not applicable.

crucial to be measured (Table B2, Appendix B). HCP/researchers/policy makers identified 12 outcomes as non-crucial (Table B3, Appendix B) and were uncertain to include 14 outcomes (Table B4, Appendix B). People with COPD only expressed opinions about crucial outcomes (could not identify outcomes that should be excluded from the COS) hence, non-crucial outcomes were not identified by these stakeholders. When combining data from both stakeholder groups, the outcomes most frequently defined as crucial were exercise capacity, dyspnoea, anxiety and depression. The most frequent non-crucial outcomes mentioned by HCPs/researchers and policy makers were lung function, handgrip muscle strength, physical activity and cognitive function.

Conflicting views were found for eight outcomes within and between stakeholder groups, i.e., considered by some people as crucial to be included in the COS and by others as non-crucial – lung function, muscle strength, physical activity, self-efficacy, anxiety and depression, exercise capacity, body mass index and balance. Both stakeholder groups did not report some outcomes (i.e., did not mention them spontaneously), hence the percentage of people not reporting, or reporting as crucial and/or non-crucial each outcome can be visualised in Fig. 1 and Table B1 (Appendix B).

A total of 68 measures, with their advantages and disadvantages from the perspectives of both stakeholders, were identified. Overall, people with COPD were less vocal about measurements, most had no strong opinions on the best measures and felt their assessments were well-chosen by their own HCPs. For 25 measures only advantages were identified, whilst for 5 only disadvantages were stated. A summarised list of the mentioned measures can be found in Table 2 with the full table with the views of stakeholders in Appendix C.

Some measures related with previously identified outcomes (Fig. 1) were not mentioned by participants and are therefore not displayed in this table.

AECOPD: Acute exacerbations of COPD; GOLD: Global initiative for chronic lung disease; PR: Pulmonary rehabilitation; AIR: Anxiety inventory for respiratory disease; DASS-21: 21-item Depression, anxiety and stress scale; GAD-7: Generalised anxiety disorder-7; HADS: The hospital anxiety and depression scale; BBS: Berg Balance scale; BESTest: Balance evaluation systems test; TUG: Timed up and go; DEXA: Dual-energy x-ray absorptiometry; MoCA: Montreal cognitive assessment; PHQ-9: Patient health questionnaire-9; BBQ: Breathlessness beliefs questionnaire; CAF: COPD Angst Fragebogen; CRQ: Chronic respiratory disease questionnaire; D-12: Dyspnoea-12 questionnaire; mMRC: Modified medical research council dyspnoea questionnaire; MDPI: Multidimensional dyspnoea profile; 6MWT: Six-minute walk test; CPET: Cardiopulmonary exercise testing; ESWT: Endurance shuttle walk test; ISWT: Incremental shuttle walk test; CIS–F: Checklist of individual strength – fatigue scale; FACIT-F: Functional assessment of chronic illness therapy fatigue scale; FI-CGA: Frailty index-Comprehensive geriatric assessment; CDS: Care dependency scale; COPM: Canadian occupational performance measure; ADL: Activities of daily living; MRADL: Manchester respiratory activities of daily living questionnaire; STS: Sit-to-stand test; SPPB: Short physical performance battery; 6PRT: Six-minute pegboard and ring test; CAT: COPD assessment test; EQ-5D: EuroQol - 5 Dimension; MRFQ: Maugueri respiratory failure questionnaire; SF-12: 12-Item short form survey; SGRQ: Saint George's respiratory questionnaire; VQ-11: Chronic obstructive pulmonary disease-specific health-related quality of life questionnaire; PAM: Patient activation measure; HHD: Hand-held dynamometry; BPI: Brief pain inventory; IPAQ: International physical activity questionnaire; CSES: COPD self-efficacy scale; PRAISE: Pulmonary rehabilitation adapted index of self-efficacy; PSQI: Pittsburgh sleep quality index; DJGLS: De Jong Gierveld Loneliness Scale.

Five themes with perspectives of both stakeholder groups were identified. Perspectives were concordant between stakeholder groups and no discrepancies related with the geographical area of participants were found.

Theme 1. Core outcomes need to be meaningful to people with COPD and show the benefits of PR

Stakeholders felt outcomes to be included in the COS needed to i) be meaningful to people with COPD and related to their daily life, as otherwise the intervention could be beneficial but lead to no significant daily difference; and ii) show PR benefits and cost-effectiveness, for advocacy and funding purposes.

