



The treatable traits of asthma in pregnancy: a clinical audit

Katarzyna Duszyk¹, Vanessa Marie McDonald^{1,2}, Dennis Thomas¹, Kelly Steel¹ and Peter Gerard Gibson^{1,2}

¹Centre of Excellence in Treatable Traits, College of Health, Medicine and Wellbeing, University of Newcastle, New Lambton Heights, NSW, Australia. ²Department of Respiratory and Sleep Medicine, John Hunter Hospital, New Lambton Heights, NSW, Australia.

Corresponding author: Peter Gerard Gibson (Peter.Gibson@newcastle.edu.au)



Shareable abstract (@ERSpublications)

Treatable traits are common among pregnant women with asthma and can be assessed by telehealth. This is a useful clinical development. <https://bit.ly/3UCW8rx>

Cite this article as: Duszyk K, McDonald VM, Thomas D, *et al.* The treatable traits of asthma in pregnancy: a clinical audit. *ERJ Open Res* 2024; 10: 00748-2023 [DOI: 10.1183/23120541.00748-2023].

Copyright ©The authors 2024

This version is distributed under the terms of the Creative Commons Attribution Non-Commercial Licence 4.0. For commercial reproduction rights and permissions contact permissions@ersnet.org

Received: 26 Oct 2023
Accepted: 5 Feb 2024

Abstract

Rationale Poor asthma control in pregnancy is associated with adverse perinatal outcomes. Treatable traits improve patient outcomes but the pattern and prevalence of treatable traits in pregnant women with asthma is unknown. Whether treatable traits in pregnant women with asthma can be identified *via* a virtual care consult is also unknown. The objective of the present study was to assess the prevalence of treatable traits in pregnant women with asthma using a virtual model of care.

Methods Pregnant women with asthma (n=196) underwent an assessment by an asthma nurse educator and a respiratory physician *via* telehealth. In this clinical audit, 16 treatable traits were assessed including two traits in the pulmonary domain, five traits in the behavioural/risk factors domain and nine traits in the extrapulmonary domain.

Results Pregnant women with asthma had a mean±SD of 7.5±2.0 treatable traits per person including 1.0±0.7 treatable traits per person in the pulmonary domain, 3.5±1.56 in the extrapulmonary domain and 2±0.9 in the risk factor/behavioural domain. Treatable traits in the behavioural/risk factor domain were most prevalent and these included limited asthma knowledge (96%), inadequate inhaler technique (84%) and no written asthma action plan (80%). On average 3.8±1.24 interventions per person were delivered for a mean±SD of 7.5±2.0 treatable traits per person.

Conclusion Virtual antenatal asthma care is a feasible approach for assessing treatable traits in pregnant women with mild asthma. Pregnant women with asthma exhibit multiple management issues. Virtual models of care might increase asthma in pregnancy service uptake and acceptability.

Introduction

Asthma is one of the most prevalent chronic diseases reported in pregnancy [1, 2]. In Australia, one in 10 pregnant women have asthma [3]. Asthma in pregnancy, and in particular asthma exacerbations, are associated with an increased risk of adverse perinatal outcomes, such as low birthweight, prematurity, perinatal mortality and neonatal hospitalisation [2, 3]. This underscores the importance of providing effective asthma management in pregnancy.

The treatable traits model of care has been proposed to address the heterogeneity and complexity of chronic airway disease and has been shown to improve patient-centred outcomes including improved quality of life and a reduced rate of hospitalisations [4–6]. The treatable traits strategy is a proposed vehicle for implementation of precision medicine in chronic airway disease. This approach allows for deconstruction of chronic airway disease into components that are measurable, clinically significant and treatable [7]. It utilises multidimensional assessment of every patient with chronic airway disease to determine the core traits associated with disease outcomes, followed by the application of targeted and evidence-based treatment [7, 8]. While the treatable traits model of care has been applied to severe asthma and COPD patient populations, it has not been, to the best of our knowledge, applied to asthma in pregnancy. In pregnancy, asthma is one of several different clinical issues that are present [9] and treatable



traits might be a useful way to assist management of the complexities of care in this situation [10], it is not known which treatable traits are most prevalent and clinically relevant in this population.

There are many deficits in asthma self-management skills among pregnant women [11]. This is likely a reflection of limited access, availability and uptake of asthma management services. Recently, the COVID-19 pandemic presented new challenges in delivering patient care. It also presented an opportunity to embrace a virtual model of care. The potential advantages of this approach include improved access and uptake of the asthma management service by pregnant women with asthma [12]. However, whether a treatable traits-based model of antenatal asthma care can be effectively applied *via* virtual care is not known.

In this study, a novel treatable traits-centred virtual model of antenatal asthma care was implemented. As part of this new service, we collected data to provide insights into the treatable traits profiles and trait prevalence in pregnant women with asthma. This study represents the first attempt to provide a novel virtual asthma treatable traits assessment and management service that may address the challenges inherent to managing asthma in pregnancy. The aim of this audit was to characterise treatable traits in pregnancy using a virtual model of care.

Methods

Study design

Pregnant women with asthma were identified by staff in the antenatal clinic at John Hunter Hospital and referred for asthma assessment and management. A comprehensive antenatal assessment was conducted by antenatal clinic staff. A trained nurse asthma educator contacted participants to offer the service, and then scheduled a nurse educator telehealth visit and a physician telehealth visit. Data were recorded on a standardised asthma assessment form. The study was approved by the Hunter New England Research Ethics Committee.

