**Development of Core Outcome Measures sets for paediatric and adult Severe Asthma (COMSA).**

Ekaterina Khaleva, Anna Rattu, Chris Brightling, Andrew Bush, Apostolos Bossios, Arnaud Bourdin, Kian Fan Chung, Rekha Chaudhuri, Courtney Coleman, Sven-Erik Dahlén, Ratko Djukanovic, Antoine Deschildre, Louise Fleming, Stephen J Fowler, Atul Gupta, Eckard Hamelmann, Simone Hashimoto, Gunilla Hedlin, Gerard H. Koppelman, Erik Melén, Clare S Murray, Charles Pilette, Celeste Porsbjerg, Katharine C Pike, Franca Rusconi, Clare Williams, Birgit Ahrens, Peter Alter, Freja Anckers, Maarten van den Berge, Katharina Blumchen, Guy Brusselle, Graham W Clarke, Danen Cunoosamy, Barbro Dahlén, Piers Dixey, Andrew Exley, Urs Frey, Erol A Gaillard, Lisa Giovannini-Chami, Jonathan Grigg, Diana Hartenstein, Liam G Heaney, Bülent Karadag, Susanne Kaul, Inger Kull, Amelia Licari, Anke H. Maitland-van der Zee, Vera Mahler, Ann-Marie M Schoos, Prasad Nagakumar, Jenny Negus, Hanna Nielsen, James Paton, Mariëlle Pijnenburg, Valeria Ramiconi, Sofia Romagosa Vilarnau , Stefania Principe, Niels Rutjes, Sejal Saglani, Paul Seddon, Florian Singer, Heribert Staudinger, Steve Turner, Susanne Vijverberg, Tonya Winders, Valentyna Yasinska, Graham Roberts on behalf of COMSA working group in the 3TR consortium.

**Authors and Affiliations**

Ekaterina Khaleva: Clinical and Experimental Sciences and Human Development in Health, Faculty of Medicine, University of Southampton, Southampton, UK. ORCID: 0000-0002-2220-7745.

Anna Rattu: Clinical and Experimental Sciences and Human Development in Health, Faculty of Medicine, University of Southampton, Southampton, UK.

Chris Brightling: Institute for Lung Health, Leicester NIHR BRC, University of Leicester, UK. ORCID: 0000-0002-9345-4903.

Andrew Bush: Centre for Paediatrics and Child Health and National Heart and Lung Institute, Imperial College; Royal Brompton Hospital, London, UK. ORCID: 0000-0001-6756-9822.

Apostolos Bossios: Department of Respiratory Medicine and Allergy, Karolinska University Hospital, Huddinge and Department of Medicine, Huddinge, Karolinska Institutet, Stockholm, Sweden. ORCID: 0000-0002-0494-2690.

Arnaud Bourdin: PhyMedExp, University of Montpellier, Montpellier, France.

Kian Fan Chung: National Heart & Lung Institute, Imperial College London, London. UK. ORCID: 0000-0001-7101-1426.

Rekha Chaudhuri: Institute of Infection, Immunity & Inflammation, University of Glasgow, Glasgow, UK.

Courtney Coleman: European Lung Foundation, Sheffield, UK

Sven-Erik Dahlén: Department of Respiratory Medicine and Allergy, Karolinska University Hospital, Huddinge and Department of Medicine, Huddinge, Karolinska Institutet, Stockholm, Sweden.

Ratko Djukanovic: NIHR Southampton Biomedical Research Centre, University Hospital Southampton, Clinical and Experimental Sciences, Faculty of Medicine, University of Southampton, Sir Henry Wellcome Laboratories, Southampton, UK. ORCID: 0000-0001-6039-5612.

Antoine Deschildre: CHU Lille, Unité de Pneumologie et Allergologie Pédiatrique, Hôpital Jeanne de Flandre F-59000 Lille, France; Univ. Lille, U1019 - UMR 8204 - CIIL - Center for Infection and Immunity of Lille, Lille, France.

Louise Fleming: National Heart and Lung Institute, Imperial College, London. ORCID: 0000-0002-7268-7433.

Stephen J Fowler: Faculty of Biology, Medicine and Health, School of Biological Sciences, Division of Infection, Immunity & Respiratory Medicine, The University of Manchester, and NIHR Manchester Biomedical Research Unit and Manchester University NHS Foundation Trust, Manchester, UK.

Atul Gupta: Department of Paediatric Respiratory Medicine, King’s College Hospital, London, UK. ORCID 0000-0002-1610-0335.

Eckard Hamelmann: Children’s Center Bethel, Department of Pediatrics, University Bielefeld, Bielefeld, Germany.

Simone Hashimoto: 1. Department of Pediatric Pulmonology, Emma Children's Hospital, Amsterdam University Medical Centers, Amsterdam, the Netherlands; 2. Department of Respiratory Medicine, Amsterdam UMC, University of Amsterdam, Amsterdam, the Netherlands. ORCID 0000-0001-8995-3817.

Gunilla Hedlin: Department of Women’s and Children’s Health and Centre for Allergy Research, Karolinska Institutet, Stockholm, Sweden.

Gerard H. Koppelman: University of Groningen, University Medical Center Groningen, Beatrix Children’s Hospital, Department of Pediatric Pulmonology and Pediatric Allergology, Groningen, the Netherlands; University of Groningen, University Medical Center Groningen, Groningen Research Institute for Asthma and COPD (GRIAC), Groningen, the Netherlands. ORCID 0000-0001-8567-3252.

Erik Melén: Department of Clinical Science and Education Södersjukhuset, Karolinska Institutet, Stockholm, Sweden. ORCID: 0000-0002-8248-0663.

Clare S Murray: Division of Infection, Immunity and Respiratory Medicine, University of Manchester, NIHR Manchester Biomedical Research Centre, Manchester University Hospitals NHS Foundation Trust, Manchester Academic Health Science Centre, Manchester, UK. ORCID: 0000-0002-8961-8055.

Charles Pilette: Department of Pulmonology, Cliniques universitaires Saint-Luc & pole of pulmonology, ENT and dermatology, Institute of experimental and clinical research (IREC), UCLouvain, Brussels, Belgium.

Celeste Porsbjerg: Department of Respiratory Medicine, Respiratory Research Unit, Bispebjerg Hospital, Copenhagen, Denmark. ORCID: 0000-0003-4825-9436.

Katharine C Pike: Department of Paediatric Respiratory Medicine, Bristol Royal Hospital for Children, Bristol, UK. 0000-0003-4911-6082.

Franca Rusconi: Department of Mother and Child Health, Azienda USL Toscana Nord Ovest, Pisa, Italy. ORCID: 0000-0002-9544-6472.

Clare Williams: European Lung Foundation, Sheffield, UK. ORCID 0000-0001-9446-0339.

Birgit Ahrens: Paul-Ehrlich-Institut, Federal Institute for Vaccines and Biomedicines, Division of Allergology, Langen, Germany.

Peter Alter: Department of Medicine, Pulmonary and Critical Care Medicine, Philipps University of Marburg (UMR), Baldingerstrasse 1, 35033 Marburg, Germany.

Freja Anckers: Patient and Public Involvement, Sweden.

Maarten van den Bergre: University of Groningen, University Medical Center Groningen, Department of Pulmonary Diseases, Groningen, the Netherlands; University of Groningen, University Medical Center Groningen, Groningen Research Institute for Asthma and COPD (GRIAC), Groningen, the Netherlands. ORCID 0000-0002-9336-7340.