It was perceived that core outcomes should help to personalise treatment, cover commonly impaired aspects at baseline, be related to prognosis, correspond to patients' goals for PR and be directly connected to the foundations of PR (e.g., exercise training).

> *"(…) like strength is so specific but it doesn't mean anything to the patient's life. Ability to get off the toilet is what matters to patients, so I think the reason why these [outcomes] should be included is because they matter to patients."*, Diana, female, Physiotherapist

> *"And I think that it is important to also look to what is relevant for a patient. Like I said, for me it is not that important if I can cycle longer on the cycle test, but it is important that I have for example more energy and that I can do more without getting breathless."*, Willow, female, person with COPD

> *"(…) I think it's playing a game a little bit, but I think that we do have to use outcomes that are going to show that it works, if we are going to talk that rehab is beneficial."*, Caleb, male, Physiotherapist

Theme 2. Comprehensive assessment and similar outcomes across settings

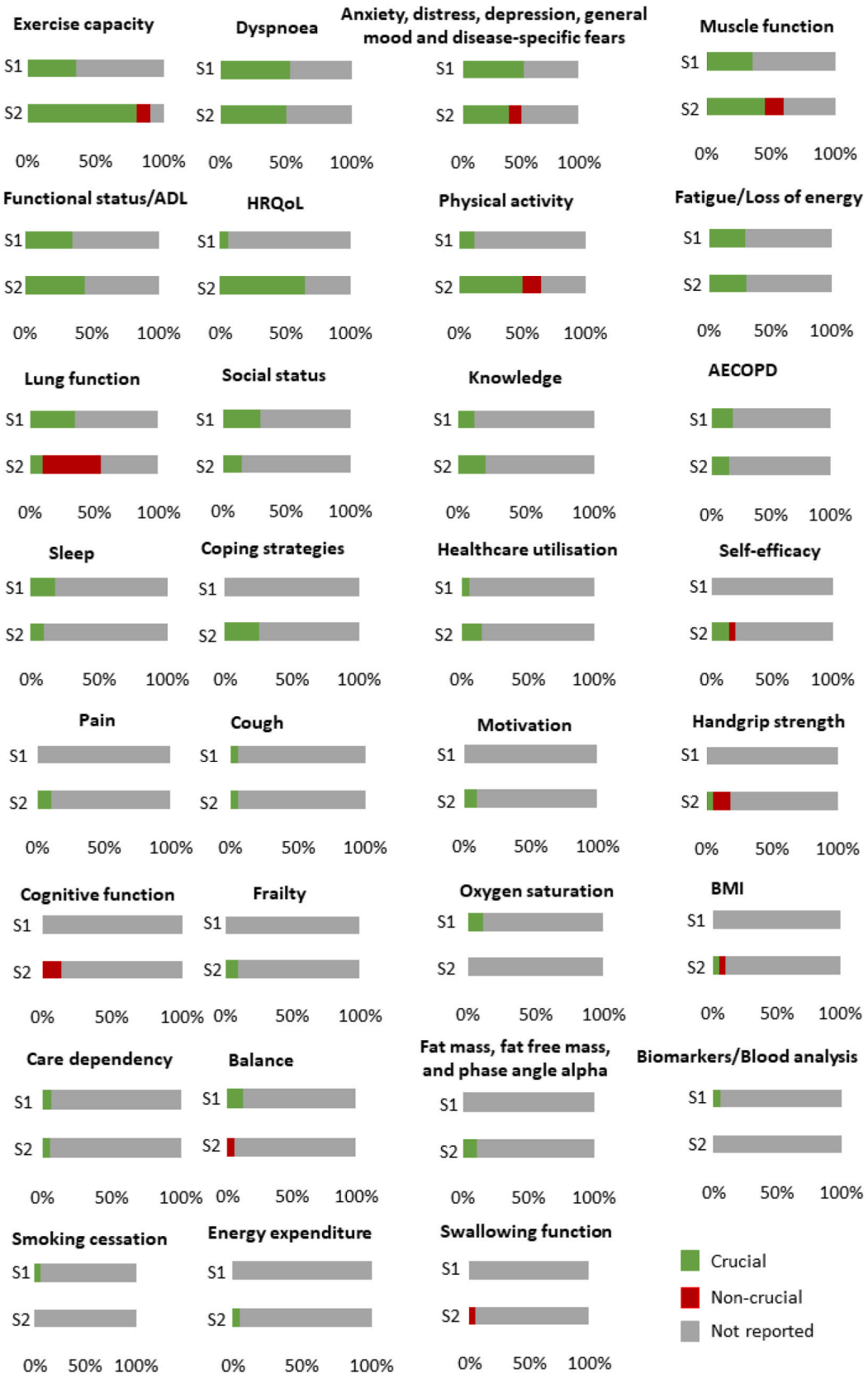

Fig. 1. Percentage of people with COPD (Stakeholder group 1 [S1], n = 17) and healthcare professionals/researchers/policy makers (Stakeholder group 2 [S2], n = 20) not reporting (not spontaneously mentioning the outcome - grey bars) or reporting each outcome as crucial (spontaneously mentioning the outcome as crucial - green bars) and/or non-crucial (spontaneously mentioning that the outcome should be excluded from the core outcome set - red bars
COPD: chronic obstructive pulmonary disease; HCP: Healthcare professionals; ADL: Activities of daily living; HRQoL: Health-related quality of life; AECOPD: Acute exacerbations of COPD; BMI: Body mass index. . (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 2
List of measures with advantages and disadvantages mentioned by both stakeholder groups (stakeholder group 1, 17 people with COPD; and stakeholder group 2, 20 healthcare professionals/researchers/policy makers).

Domain/Measure	Advantages	Disadvantages
AECOPD and healthcare utilisation		
GOLD ABCD assessment tool	• Developed by experts	Not mentioned
No. AECOPD previous year	• Important to have a long-term view	• Not robust enough
No. AECOPD during PR	• Recall is not too bad	Not mentioned
No. hospitalisations	• Can be improved with PR	Not mentioned
Anxiety and distress		
AIR	• Distinguishes anxiety symptoms from respiratory ones • Measures panic	• Not as convenient as other measures (does not measure depression)
DASS-21	• Also measures stress • Available for free	Not mentioned
GAD-7	• Good for primary care • Available for free	Not mentioned
HADS	• Does not have somatic items • Psychometrically robust • Frequently used • Also assesses depression • Short and easy to use	• It should be discussed with a trained professional • It is outdated • Not available for free • Not disease-specific
Balance		
BBS	Not mentioned	
BESTest (full version)	Not mentioned	• Time consuming
Brief-BESTest	• Allows personalising treatment	Not mentioned
Mini-BESTest	• Allows personalising treatment	Not mentioned
TUG	• Easy to use as a first screen measure • Can also measure functional status	Not mentioned
Body composition		
Bioelectrical impedance	• Quick to use	• Some equipment is not very accurate
DEXA	• Psychometrically robust • Important to detect comorbidities	• Not feasible for most settings/countries
Cognitive function		