Katharina Blumchen: Department of Children and Adolescent Medicine, Division of Pneumology, Allergology, Cystic fibrosis, University Hospital Frankfurt, Goethe-University, Frankfurt, Germany.

Guy Brusselle: Department of Respiratory Medicine, Ghent University Hospital, Ghent, Belgium.

Lisa Giovannini-Chami: 1. Pediatric Pulmonology and Allergology Department, Hôpitaux pédiatriques de Nice CHU-Lenval, Nice, France; 2. Université Côte d’Azur, France.

Graham W. Clarke: Translational Science and Experimental Medicine, Research and Early Development, Respiratory & Immunology, BioPharmaceuticals, R&D, AstraZeneca, Gothenburg, Sweden. ORCID 0000-0002-0193-2948.

Danen Cunoosamy: Global Medical Director, Global Medical Affairs Respiratory, Allergy & GI, Sanofi Genzyme, Cambridge, MA, USA.

Barbro Dahlén: Department of Respiratory Medicine and Allergy, Karolinska University Hospital, Huddinge and Department of Medicine, Huddinge, Karolinska Institutet, Stockholm, Sweden.

Piers H A Dixey: 1. National Heart Lung institute, Imperial College, London, UK; 2 Royal Brompton Hospital, London, UK. ORCID: 0000-0003-3080-8978.

Andrew Exley: Adept Biologica Consulting Limited, London, UK. ORCID: 0000-0002-2628-6129.

Urs Frey: University Children’s Hospital Basel, University of Basel, Switzerland. ORCID: 0000-0003-3773-2822.

Erol A Gaillard: University of Leicester, Department of Respiratory Sciences, Leicester NIHR Biomedical Research Centre (Respiratory theme), Leicester, UK.

Jonathan Grigg: Queen Mary University of London, London. ORCID: 0000-0003-3109-6028.

Diana Hartenstein: Paul-Ehrlich-Institut, Federal Institute for Vaccines and Biomedicines, Division of Allergology, Langen, Germany.

Liam G Heaney: Wellcome-Wolfson Centre for Experimental Medicine School of Medicine, Dentistry and Biomedical Sciences, Queen's University Belfast, UK.

Bülent Karadag: Marmara University Faculty of Medicine, Division of Pediatric Pulmonology, Istanbul, Turkey.

Susanne Kaul: Paul-Ehrlich-Institut, Federal Institute for Vaccines and Biomedicines, Division of Allergology, Langen, Germany.

Inger Kull: Department of Clinical Science and Education Södersjukhuset, Karolinska Institutet, Stockholm, Sweden. ORCID 0000-0001-6096-3771.

Amelia Licari: Pediatric Clinic, Fondazione IRCCS Policlinico San Matteo, University of Pavia, Pavia, Italy. ORCID 0000-0002-1773-6482.

Anke H Maitland-van der Zee: 1. Department of Respiratory Medicine, Amsterdam UMC, University of Amsterdam, Amsterdam, the Netherlands 2. Dept. of Paediatric Respiratory Medicine and Allergy, Emma’s Children Hospital, AmsterdamUMC, University of Amsterdam, the Netherlands. ORCID: 0000000204143442

Vera Mahler: Paul-Ehrlich-Institut, Federal Institute for Vaccines and Biomedicines, Division of Allergology, Langen, Germany. ORCID: **0000-0001-6471-1811.**

Ann-Marie M Schoos: COpenhagen Prospective Studies on Asthma in Childhood (COPSAC), Herlev and Gentofte Hospital, University of Copenhagen, Copenhagen, Denmark; Department of Pediatrics, Slagelse Sygehus, Slagelse, Denmark. ORCID: [0000-0002-5827-0885](https://orcid.org/0000-0002-5827-0885).

Prasad Nagakumar: 1. Department of Respiratory Medicine, Birmingham Children’s Hospital, Steelhouse lane, Birmingham, UK. 2. Institute of inflammation and Ageing, University of Birmingham. ORCID: 0000-0003-0837-0308.

Jenny Negus: Public and Patient Involvement, UK. ORCID:0000-0002-7542-0443.

Hanna Nielsen: Faculty of Medicine, Karolinska Institutet, Sweden; Patient and Public Involvement, Sweden.

James Paton: School of Medicine, College of Medical, Veterinary, and Life Sciences, University of Glasgow, Glasgow, UK. ORICID: 0000-0002-9896-7855.

Mariëlle W Pijnenburg: Erasmus MC – Sophia Children’s Hospital, University Medical Centre Rotterdam, Department of Paediatrics/ Paediatric Respiratory Medicine and Allergology, Rotterdam, The Netherlands. ORCID: 0000-0003-0902-0860.

Sofia Romagosa Vilarnau: European Federation of Allergy and Airways Diseases Patients’ Associations, Brussels, Belgium.

Valeria Ramiconi: European Federation of Allergy and Airways Diseases Patients’ Associations, Brussels, Belgium.

Stefania Principe: 1. Department of Respiratory Medicine, Amsterdam UMC, University of Amsterdam, Amsterdam, the Netherlands; 2. Department of Pulmonary Medicine; AOUP “Policlinico Paolo Giaccone”, University of Palermo, Palermo, Italy. ORCID: 0000-0001-7277-699X.

Niels Rutjes: Department of Pediatric Pulmonology & Allergy. Amsterdam UMC, Emma Children’s Hospital, Amsterdam, The Netherlands. ORCID: 0000-0002-3996-1963.

Sejal Saglani: National Heart and Lung Institute, Imperial College London, UK. ORCID: 0000-0001-5192-6418.

Paul Seddon: Respiratory Care, Royal Alexandra Children’s Hospital, Brighton, UK. ORCID: 0000-0003-2136-958X.

Florian Singer: 1.Department of Respiratory Medicine, University Children’s Hospital Zurich and Childhood Research Center, Zurich, Switzerland. 2. Division of Paediatric Pulmonology and Allergology, Department of Paediatrics and Adolescent Medicine, Medical University of Graz, Austria. ORCID: 0000-0003-3471-5664.

Heribert Staudinger: Therapeutic Area Immunology and Inflammation, Sanofi Genzyme, Bridgewater, USA.

Steve Turner: 1. Women and children division, NHS Grampian, Aberdeen, UK; 2. Child Health, University of Aberdeen, Aberdeen, UK. ORCID: 0000-0001-8393-5060.

Susanne J.H. Vijverberg: 1. Department of Respiratory Medicine, Amsterdam UMC, University of Amsterdam, Amsterdam, the Netherlands; 2. Department of Pediatric Pulmonology, Emma’s Children Hospital, Amsterdam UMC, University of Amsterdam, the Netherlands. ORCID: 0000-0002-4579-4081.

Tonya Winders: Allergy & Asthma Network, Vienna, VA, USA; Global Allergy & Airways Patient Platform, Vienna, AT. ORCID: 0000-0001-7689-6438.