MoCA	• It is the measure with most information for COPD	• Not comprehensive enough
Depression		
DASS-21	• Also measures anxiety and distress • Available for free	Not mentioned
HADS	• Does not have somatic items • Psychometrically robust • Frequently used • Also assesses anxiety • Short and easy to use	• It should be discussed with a trained professional • It is outdated • Not available for free • Not disease-specific
PHQ-9	• Available for free • Good for primary care	Not mentioned
Disease-specific fears		
BBQ	• Available in English	Not mentioned
CAF	• Comprehensive	• Needs translation/cultural adaptation
Dyspnoea		
Borg scale	• Possible to measure more than intensity of dyspnoea • Good to use during physical activity/exercise • The original is more precise than the modified	• Very generic • Takes time to get familiarised
CRQ dimension	• Psychometrically robust	Not mentioned
D-12	• Comprehensive assessment	Not mentioned
	• Short and easy to use	
mMRC	• Frequently used • More functional than other measures • Psychometrically robust • Short and easy to use	• Not very responsive to PR • Difficult for some patients to understand
MDPI	• Comprehensive	Not mentioned
Energy expenditure		
Indirect calorimetry	• Psychometrically robust	•Most are not mobile
Exercise capacity		
6MWT	• Affordable • More functional than other tests • Psychometrically robust • Shows the benefits of PR • Meaningful to patients • Familiar • Complements CPET • Better for more impaired patients • Feasible in clinical practice • Easy to perform • Useful to adjust oxygen therapy • Useful for exercise prescription	•Needs a long corridor •Might scare patients and cause dropouts •Needs a practice test •It's self-paced so it does not show real endurance capacity •Not meaningful for daily activities •Not the most responsive measure for PR •Not very comprehensive compared to other tests •Type of floor might influence the results •Not possible to use in patients with some disabilities
CPET	• Complements the 6MWT • Good to assess safety of the intervention • Gives a lot of information	•Difficult to do for some patients •Not feasible for most settings/countries •It might not reflect endurance capacity •Not very responsive to PR •Not functional enough
ESWT	• Not self-paced • Good for exercise prescription	•Difficult to implement •It is necessary to also do an ISWT
ISWT	• Measures maximum exercise capacity • Good for patients with more capacity • Feasible in clinical practice • Good for exercise prescription • Not self-paced	•Might scare patients and cause dropouts •Time consuming •Does not complement CPET •It is also necessary to do an ESWT •Not very good for patients with low capacity
Step tests (not specified)	• Complements a walking test	•Not feasible for most settings/countries (human resources) •Not meaningful to patients
Fatigue		
CIS–F	• Short and easy to use	•There are not enough studies
FACIT-F	• Comprehensive	Not mentioned
Frailty		
FI-CGA		•Not responsive to PR
Fried's phenotype	• Responsive to PR	•Not comprehensive enough
Handgrip dynamometry	• Quick and easy to use • Correlates with other strength measures	Not mentioned
TUG	• Quick and easy to use • Correlates with other strength measures	Not mentioned
Functional status/ADL		
CDS	• Easy to use • Comprehensive	•Has a ceiling effect
COPM	• Allows personalising treatment • Good for the home setting	•Requires a trained occupational therapist •Difficult to use in research •Time consuming
Glittre ADL test	• Comprehensive • Meaningful to patients	•Causes high levels of fatigue