Valentyna Yasinska: Department of Respiratory Medicine and Allergy, Karolinska University Hospital, Huddinge and Department of Medicine, Huddinge, Karolinska Institutet, Stockholm, Sweden. ORCID: 0000-0002-1379-1265

Graham Roberts: Clinical and Experimental Sciences and Human Development in Health, Faculty of Medicine, University of Southampton, Southampton, UK; Paediatric Allergy and Respiratory Medicine, University Hospital Southampton NHS Foundation Trust, Southampton, UK. ORCID: 0000-0003-2252-1248

**Correspondence Address:** Professor Graham Roberts, Paediatric Allergy and Respiratory Medicine, University Child Health (MP803), University Hospital, Southampton NHS Foundation Trust, Tremona Road, Southampton SO16 6YD, UK. Tel.: +44 (0) 2380796160 E-mail: g.c.roberts@soton.ac.uk

# **ABSTRACT**

**Background:** Effectiveness studies withbiological therapies for asthma lack standardised outcome measures. The COMSA (Core Outcome Measures sets for paediatric and adult Severe Asthma) working group sought to develop Core Outcome Measures (COM) sets to facilitate better synthesis of data and appraisal of biologics in paediatric and adult asthma clinical studies.

**Methods:** COMSA utilised a multi-stakeholder consensus process among patients with severe asthma, adult, and paediatric clinicians, pharmaceutical representatives and health regulators from across Europe. Evidence included a systematic review of development, validity, and reliability of selected outcome measures plus a narrative review and a pan-European survey to better understand patients’ and carers’ views about outcome measures. It was discussed using a modified GRADE Evidence to Decision framework. Anonymous voting was conducted using predefined consensus criteria.

**Results:** Both adult and paediatric COM sets include forced expiratory volume in 1 second (FEV1) as z scores, annual frequency of severe exacerbations and maintenance oral corticosteroid use. Additionally, the paediatric COM set includes the Paediatric Asthma Quality of Life Questionnaire, and Asthma Control Test (ACT) or Childhood-ACT while the adult COM includes the Severe Asthma Questionnaire and the Asthma Control Questionnaire-6 (symptoms and rescue medication use reported separately).

**Conclusions:** This patient-centred collaboration has produced two COM sets for paediatric and adult severe asthma. It is expected that they will inform the methodology of future clinical trials, enhance comparability of efficacy and effectiveness of biological therapies, and help assess their socioeconomic value. COMSA will inform definitions of non-response and response to biological therapy for severe asthma.

***Key words:*** *biological therapy, clinical trials, consensus, outcome measure, treatment outcome, severe asthma.*

**Take home message:**

A European multi-stakeholder working group has reached a consensus on Core Outcome Measures sets for paediatric and adult Severe Asthma (COMSA). These should inform future clinical trials and enhance comparability of findings.

**Abbreviations:**

ACT: Asthma Control Test

ACCI: Asthma Control and Communication Instrument

ACQ: Asthma Control Questionnaire

AQLQ: Asthma Quality of Life Questionnaire

AQLQ-S: Asthma Quality of Life Questionnaire Standardised

CASI: Composite Asthma Severity Index

C-ACT: Childhood Asthma Control Test

COM: Core Outcome Measures

COMET: Core Outcome Measures in Effectiveness Trials

COMSA: Core Outcome Measures sets for paediatric and adult Severe Asthma

COVID-19: coronavirus disease-19

COM-E: extended Core Outcome Measurement set

EAACI: European Academy of Allergy and Clinical Immunology

EFA: European Federation of Allergy and Airways Diseases Patients’ Associations

ELF: European Lung Foundation

ERS/ATS: European Respiratory Society / American Thoracic Society

FeNO: fractional exhaled nitric oxide

FEV1: forced expiratory volume in 1 second

FVC: forced vital capacity

GINA: Global Initiative for Asthma

GLI: Global Lung Function Initiative

GRADE: Grading of Recommendations, Assessment, Development and Evaluations

MART: maintenance and reliever therapy

MCID: minimal clinical important difference

MID: minimal important difference

Mini-AQLQ: Mini Asthma Quality of Life Questionnaire

Mini-PAQLQ: Mini Paediatric Asthma Quality of Life Questionnaire

mOCS: maintenance oral corticosteroids

OCS: oral corticosteroids

PAQLQ: Paediatric Asthma Quality of Life Questionnaire

PAQLQ-S: Paediatric Asthma Quality of Life Questionnaire-Standardised

PEF: peak expiratory flow

PROM: patient-reported outcome measures

PWG: patient working group

QoL: quality of life

SAQ: Severe Asthma Questionnaire

3TR: Taxonomy, Treatments, Targets, and Remission

# INTRODUCTION

Severe asthma is defined by the European Respiratory Society / American Thoracic Society (ERS/ATS), as asthma which requires treatment with high-dose inhaled corticosteroids and a second controller and/or systemic corticosteroids to prevent it from becoming ‘uncontrolled’ or which remains ‘uncontrolled’ despite this therapy.1 Severe asthma affects approximately 5-10% of patients with asthma1; however, there is variability in the prevalence estimates in children and adults2. It is associated with a significant impact on quality of life (QoL)3, treatment4,5, and socioeconomic4,6-8 burden. Many patients with severe asthma miss school9, or are unable to maintain full-time employment10, and some fail to respond to traditional asthma treatments.

Biological therapies for severe asthma improve individual patient outcomes.11 A series of systematic reviews reported that biologics improve asthma control and QoL and decrease exacerbation rates and rescue medication use.12-14 However, there is significant heterogeneity in which outcome measures are reported and what definitions are used in clinical trials. This makes it challenging to draw definite conclusions about the relative effectiveness of different biological agents; particularly given the paucity of head-to-head trials. Additionally, there are different eligibility criteria for initiating biologics in paediatric and adult patients15,16 and this makes comparisons between different trials difficult. Although validated and reliable outcomes or outcome measures for asthma have been recommended in the NIH series17-22, coreASTHMA23, clinical asthma registries24 and asthma trials25, there is no agreement on what is the most appropriate Core Outcome Measurement (COM) set for trials with biological therapies in severe asthma. A COM set is a minimum, standardised group of outcome measures that should be used and reported in all future clinical trials.26 The development of a COM set requires a multi-step process involving all relevant stakeholders including clinicians, and patients and their families to identify outcome measures that have suitable measurement properties, are most relevant, and are feasible for use.

To address the need for a robust set of outcome measures for severe asthma, we aimed to develop pan-European consensus patient-centred COM sets for use in studies of biological therapies in paediatric and adult patients with severe asthma. Having standardised COM sets would enable improved reporting and synthesis of outcome measures and therefore reduce publication bias, allow meaningful comparisons of efficacy and effectiveness of different biological therapies, and improve policy and patient-doctor shared decision making.

# METHODS

The COMSA initiative is registered on the Core Outcome Measures in Effectiveness Trials (COMET) database (<https://www.comet-initiative.org/Studies/Details/1698>). The approach was adapted from the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) initiative to select outcome measurement instruments for the COM set26 and is reported in accordance with the Core Outcome Set–Standards for Reporting statement.27**(Table S1).** Approval was gained from the University of Southampton ethics committee (ERGO 56181). This project is part of the 3TR (Taxonomy, Treatments, Targets, and Remission) consortium (<https://3tr-imi.eu>) funded by the European Commission’s Innovative Medicines Initiative 2.