(*continued on next page*)

Table 2 (*continued*)

Domain/Measure	Advantages	Disadvantages
Londrina ADL protocol	• Easy to perform • Patient-friendly	Not mentioned
MRADL	• Comprehensive • Responsive to PR	Not mentioned
Sit-to-stand tests (not specified)	• Good for small spaces/ home • Meaningful to patients • Good for people with low capacity • Feasible for different settings/countries	•There are not enough studies •Need to be standardised
1-min STS	• Easy to do • Patient-friendly • Can be used to also assess muscle function	•Might scare patients
30-s STS	• Can be used to also assess muscle function • Good for home/tele-rehabilitation • Meaningful to patients	Not mentioned
SPPB	Not mentioned	•Has a ceiling effect •Not feasible for all settings
6PRT	• Meaningful to patients	• Might cause pain
HRQoL		
CAT	• Feasible for most settings • Can be used to assess risk change in the ABCD assessment tool • Can be used to assess each symptom	• Not comprehensive enough • Difficult for some patients • Not good enough to assess the impact of dyspnoea on quality of life • Does not really assess quality of life • Scores depend on how the patient feels at the moment • Not very personalised
CRQ	• Not too long • Psychometrically robust • Frequently used • Has personalised questions • It is respiratory-specific • Comprehensive	Not mentioned
EQ-5D	• Also assesses pain • Measures well the construct of quality of life • Helps with cost-effectiveness analysis	• Not disease-specific
MRFQ	• Good for several respiratory diseases	Not mentioned
SF-12	• Measures well the construct of quality of life	Not mentioned
SGRQ	• Psychometrically robust • Can be used in respiratory diseases other than COPD • Good for research • Respiratory-specific	• Time consuming • Needs help of an HCP • Too generic • It is an old measure
VQ-11	• Quick and easy to use	Not mentioned
Motivation		
PAM	• Overall good measure	• Time consuming
Muscle function		
HHD	• Quick and easy to use	• Only good for weak patients • Does not reflect endurance which is important
Isokinetic system	• Psychometrically robust	• Not feasible for most settings/countries
Maximum repetitions	• Possible to measure strength and endurance • Important to prescribe exercise • Improves with PR – can be a motivator	• Not feasible for all settings • Not meaningful for daily life • Difficult to measure in some patients with disability
Maximum respiratory mouth pressures	• Quick and easy to use	• Does not reflect endurance which is important
Strain gauge	• Valid measure	• Not commercially available
Pain		
BPI	• Comprehensive	Not mentioned
Physical activity		
Accelerometery	• Frequently used • Optimal way to measure physical activity	• Not feasible for most settings
IPAQ		• Subjective
Pedometers	• Objective measure • Reliable • Inexpensive	• Not valid enough • Not comprehensive enough • Not patient-friendly
PROactive instruments	• Psychometrically robust	Not mentioned
Smartphones and wearables	• Generate a lot of useful data • More valid than a questionnaire • Easy to wear • Will become more psychometrically robust in the future • Useful to motivate patients	• Not psychometrically robust enough • Data is difficult to analyse • Might be difficult to use for some patients
Self-efficacy		
CSES	• Familiar	• Might be outdated
PRAISE	Not mentioned	• Might not be responsive to PR
Sleep		
PSQI	• Good measure for PR	Not mentioned
Social status		
DJGLS	• It's familiar	Not mentioned