## Participants for COM sets consensus process

Four key stakeholder groups were involved:

1. Paediatric and adult patient representatives with severe asthma – these included the 3TR Respiratory Adult and Youth Patient Working Groups (PWG) as well as patient advocacy organisations including the European Lung Foundation (ELF), European Federation of Allergy and Airways Diseases Patients’ Associations (EFA), Global Allergy & Airways Platform (GAAPP) and Lovexair. The ELF and EFA recruited patients and carers of patients with severe asthma from across Europe through their networks to capture a range of disease duration, unique experiences, and treatments, including biological therapy. Monthly calls with the two PWGs were held throughout the project to ensure a patient-centred approach in deciding the COM set for severe asthma. At these meetings, patients and patient advocates received online training about clinical trial design, outcome selection, core outcomes, the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) approach, and the consensus process. Minutes and training materials were shared with PWG members after each call.

2. Paediatric and adult respiratory were invited by the lead (G.R.) and senior investigator (E.K.) and included paediatricians, allergists, respiratory clinicians, nurses, researchers, and methodologists. The selected world-leading physicians had a broad range of clinical knowledge and expertise in managing patients with severe asthma on biologics. None of the participants were involved in the development of specific outcome measurement instruments.

3. Pharmaceutical industry representatives from AstraZeneca, Sanofi, Roche, Novartis who are partners in the 3TR consortium.

4. Regulators from European medicinal products regulatory authorities (hereafter referred to as “health regulators”). The selected health regulators had a broad range of regulatory knowledge and/or were specialised in the field of paediatric and/or adult allergology and respiratory medicine.

## Overview of COM set development

Paediatric (children and adolescents aged 6-17 years) and adult (≥18 years) COM sets were developed using a similar multi-stage approach to synthesise the evidence and achieve consensus **(Figure 1).**

### Stage 1: A systematic review to identify and appraise priority outcome measures for severe asthma

The detailed methods used to develop COM sets are provided in the systematic review.28 In brief, Step 1 involved the generation of a list of ‘candidate’ asthma outcome measures from a systematic literature search from the previous two years. Step 2 involved a modified two-round Delphi exercise amongst four stakeholder groups and a moderated web-conference to select ‘key’ outcome measures (rated as ‘critical’ or ‘important’29). Step 3 involved a systematic literature search28 to identify ‘initial’ validation studies for the key outcome measures and compare against good measurement properties criteria using modified COSMIN methodology.30-32

### Stage 2: Capturing patients’ and carers’ views

A narrative review was undertaken by two reviewers (CC, CW) to synthesise evidence about patients’ and carers’ perceptions and opinions about outcome measures for severe asthma. Three bibliographic databases were searched from the year 2000. Full details are provided in the online supplement.

A cross-sectional pan-European survey was conducted to gain insight in the perspectives of the wider patient population about outcome measures used for severe asthma. See online supplement for further details.

### Stage 3: Multi-stakeholder consensus meetings

The aim of the consensus meetings for paediatric and adult outcome measures was to provide an opportunity to better understand views of different stakeholder groups, discuss key issues, resolve any disagreements, and reach consensus on the final COM sets.

#### Initial meetings to reduce to priority outcome measures

The systematic review evidence, together with the results of a narrative review and a pan-European survey of patients’ and carers’ perceptions and preferences about outcome measures for severe asthma (see online supplement) were discussed in two initial multi-stakeholder meetings. Materials were provided a week before meetings. Patient-reported outcome measures (PROM) such as asthma-specific QoL, general QoL, asthma control, asthma symptoms, composite outcome measures were discussed in the first meeting followed by online voting to select eight priority PROMs. Clinical and healthcare use outcome measures such as forced expiratory volume in 1 second (FEV1), fractional exhaled nitric oxide (FeNO), peak expiratory flow (PEF), FEV1/FVC ratio (FVC, forced vital capacity), blood and/or sputum eosinophils, hospitalisations, exacerbations, adverse events, oral corticosteroid (OCS) use were discussed at the second meeting followed by online voting to select four priority outcome measures.28 Results were presented using the GRADE system.33

#### Consensus meeting to decide on COM sets

Prior to the adult and paediatric consensus meetings, all participants received the agenda, reading materials, including results of the systematic review about the development and measurement properties of priority outcome measures28, comments from previous multi-stakeholder discussions, original copies of questionnaires, results of the pan-European survey (online supplement) and narrative review (online supplement) as well as data from the EAACI systematic reviews12-14 and a systematic review of real-life studies on biological therapies34. All materials included summaries of the results in lay language, with an additional lay glossary of terms. Participants were invited to attend optional drop-in sessions to ask questions about materials prior to the consensus meetings.

Primary consideration was given to content validity results about relevance, comprehensiveness, and comprehensibility as per COSMIN guidance on selecting core outcome measurement instruments26 as well as patient-centred literature. During previous discussions participants highlighted that the ideal outcome measures for biological trials should also have good responsiveness, established minimal clinical important difference (MCID) / minimal important difference (MID) and be relevant to severe asthma patients. Participants were invited to share their views, refine definitions, address discrepancies across stakeholders and suggest possible combinations of outcome measures.

The online consensus meetings were held on 7th June 2021 to evaluate the evidence for adult and on 20th July 2021 for paediatric severe asthma to ratify the final COM sets. Although these meetings were initially planned to be face-to-face with all stakeholder groups, this was changed to virtual meetings due to the coronavirus disease-19 (COVID-19) public health restrictions. Each meeting was recorded to facilitate minutes, and a link was shared with those participants who were not able to attend.

#### COM set voting

An anonymised electronic voting process was employed after the meetings. All 3TR participants received minutes, evidence discussed at the meetings, and a link to an online voting form to share their views. Along with minimal demographic information, in the first-round participants were asked to select up to five and six outcome measures for paediatric and adult COM sets respectively and rank them in the order of importance. A free-text comment box was available to provide rationale and further arguments for inclusion or exclusion of outcome measures.Votes from clinicians, researchers, pharmaceutical representatives, and health regulators were included in the ‘academic’ group while votes from patients and patient representatives were classified into the ‘patient’ group. Outcome measures that scored ≥70% of the panellist’s groups (patient or academic) votes were judged to have met consensus for inclusion based on COMET guidelines and previous patient-centred COM sets.35,36 Several reminders were sent to improve participation in the voting.

Results of the first round were analysed and collated into a summary of votes and comments divided by stakeholder group. Prior to the next round of voting, this summary was shared with the 3TR panel (four key stakeholder groups) who were invited to provide further comments about the group of outcome measures where consensus was not achieved (<70% agreement). Subsequently, all participants were invited to take part in round 2 (and additionally round 3 for the adult COM set) voting for these outcome measures. A summary of all comments as well as initial voting results and evidence with comments from the meetings were included in the invitation email.

## Statistical analysis

All data from the pan-European survey and online voting were analysed using SPSS software version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to describe respondent characteristics. Medians with lower and upper quartiles are presented for continuous variables given the distribution of the data. Frequency tables with percentages are provided for categorical variables. Summary tables and figures were used to represent the results.

# **RESULTS**

## Stage 1: A systematic review to identify and appraise priority outcome measures for severe asthma (Figure 1)

Step 1 led to the identification of 96 candidate outcome measures. These were reduced to 55 key measures in the modified Delphi exercise (Step 2). Subsequently, following the systematic literature search, and multi-stakeholder meetings, eight, and nine, priority outcome measures were identified for adult and paediatric populations respectively (Step 3). The validity and reliability of the priority measures (Step 4) are discussed elsewhere.28

## Stage 2: Capturing patients’ and carers’ views (Figure 1)

### Narrative review

The systematic literature search found 127 papers out of which seven papers met the inclusion criteria **(Figure S1).** Patient perspectives were extracted about the following outcome measures: PEF monitoring37-39, hospitalisations3,37,38,40, exacerbations41, adverse events3,37,38,40-42, and reducing OCS use37,38,40-42. Avoiding hospitalisation, decreasing OCS use and related side effects, and reducing the number and severity of exacerbations are treatment priorities identified by patients. More details are available in the online supplement.

### A pan-European survey

A total of 201 (87%) patients and 31 (13%) parents/carers of patients with severe asthma completed the survey. Most were female (77% and 87% patients and parents/carers, respectively), had completed university education (59% and 71%) and 54% were being treated with a biological therapy **(Table S2).**

Patients and carers identified the following characteristics in regard to filling out questionnaires as ‘very important’: ‘longer recall period e.g. ≥2 weeks’ (59% and 65%), ‘accurate results even if it takes longer to complete’ (51% and 32%), ‘opportunity to complete at home’ (39% and 45%) and ‘using either a mobile app (40% and 29%) or computer’ (39% and 48%) **(Figure 2).** Responders were willing to complete a questionnaire once every month (38% and 16%) or as often as their doctor recommends (34% and 36%). It should ideally take only 6-10 minutes (45% and 36%) **(Figure S2, Table S3).**

The following characteristics of lung function tests were favoured the most and rated as ‘very important’ in the survey: ‘accuracy of the results’ (83% and 65%) and ‘safe to complete’ (67% and 59%) **(Figure S3, S4, Table S4).** Further results, themes and quotes can be found in **Figures S5, S6 and Tables S5-S6.**

When survey respondents were asked to select only five outcomes, they ranked the following as first or second most important for patients and parents/carers, respectively: emergency hospital admissions due to asthma (64% and 29%), lung function (49%, and 36%), QoL questionnaires (42% and 39%), exacerbations (40% and 40%) and OCS use (37% and 100%) **(Figure 3).**

## Stage 3: Multi-stakeholder consensus meetings (Figure 1)

#### Adult Core Outcome Measures set

#### A total of 35 participants comprised the multi-stakeholder panel for the Adult COM set consensus meeting including 19 (54%) clinicians,9 (25%) patients and patient advocates, 4 (11%) health regulators and 3 (9%) pharmaceutical representatives. The main discussions about the priority outcome measures are summarised below and results of the final COM set reported at the end.

**Asthma-specific quality of life questionnaires.** Four instruments were considered including Asthma Quality of Life Questionnaire43-45 (AQLQ), Asthma Quality of Life Questionnaire Standardised45,46 (AQLQ-S), Mini Asthma Quality of Life Questionnaire45,47 (Mini-AQLQ) and Severe Asthma Questionnaire48-50 (SAQ). SAQ had a ‘moderate’ modified GRADE rating for development, whereas other QoL instruments were rated lower.28 Responsiveness to change was rated ‘low’ to ‘very low’ for all questionnaires; MCID/MID is only reported for AQLQ and SAQ50, with the AQLQ MCID being quoted for AQLQ-S and Mini-AQLQ. Patients highlighted that the Mini-AQLQ might not accurately represent the full AQLQ. The SAQ was highly endorsed as the only questionnaire developed with input from patients with severe asthma and includes items about fatigue and OCS side effects unlike others. Given the novelty of the SAQ, it was suggested that the AQLQ or AQLQ-S should be considered for inclusion in the COM set to allow comparisons with results from previous studies.

**Asthma control outcome measures.** The Asthma Control Test51-53 (ACT), Asthma Control Questionnaire ACQ-654-56 (symptoms and rescue medication use) and ACQ-5 (symptoms only)54-56 were discussed at length.None were developed with input from patients with severe asthma and were rated ‘very low’ in terms of development. Responsiveness to change was rated ‘low’ and ‘very low’ but MCID/MID data are available for all instruments. The response format of the ACQ was preferred compared to the ACT by patients; while ACQ-6 contains an item about rescue medication use which is lacking in ACQ-5. However, ACQ-6 does not differentiate between the different rescue medications and their dosing; therefore, it was suggested to report it as ACQ-5 to describe symptoms and rescue medication use separately.

**Composite outcome measure.** The Asthma Control and Communication Instrument57 (ACCI) was rated ‘low’ and ‘very low’ for the developmental and validation process with no data about responsiveness and MCID/MID. Clinicians highlighted that it is rarely used in practice and clinical trials due to the complex scoring system.

**Clinical outcome measures.** Clinicians noted that FEV1 changes exceed the MID in some studies with biologics, and it is associated with mortality and future risk of exacerbations.12-14 Reporting of FEV1 as z scores using the Global Lung Function Initiative (GLI) predictive equations58 was agreed by the panel.

**Healthcare resource use.** The ATS/ERS definition25 of severe exacerbation defined as events requiring systemic corticosteroids for ≥ 3 days and/or a hospitalization/emergency room visit for asthma requiring systemic corticosteroids was selected, with exacerbations effectively demonstrating the effectiveness of biologics for different asthma endotypes. However, the more recent ERS/EAACI statement suggests the definition should be based on ≥ 5 days of OCS.59 Annual severe exacerbation frequency should be reported. Use of maintenance OCS (mOCS) defined as daily or alternate day use was considered important for inclusion by all stakeholder groups. Median (25th, 75th centiles) dose and proportion on mOCS should be reported.

**Ratified COM set for adults**. The number of participants who voted in each round is listed **in Table 1**. After the third round, five outcome measures reached the 70% consensus threshold and formed the final COM set for adults with severe asthma: SAQ, ACQ-6 (symptoms and rescue medication use reported separately); FEV1; severe exacerbations; mOCS use **(Figure 4, Figure S7-S9, Table S7-S9)**. Characteristics and availability of selected outcome measures in the adult COMSA is reported in **Table 2.** No clear consensus was achieved on whether AQLQ or AQLQ-S should be used in the extended COM set (COM-E). However, a suggestion was made to additionally include AQLQ in the short term as it includes activities tailored to the patient and would enable retrospective comparisons.

#### Paediatric Core Outcome Measures Set

A total of 28 participants comprised the multi-stakeholder panel for the Paediatric COM consensus meeting including 13 (46%) clinicians, 12 (43%) patients and patient advocates, and 3 (11%) health regulators. The main discussions are summarised below.

**Asthma-specific quality of life questionnaires.** The Paediatric Asthma-Quality of Life Questionnaire60-63 (PAQLQ), Paediatric Asthma Quality of Life Questionnaire-Standardised60,62,63 (PAQLQ-S) and Mini- Paediatric Asthma Quality of Life Questionnaire62,63 (Mini-PAQLQ) were reviewed. None appear to have been developed with input from patients with severe asthma. Panellists highlighted that when activities are specified (PAQLQ-S) it is easier to compare between patients, but this could be less relevant for individual patients. Responsiveness to change was rated as ‘low’ to ‘very low’. The MCID for PAQLQ is available and is used for other questionnaires. Some important concepts for severe asthma are not covered in the asthma-specific QoL questionnaires, e.g. “missed school days” and fatigue.