Stakeholders felt it was necessary to have a comprehensive assessment (multiple and distinct domains) in the COS, as it would allow to have a broad picture of the patient's health and their improvements with PR. Furthermore, they thought outcomes should be similar across settings to enable comparisons and provide patients with same quality assessment and treatment.

> *"(…) given that they [i.e., the set of outcomes] are broad enough, that they try to target different aspects of what people with COPD would need, so I would say a core outcome set of 3 to 5 [outcomes] would be ideal to be implemented across different settings, I feel."*, Tobias, male, Psychologist

> *"Not only one or two physical variables, but a set of different ones. Of course, each person is different so it needs to be adjusted, but I think you should assess all dimensions, the physical part, the nutritional part, the psychological part. All of those dimensions and variables, but of course in some people some are more important than others, but they should always be present.",* Elizabeth, female, person with COPD

> *"The disadvantage [of assessing* different *outcomes in different settings] is that the disease is the same so, if one person does one thing and the other does another, this treatment was better for who? Me or him/her?",* George, male, person with COPD

Theme 3. Balance between optimal and practical measures

A great concern, for both stakeholder groups, was to include measures feasible for all, reasonably priced, short and simple, available in different languages (i.e., questionnaires), patient-friendly and preferably already commonly used by clinicians and researchers. Nonetheless, they thought the COS needed to strike the right balance between practicality and rigor and should contain psychometrically robust and comprehensive measures which reveal patients' treatable traits. Most people also recognised that although the outcomes should ideally be the same for different settings, having the same measures would be

challenging and adapting them to the context/resources might be therefore necessary.

> *"Minimal equipment, that you don't have massive requirements on space and things like that, or the staffing required to do those tests. In an ideal world, I'm just, especially considering I guess the kind of virtual models that we're having to work with at the moment, even something that can be done sort of safely remotely, for example, might be quite important.",* Lily, female, Researcher

> *"Not too expensive, yet valid. So that our results are trustworthy, outcomes are trustworthy. So, both economical perspective and practical perspective. And user-friendly. It should not be hard for the patient, it's one of the most important things.",* Norah, female, Dietitian

> "*Now, a hospital or a rehabilitation centre are different. The hospital has one way to do things and the conditions are different. In a clinic the conditions are different, because sometimes they don't have the machines, the treadmills, other things.",* Charles, male, person with COPD

Theme 4. A COS is needed to benchmark PR and advance knowledge

Participants thought the COS was important for benchmarking PR, as this would improve the quality of care for people with COPD, by acknowledging centres with best practices through audits. Furthermore, the COS was also perceived to advance knowledge in the field, by pooling data and facilitating comparisons across studies, producing meta-analysis, defining the optimal PR model, and generating new research questions. Participants also vocalised that a COS could help people with COPD to navigate through the health system, by transporting their results and avoiding repetition of assessments, and facilitating comparisons of their results with their peers.

Clarification of why the final outcomes and measures were chosen and endorsement by a credible source, such as recognised international societies, were perceived as fundamental for COS uptake by both stakeholders.

Additionally, they thought it should be disseminated locally, nationally, and internationally through various means, such as organisations (patients and professionals), social media, websites, directly to PR centres and HCPs, industry partners and researchers (e.g., publications, scientific meetings). Nevertheless, some concerns about having strict rules in outcome measurement were raised, as these could hinder personalisation of assessments and PR.