**Asthma control outcome measures.** The ACT51,53 (≥12 years), Childhood Asthma Control Test64,65 (C-ACT) (4-11 years), ACQ-7 (symptoms, rescue medication use, and FEV1)54,56,66,67, ACQ-654,56,66 (symptoms and rescue medication use) and ACQ-554,56,66 (symptoms only) (≥6 years) were discussed. An assessment of control over 4 weeks was suggested to be advantageous. Some clinicians proposed using ACQ-6 to harmonise the paediatric COM set with the adult one and facilitate transition between services. Patient advocates expressed a particular preference for ACT and C-ACT as they both include a global question about self-rating of control.

**Composite outcome measure.** The Composite Asthma Severity Index68,69 (CASI) was deprioritised as it does not include items relating to QoL and activity limitations and was not developed with patient input.

**Clinical outcome measures**. Most children aged ≥5 years can perform spirometry reliably.70 FEV1 may not always reflect current degree of asthma control71, however clinicians suggested that low FEV1 predicts future risk of exacerbations, which is also supported by the literature.72 Reporting of FEV1 as z- scores using the GLI predictive equations58 was agreed by the panel. Most participants felt that FeNO was useful biomarker in understanding and managing asthma73 although consensus was not reached for it to be one of the patient-centred, core outcome measures

**Healthcare resource use.** Exacerbation was ranked within the top five most important outcome measures by patients in the pan-European survey and shown to have good responsiveness to change in different biologics. The panel agreed to use annual frequency of severe exacerbations defined by the ATS/ERS definitions.25

Maintenance OCS use as per the adult COMs was selected. Some clinicians thought that mOCS use was not important for children as it is used very infrequently; however, others noted that reduction in OCS use is a major criterion to assess whether a biologic has been effective. Additionally, carers in the pan-European survey indicated that OCS use is one of the most important aspects especially due to the associated side effects. Being treated with mOCS was selected as OCS bursts should be captured by severe exacerbations.

**Ratified COM set for paediatric severe asthma**. After the second round of voting, five outcome measures for paediatric severe asthma reached the 70% consensus threshold: FEV1, severe exacerbations, PAQLQ, mOCS use and ACT/C-ACT **(Table 3, Figure 5, Figures S10, S11, Table S10-11).** Characteristics and availability of selected paediatric COMSA is reported in **Table 2.**

# **DISCUSSION**

In this multi-step consensus process involving four key stakeholder groups, we developed adult and paediatric COM sets to standardise outcome reporting for severe asthma biological trials. Through multi-stakeholder consensus meetings and multiple rounds of voting, we identified five core outcome measures for adult and paediatric clinical trials that are important to patients, clinicians, pharmaceutical representatives, and health regulators. Our recommendations were informed by data from a pan-European survey, a narrative literature review, plus the developmental and validation process including applicability for severe asthma, responsiveness to change, and availability of MCID from systematic reviews.

The COM sets we present are novel since they focus specifically on severe asthma. The COMSA initiative builds on the coreASTHMA project that aimed to harmonise collection and reporting of outcomes in patients with moderate to severe asthma.23 Both initiatives selected exacerbations, asthma-specific QoL and change in asthma control as core outcomes; however, COMSA aimed to select specific outcome measures to assess QoL and asthma control and also included FEV1 and mOCS use. Furthermore, coreASTHMA included asthma-specific emergency department visits and asthma-specific hospital stay or admission. These outcomes were discussed by the COMSA panellists in multi-stakeholder discussions prior to the consensus meeting and were excluded due to variable admission protocols and differences in healthcare settings.

Using PROMs is important to understand the effect of asthma treatment on patients’ QoL and experience with biological treatment. Panellists strongly advocated the inclusion of SAQ in the adult set; although currently validation data are only available for UK and Portugal population, further studies are underway to adapt the SAQ to other languages, settings and for children. The advantages of using this outcome measure were that it is the only instrument that is developed for severe asthma patients and scored well for validation and reliability. However, while AQLQ has a longer history and experience in use, it was not specifically developed for severe asthma and does not assess side effects of OCS use and the psychological burden for these patients.

Generic outcome measures (for example generic QoL instruments) were not selected, but we acknowledge they are imperative to facilitate comparisons of burden across diseases and cost-effectiveness analysis of biological therapies.74,75 The AQLQ would also be more appropriate for asthma studies enrolling mild, moderate and severe participants.

Identifying an asthma control instrument that would be relevant for severe asthma was noted as a challenge. The GINA-2021 report recommends using MART (maintenance and reliever therapy) for adolescents and adults with asthma at all treatment steps and prefers ACQ-5 as the ACQ-6 rescue question is not valid for MART.76 However, ACQ-6 was rated as a more relevant outcome measure for the COM set but it should be reported as ACQ-5 (asthma symptoms) and rescue medication use separately. Lastly, during the consensus process it was suggested that trials should record comorbidities as many patients, especially children and adolescents, have other allergic conditions and several biologics can impact on more than one disease. However, the focus of this work is severe asthma, and it was suggested that separate COMs should be considered for other comorbidities.

## Strengths and limitations

Our study has several strengths. The COMSA was developed through a methodologically robust and multi-national consensus process according to the modified guidance from the COMET initiative. It incorporated perspectives from four stakeholder groups including patients with severe asthma from across Europe. Translators were available for patients to prevent any selection bias and incorporate wider patient perspectives during meetings and online voting. Additionally, qualitative analysis of comments from the multilingual pan-European survey allowed further representation of views of patients and carers. Throughout the project, researchers collaborated with ELF and EFA representatives who have extensive experience of working with patients to ensure comprehensibility of the process. Furthermore, we used a systematic and transparent approach in assessing the development and measurement properties of priority outcome measures by applying COSMIN guidelines and synthesised the evidence using the modified GRADE approach.30-32 Lastly, having online consensus meetings and voting allowed an interactive exchange of views from a wider range of representatives from across Europe.

We acknowledge some limitations. We aimed to develop patient-centred COM sets; however, some core outcome measures were not highly favoured from the patient perspective. Furthermore, the systematic review did not identify any validation data for the priority clinical and healthcare use measures for severe asthma and so decisions were based on expert consensus. Although a considerable number of expert clinicians, patients with severe asthma, patient representatives, pharmaceutical representatives and health regulators were involved from across Europe, it would have been useful to have included more especially from the latter two groups. It would also have been helpful to have additional non-UK clinicians although we had good involvement of healthcare professionals. We chose to include a relatively low number of patient representatives to ensure that we could provide them considerable support and training to allow them to provide could meaningful input into the development process. This limitation was mitigated by the pan-European patient survey which widened the input of patient views. Lastly, it is important to highlight that COMSA is a minimum set only and other outcome measures could also be included by study investigators according to their research needs.

## Research agenda

The development of a QoL outcome measure specifically for children and adolescents with severe asthma was identified as a major unmet need. Currently, paediatric QoL PROMs do not assess all possible impairments such as anxiety, and activity limitations specific to severe asthma. As highlighted by the PWG and pan-European survey, most of the questionnaires are not accessible online or via mobile application, thus further development and validation is needed. Furthermore, there is an unmet need for long term outcomes, and also importantly, disease-modifying outcome measures in severe asthma including disease remission.

Panellists also noted that side effects of OCS and biologics, and adherence to therapy, should be considered as important outcome measures. Due to the lack of validated and reliable methods of collecting these data as well as data for the clinical and healthcare outcome measures for severe asthma, this was considered as a research gap. Therefore, the COMSA should be updated once new data is available. Researchers should also develop a more robust means of measuring reliever use that takes into account the different relivers such as salbutamol, terbutaline and the MART approach. Lastly, there is also a need for data specifically from paediatric studies with biologics to assess responsiveness to change of outcome measures.