> *"There needs to be consistent standards for lung clinics to qualify for doing pulmonary rehabilitation. And there needs to be something like a quality assurance institution that controls clinics for that.",* Simon, male, person with COPD

> *"Well, one thing is the metadata to get the bigger picture of how this kind of treatment is helping patients. A group of 15 is a too small population for measuring or saying something about the outcome. (…) And therefore, a core list of outcomes is of course improving the population and the ability for the scientist to actually provide good recommendations. (…) And I think it's a good thing to make this kind of core parameters so that people around the world can learn from each other and make these kind of treatments and programs the best possible."*, Harrison, male, person with COPD

> *"I think the thing that to me makes the biggest impact locally, and I don't know what it's like in other countries, but if you get societal approval in different countries, and it goes into societal or, you know, thoracic societies, respiratory societies, as recommended practice, as opposed to just publishing a paper on it, I don't think the publication actually changes the practice, but if then it comes into your national or local guidelines, that's the thing that it will cause people to change."*, Caleb, male, Physiotherapist

Theme 5. Reluctance to change outcomes/measures used by HCPs and using the COS as a maximum set of outcomes might be the pitfalls

Participants highlighted reluctance to change routine clinical practice by HCPs as the most probable barrier for COS uptake. They thought that changing the measures and equipment of different centres and countries would be challenging as people might refuse to change their practice due to tradition, ownership of choice of assessment, lack of knowledge on the advised measures or simply because they would not see the advantage of having a minimum standardised set of outcomes.

Moreover, stakeholders showed concern with the implementation of the COS, as some centres could end up viewing the COS as a maximum number of measurements, not measuring other important outcomes for specific situations/patients.

> *"'Hey, I've been in this field for 30 years and I know what the hell I'm doing'. (…) And I don't know if that's real or not, but some [professionals] may feel actually threatened by it. Like, 'are we actually delivering the product, we say we're delivering?'."*, Patrick, male, person with COPD

> *"I mean, you ask for a behaviour change, and we all know how difficult it is to induce behaviour change. It's not different from making people move and that's very challenging so, if they been doing something for years, maybe decades, and a core outcome set might ask them to maybe change their practice, so that might be a pitfall. Healthcare providers will not be willing to change their practice, and I think there the challenge is to find the right communications, to target the right people.",* Connor, male, Physiotherapist

> *"The only thing is, when we have a core outcome set, it should be a minimum, and you should be able to do broader assessments and it should not be 'okay we only have to do this'."*, Delilah, female, MD

5. Discussion

This study provided important insights into outcome measurement in PR from the perspectives of different international stakeholders. It informed the development of a COS by defining that the COS should include outcomes that are meaningful to patients and show PR benefits, and measures that are feasible for different settings but psychometrically robust.

This study included four continents, and people from different backgrounds, hence providing an international picture of which outcomes are meaningful to key PR stakeholders, advantages, and disadvantages of using different measures, and usefulness and possible pitfalls of the COS.

The most frequent crucial outcomes identified in this study were exercise capacity, dyspnoea and anxiety and depression. It is likely they will end up in the final COS since these are also some of the most measured outcomes in PR trials [5]. This is partly in line with a recent expert consensus that advised exercise capacity, dyspnoea, quality of life, nutritional status and occupational status as the essential components to be assessed in PR [22], and with a COS developed for COPD in primary care physiotherapy practices which included exercise capacity, muscle strength, physical activity, dyspnoea and quality of life as core outcomes [23]. However, it is important to note that the expert consensus gathered mostly HCP, overlooking patients' perspectives, which is fundamental for the development of a COS.

Conflicting views were observed regarding the inclusion of lung function, muscle strength, physical activity, self-efficacy, anxiety and depression, exercise capacity, body mass index and balance. Moreover, some outcomes were not identified as crucial by both stakeholder groups (i.e., swallowing function, cognitive function) and others were only identified as crucial by one of the stakeholder groups (i.e., coping strategies, pain, motivation, frailty, oxygen saturation, fat mass, fat free mass and phase angle alpha, balance, biomarkers/blood analysis,

smoking cessation, energy expenditure). These findings highlight the importance of conducting a Delphi survey with all key stakeholders to achieve consensus on what should be measured as a minimum in PR.