## Conclusions

In conclusion, we have developed evidence-based and patient-centred core outcome measurement sets for paediatric and adult severe asthma biological therapy trials. The COMSA should be recommended to increase consistency in reporting of outcome measures, and to improve comparability of studies and certainty of evidence to guide policy-making and clinical practice. These COM sets will inform future work for the development of definitions of response and non-response to biological therapies for severe asthma. Regular review and updates are necessary to ensure that the COM sets reflect current clinical practice. There is a need to develop an approach for monitoring implementation of these COM sets, and global uptake of the agreed core outcome measures in research and practice.

## Contributions

G. Roberts and E. Khaleva: conceptualisation and methodology; E. Khaleva: statistical analysis of the votes; E. Khaleva: development of the survey; A. Rattu, C. Coleman and C. Williams: review of the survey; E. Khaleva: statistical analysis of the survey data and writing up; E. Khaleva and A. Rattu: thematic analysis of comments from the survey; E. Khaleva and A. Rattu: search strategies, title and abstract screening for the narrative review; C. Coleman and C. Williams: title, abstract and full-text screening and writing up of the narrative review; E. Khaleva: drafting of the original manuscript; all authors reviewed, edited and approved the manuscript.

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**Table 1.** Demographic information about survey respondents in the voting process to agree on adult COMSA.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Clinician and researcher**n (%) | **Patient representative**n (%) | **Pharmaceutical representative**n (%) | **Health regulator**n (%) |
| Round 1 n=30 | Round 2 n=31 | Round 3 n=26 | Round 1 n=11 | Round 2n=11 | Round 3 n=14 | Round 1 n=3 | Round 2n=1 | Round 3 n=4 | Round 1 n=5 | Round 2n=4 | Round 3 n=5 |
| **Country**  |   |   |  |   |   |   |   |   |   |  |  |  |
| Belgium | 2 (7) | 2 (7) | 1 (4) | - | - | - | - | - | - | - | - | - |
| Denmark | 1 (3) | 2 (7) | - | - | - | - |  | - | - |  | - |  |
| France | 2 (7) | - | 1 (4) | - | - | - | - | - | - | - | - | - |
| Germany | 2 (7) | 2 (7) | 1 (4) | - | - | - | 1 (33) | - | 1 (25) | 4 (80) | 3 (75) | 4 (80) |
| Ireland | - | - | - | 2 (18) | 1 (9) | 2 (14) | - | - | - | - | - | - |
| Italy | 2 (7) | 1 (3) | - | 2 (18) | 1 (9) | 2 (14) | - | - | - | - | - | - |
| Netherlands | 2 (7) | 3 (10) | 5 (19) | 1 (9) | 2 (18) | 2 (14) | - | - | - | - | - | - |
| Poland | 3 (10) | 1 (3) | 2 (8) | - | - | - | - | - | - | - | - | - |
| Portugal | - | - | - | 1 (9) | - | - | - | - | - | - | - |  |
| Spain | 1 (3) | 1 (3) | - | - | 1 (9) | 1 (7) | - | - | - | - | - | - |
| Sweden | 3 (10) | 6 (19) | 4 (15) | 2 (18) | 2 (18) | 2 (14) | 1 (33) | 1 (100) | 1 (25) | - | - | - |
| Switzerland | - | - | - | - | - | - | - | - | 1 (25) | - | - | - |
| United Kingdom | 12 (40) | 13 (42) | 12 (46) | 3 (27) | 3 (27) | 4 (29) | - | - | - | 1 (20) | 1 (25) | 1 (20) |
| United States | - | - | - | - | 1 (9) | 1 (7) | 1 (33) | - | 1 (25) | - | - | - |
| **Gender** |  |  |  |  |  |  |  |  |  |  |  |  |
| Male | 22 (73) | 19 (61) | 17 (65) | 2 (18) | 2 (18) | 3 (21) | 3 (100) | 1 (100) | 4 (100) | 1 (20) | 1 (25) | 1 (20) |
| Female | 8 (27) | 12 (39) | 9 (34.6) | 9 (82) | 9 (82) | 11 (79) | - | - | - | 4 (80) | 3 (75) | 4 (80) |
| **Age group (years)** |  |  |  |  |  |  |  |  |  | - |  |  |
| 18-25 | 1 (3) | 1 (3) | 1 (4) | 2 (18) | 2 (18) | 2 (14) | - | - | - | - | - | - |
| 26-36 | 2 (7) | 3 (10) | 2 (8) | 2 (18) | 2 (18) | 2 (14) | - | - | - | - | - | - |
| 37-47 | 6 (20) | 8 (26) | 9 (35) | 2 (18) | 3 (27) | 4 (29) | 1 (33) | 1 (100) | 3 (75) | - | - | - |
| 48-58 | 13 (43) | 12 (39) | 10 (39) | - | 2 (18) | 2 (14) | 2 (67) | - | 1 (25) | 4 (80) | 3 (75) | 4 (80) |
| 59-69 | 8 (27) | 7 (23) | 3 (12) | 4 (36) | 1 (9) | 2 (14) | - | - | - | 1 (20) | 1 (25) | 1 (20) |
| 70-80 | - | - | 1 (4) | 1 (9) | 1 (9) | 2 (14) | - | - | - | - | - | - |
| **Online meeting** |  |  |  |  |  |  |  |  |  |  |  |  |
| Yes | 16 (53) | 16 (52)  | 12 (46) | 8 (73) | 8 (73) | 10 (71) | 2 (67) | 1 (100) | 2 (50.0) | 4 (80) | 3 (75) | 4 (80) |
| No | 14 (47) | 15 (48) | 14 (54) | 3 (27) | 3 (27) | 4 (29) | 1 (33) | - | 2 (50.0) | 1 (20) | 1 (25) | 1 (20) |

Percentages are rounded to zero decimal places so totals may not add up to 100%.

**Table 2.** Characteristics of the questionnaires selected for the adult and paediatric COMSA

| Scale(year) | Modes of administration | Target population  | Time to complete | Patient/carer report | Recall period | No. of questions, response format(s) | Scoring method | Original language, translations\* | License and costs |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *Questionnaires selected for the adult COMSA* |
| SAQ48 (2018) | -Self-complete-Paper form  | 16–78 years  | 3-6 minutes | Patient | 2 weeks | -SAQ: 16 questions7-point Likert scale: 1=very, very difficult, 7=no problem-SAQ-global: 100-point scale 0 = no quality of life, 100 = perfect quality of life | - SAQ: average of responses; range=1-7 - SAQ-global: range= 0-100 | - English (UK- 2 validated translations- several unpublished translations | - Copyrighted by University of Plymouth and University Hospitals Plymouth NHS Trust- Free for non-commercialclinical practice and research- Fees may apply for funded research, healthcare organizations, commercial use |
| ACQ-655\*\*symptoms + rescue medication(2001) | - Self-complete - Paper form- Interactive web- Electronic devices | ≥6 years  | NR | Patient | 1 week | - 6 questions- 7-point Likert scale: 0=no impairment, 6= maximum impairment | - Average of responses; range=0-6 | - English (UK)- 111 translations | - Copyrighted by questionnaire developer, QOL Technologies Ltd- Free for non-commercial clinical practice and research- Otherwise, there is a one-time fee- Electronic version requires a user fee |
| *Questionnaires selected for the paediatric COMSA* |
| PAQLQ60(1996) | - Self-complete - Paper form-Interviewer- administered version (≤ 11 years) | 7-17 years  | -10-15 minutes at initial visit- 5-10 minutes at follow ups | Patient  | 1 week | - 23 questions- 7-point Likert scale: 1=severe impairment, 7=no impairment | - 3 subscales - Average of responses;range= 1-7 | - English (North America)- 62 translations | - Copyrighted by questionnaire developer, QOL Technologies Ltd- Free for use in non-commercialclinical practice and research- Otherwise, there is a one-time fee |
| C-ACT65 (2007) | - Self-complete- Paper form- Web-based | Children / carer of children aged 4–11 years | NR but web-based version takes 5 minutes to complete | Patient andcarer | 4 weeks | - For children (4 questions): 4-point Likert scale: 0= ‘very bad’, 3= ‘very good’ including pictures of a child’s face with matching expressions-For carers (3 questions): 6-point Likert scale: 0= ‘everyday’, 5= ‘not at all’ | -Sum of the item responses; range=0-27- ≤19 points= uncontrolled asthma | - English (USA)- 27 translations  | - Copyrighted by GlaxoSmithKline Ltd- Free for non-commercial clinical practice and research- Fee may apply for commercial use |
| ACT51 (2004) | - Self-complete- Interviewer-administered- Paper form- Web-based - Telephone  | ≥12 years  | 1-2 minutes | Patient  | 4 weeks | - 5 questions, 5-point scale - Questions about symptoms and activities: 1=all the time, 5= not at all- Patient self-rating of control: 1=not controlled at all, 5=completely controlled | - Sum of the item responses; range=5-25- ≤19 points= uncontrolled asthma | - English (USA)- 179 translations | - Copyrighted by Quality Metric Inc- Permission required for use |

ACQ, Asthma Control Questionnaire; C-ACT, Childhood Asthma Control Questionnaire; ACT, Asthma Control Test; COMSA, Core Outcome Measures set for Severe Asthma, PAQLQ, Paediatric Asthma Quality of Life Questionnaire; QoL, Quality of Life; NR, not reported; SAQ, Severe Asthma Questionnaire. **\***The number of translations is an estimate sourced from sites and manuals of the instruments available in English.The ACQ-6 should be reported as the ACQ-5 to describe symptoms and rescue medication use separately.

 **Table 3.** Demographic information about survey respondents in the voting to agree on paediatric COMSA.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Clinician and researcher**n (%) | **Patient representative**n (%) | **Pharmaceutical representative**n (%) | **Health regulator**n (%) |
| Round 1n=36 | Round 2n=34 | Round 1n=13 | Round 2n=9 | Round 1n=1 | Round 2n=2 | Round 1 n=3 | Round 2 n=3 |
| **Country of residence** |   |  |   |  |   |  |  |  |
| Denmark | 1 (3) | 1 (3) | - | - | - | - | - | - |
| France | 2 (6) | 1 (3) | - | - | - | - | - | - |
| Germany | 2 (6) | 1 (3) | - | - | - | - | 3 (100) | 3 (100) |
| Ireland | - | - | 1 (8) | 1 (11) | - | - | - | - |
| Italy | 2 (6) | 2 (6) | 2 (15) | 1 (11) | - | - | - | - |
| Netherlands | 4 (11) | 3 (9) | 1 (8) | - | - | - | - | - |
| Poland | 2 (6) | 1 (3) | - | - | - | - | - | - |
| Sweden | 4 (11) | 4 (12) | 5 (39) | 3 (33) | - | 1 (50) | - | - |
| Switzerland | 1 (3) | 2 (6) | - | - | - | - | - | - |
| Turkey | 1 (3) | 1 (3) | - | - | - | - | - | - |
| United Kingdom | 17 (47) | 18 (53) | 3 (23) | 3 (33) | - | - | - | - |
| United States | - | - | 1 (8) | 1 (11) | 1 (100) | 1 (50) | - | - |
| **Gender** |  |  |  |  |  |  |  |  |
| Male | 19 (53) | 19 (56) | 2 (15) | 1 (11) | 1 (100) | 2 (100) | - | - |
| Female | 17 (47) | 15 (44) | 11 (85) | 8 (89) | - | - | 3 (100) | 3 (100) |
| **Age group (years)** |  |  |  |  |  |  |  |  |
| 12-17 | - | - | 3 (23) | 1 (11) | - | - | - | - |
| 18-25 | 1 (3) | 1 (3) | 2 (15) | 2 (22) | - | - | - | - |
| 26-36 | 2 (6) | 2 (6) | 2 (15) | 2 (22) | - | - | - | - |
| 37-47 | 9 (25) | 7 (21) | 3 (23) | 3 (33) | - | 1 (50) | - | - |
| 48-58 | 14 (39) | 15 (44) | 1 (8) | 1 (11) | - | 1 (50) | 3 (100) | 3 (100) |
| 59-69 | 8 (22) | 7 (21) | 1 (8) | - | - | - | - | - |
| 70-80 | 2 (6) | 2 (6) | 1 (8) | - | - | - | - | - |
| Prefer not to say | - |  | - |  | 1 (100) |  | - |  |
| **Online meeting** |  |  |  |  |  |  |  |  |
| Yes | 21 (58) | 21 (62) | 8 (62) | 6 (67) | - | - | 3 (100) | 2 (67) |
| No | 15 (42) | 13 (39) | 5 (39) | 3 (33) | 1 (100) | 2 (100) | - | 1 (33) |

Percentages are rounded to zero decimal places so totals may not add up to 100%.

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**Figure legends.**

**Figure 1.** Core outcome measurement set development process. COMSA: Core Outcome Measures for paediatric and adult Severe Asthma.

**Figure 2.** Patients’ and carers’ views about characteristics of questionnaires for assessment of severe asthma according to the pan-European survey.

**Figure 3.** Overall views of patients and carers about outcome measures for assessment of severe asthma according to the pan-European survey. Respondents were asked to select the five outcome measures and rank their importance from 1=most important to 5=least important, for use in future severe asthma trials and clinical practice.

**Figure 4.** The adult core outcome measures set for severe asthma clinical trials. COMSA: Core Outcome Measures for paediatric and adult Severe Asthma. Forced expiratory volume in 1 second (FEV1) should be reported as z-scores using the Global Lung Function Initiative (GLI) predictive equations58; annual severe exacerbations as per ATS/ERS definition25 and maintenance oral corticosteroid (mOCS) use defined as daily or alternate day use ((median (25th, 75th centiles) dose and proportion on mOCS should be reported)). The ACQ-6 should be reported as the ACQ-5 to describe symptoms and rescue medication use separately.

**Figure 5.** The paediatric core outcome measures set for severe asthma clinical trials. COMSA: Core Outcome Measures for paediatric and adult Severe Asthma. Forced expiratory volume in 1 second (FEV1)should be reported as z-scores using the Global Lung Function Initiative (GLI) predictive equations58; annual severe exacerbations as per ATS/ERS definition25 and maintenance oral corticosteroid (mOCS) use defined as daily or alternate day use ((median (25th, 75th centiles) dose and proportion on mOCS should be reported)). The Childhood Asthma Control Test should be used for children 4-11 years old, and the Asthma Control Test is for children 12-18 years old.