Furthermore, although it is known that resting lung function remains unchanged and is not a goal of PR [24,25], stakeholders, particularly patients, seem to value it as an outcome of PR. This result in combination with the fact that patients were less comfortable naming non-crucial outcomes and discussing measures due to lack of knowledge, underlines the need of clarifying to patients what is being measured with each measure, why and what effects can be expected from PR. In fact, studies have highlighted the need to promote health literacy for people with COPD, with up to 59% of patients with limited health literacy [26,27].

In the present study no list of outcomes was provided to participants, i.e., they had to think about the crucial outcomes for them. Therefore, it is possible that when confronted with the outcomes to be scored in a Delphi survey, some outcomes that were rarely reported, especially by patients (e.g., health-related quality of life) will be classified as important.

This study also revealed future challenges for the COS uptake. Firstly, the choice of the most suitable measure for each outcome will be highly challenging, as stakeholders emphasized the COS only to be useful if measures are practical across different settings and resources. Hence, it is possible that some gold-standards will not be recommended and an additional consensus-method might be needed [28] to have a balance between quality and feasibility. Furthermore, although advantages and disadvantages of measures are displayed in this manuscript and might be useful in the future to decide "how to measure" the COS, a systematic review of their measurement properties before drawing recommendations is necessary.

Additionally, due to the importance of the COS for benchmarking PR and conducting more robust studies, strategies are needed to minimise the possible reluctance of HCPs to change and its misuse as a maximum rather than a minimum set of measurements. Strategies such as having the COS advised by a trusted source (i.e., internationally recognised respiratory society), advising measures that are already commonly used, and explaining the importance of the COS, might be important to minimise reluctance to change among HCPs. Although the use of the COS as a maximum of measurements for PR cannot be avoided, the number of outcomes to be included in the COS should be carefully thought. Five to nine outcomes have been advised by COS initiatives in other fields [29], but this may need to be further discussed for PR, as with too little outcomes the assessment might not be comprehensive enough, and with too many outcomes people might not have time to assess other relevant aspects for their patients or research. Some of these advantages and challenges, such as the COS being useful for meta-analysis, and the difficulty on 'how' to measure once the 'what' has been defined, have also been previously recognised on a study exploring the uptake of COS in Cochrane systematic reviews [30]. Furthermore, in an era of personalised medicine, the outcomes and measures to be included in the COS should not preclude conducting more comprehensive and personalised assessments of people with COPD, nor tailoring PR to each individual's needs.

This study provided a list of outcomes, that combined with those reported in the literature [5], will inform a future Delphi survey to achieve consensus on what should be measured as a minimum in PR.

Some limitations need to be acknowledged. The interviews were conducted in several languages, and some were translated to English (only forward translation), hence it is possible that some cultural inherent expressions and meanings got lost. Nonetheless, all translations and English-speaking interviews were conducted by English proficient speakers. Similarly to published COS in other areas, Africa and Asia were underrepresented in this study [31]. Additionally, although we had participants from the American continent, there was a lack of views from large countries such as the United States of America or Argentina. Hence, future research for this COS (i.e., Delphi survey), should include people from these continents/countries, as resources and PR practices may vary and therefore their perspectives are important to consider. Additionally, views of informal carers although previously explored [16], could be important, but were not included in this study due to difficulties in recruitment. Hence, future steps of the COS (e.g., Delphi and consensus meeting) should include these participants.

6. Conclusion

This study provided important insights into outcome measurement in PR from the perspectives of different international stakeholders and provided a list of outcomes that combined with outcomes prevenient from the literature will inform a future consensus study. Future studies should include informal carers in the process and achieve consensus on 'what' to measure and 'how' to measure in PR.

CRediT authorship contribution statement

Sara Souto-Miranda: Conceptualization, Methodology, Formal analysis, Investigation, Visualization, Project administration, Funding acquisition, Writing – original draft. **Anouk W. Vaes:** Methodology, Validation, Investigation, Resources, Writing – review & editing. **Rainer Gloeckl:** Methodology, Validation, Investigation, Resources, Writing – review & editing. **Anita Grongstad:** Methodology, Validation, Investigation, Resources, Writing – review & editing. **Martijn A. Spruit:** Conceptualization, Software, Validation, Supervision, Funding acquisition, Methodology, Resources, Project administration, Writing – review & editing. **Alda Marques:** Conceptualization, Methodology, Software, Validation, Resources, Supervision, Project administration, Funding acquisition, Writing – review & editing.

Declaration of competing interest

None.

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Appendix A. Supplementary data

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