Asthma diagnosis

At recruitment, the women had a prior doctor's diagnosis of asthma and reported asthma symptoms in the prior year or had used asthma medication in the past year. They were then assessed by a specialist asthma nurse educator and a respiratory physician in two telehealth visits. These assessments reviewed the patient's asthma history (typical symptoms, symptom pattern, variability and triggers, age of onset, medication use and response to medication, exacerbation severity and pattern), asthma control and medication use. The label of doctor-diagnosed asthma was validated by the respiratory physician assessment.

We assessed 16 treatable traits by clinical audit including two treatable traits in the pulmonary domain, nine in the behavioural/risk factors domain and five in the extrapulmonary domain (table 1). From published reports of treatable traits, the implementation team identified 16 treatable traits that were potentially suitable for telehealth assessment and management in a population with mild asthma. The primary data sources for trait prevalence were assessments completed and recorded by an asthma nurse educator, a respiratory physician and the maternal health team (midwife and obstetric physician) at Hunter New England Local Health District between 2020 and 2021. Respiratory nurse and respiratory physician assessments were both conducted *via* telehealth, while obstetric assessments were conducted *via* a mix of face-to-face and telehealth assessments.

Analysis

Deidentified patient data were entered and stored in the REDCap clinical data storage database. Collected data were exported to an Excel spreadsheet and analysed in STATA statistical software (version 17.0, StataCorp LLC, Texas, USA). Descriptive statistics, including mean, standard deviation (SD) and/or median and quartiles (Q1, Q3), were used to characterise the data for normally and non-normally distributed variables, respectively. Prevalence of treatable traits was expressed as a percentage. Correlations between the number of treatable traits and asthma control, pregnancy complications and perinatal complications were reported using Pearson's correlation coefficient. Significance was accepted when $p < 0.05$.

Results

We assessed 196 pregnant women with a doctor's diagnosis of asthma. Participants had a mean \pm SD age of 30 \pm 5.0 years. Current smoking was identified in 13% of women and 24.6% were ex-smokers. Baseline obstetric characteristics are described in table 2. Low risk pregnancies were identified in 51.1% of patients, with the remaining classified as high risk. Patients were allocated to a model of antenatal care based on pregnancy risk assessment during an initial antenatal visit. The allocated models of antenatal care are summarised in table 2. Pregnancy complications are summarised in table 3.

TABLE 1 Treatable traits assessed in pregnancy

Trait	Trait identification marker	Trait prevalence (%)
Pulmonary domain		
Eosinophilic airway inflammation	Peripheral blood eosinophil count $>300 \text{ cells} \cdot \mu\text{L}^{-1}$	53.0
Neutrophilic inflammation	Peripheral blood neutrophil count $>8 \times 10^9 \cdot \text{L}^{-1}$	42.0
Extrapulmonary domain		
Obesity	Body mass index $>30 \text{ kg} \cdot \text{m}^{-2}$	63.0
Anaemia	Haemoglobin $\leq 110 \text{ g} \cdot \text{L}^{-1}$	6.2
Iron deficiency without anaemia	Ferritin $\leq 30 \mu\text{g} \cdot \text{L}^{-1}$	67.0
Depression	History	39.0
Anxiety	History	50.0
Vocal cord dysfunction	Clinician diagnosis and compatible history	4.6
Obstructive sleep apnoea	Polysomnography	4.6
Gastro-oesophageal reflux disease	History	45.0
Rhinosinusitis	History	67.0
Behavioural/risk factor domain		
Lack of written exacerbation management plan	Questionnaire	80.0
Smoking (current smoker)	Self-reported	13.3
Inadequate inhaler technique	Direct observation	83.5
Inadequate adherence	Standardised assessment	35.9
Limited asthma knowledge	Standardised assessment	96.0

Asthma assessment

On assessment by the asthma nurse using a standardised 7-day asthma symptoms questionnaire, 35.7% of patients had good asthma control, while 43.4% and 20.9% were deemed to have partial and poor asthma control, respectively. The five most commonly reported asthma symptoms previously experienced by participants were dyspnoea (94.9% of participants), cough (80%), chest tightness (76%), wheeze (74.5%) and sputum production (26.5%). Almost half (48%) of participants were managing their asthma with as-required salbutamol monotherapy, while 38% were prescribed regular inhaled corticosteroid/long-acting β_2 agonist (LABA) combination inhaler with as-required salbutamol. Only 8.4% of pregnant women with asthma were taking a maintenance inhaled corticosteroid and as-required salbutamol. The symbicort (formoterol/budesonide) maintenance and reliever therapy (SMART) regimen was used by 3.6% of women. Only 1% of participants were taking maintenance inhaled corticosteroid, as-required salbutamol and ipratropium treatment, and 1% of women were on a combination of inhaled corticosteroid/LABA with as-required salbutamol and long-acting antimuscarinic treatment (LAMA). The majority of patients had infrequent asthma exacerbations, with a median asthma exacerbation rate of 0 (IQR 1) per 12 months.

Treatable traits assessment

The prevalence of treatable traits in the pulmonary, extrapulmonary and behavioural/risk factor domains is shown in table 1. Pregnant women with asthma exhibited between 1 to 12 treatable traits, with a mean \pm SD of 7.5 \pm 2.0 of the 16 traits assessed per person. There were between 0 and 2 pulmonary traits with a mean \pm SD of 1 \pm 0.7 trait per person in the pulmonary domain. Patients exhibited a mean \pm SD of 3.5 \pm 1.56

TABLE 2 Baseline obstetric characteristics and allocated model of antenatal care

Obstetric characteristics	Median (interquartile range)
Maternal age, years	30.0 (6)
Gravidity	2.0 (3)
Parity	1.0 (2)
Gestational age at first antenatal assessment, weeks	13.5 (4.6)
Gestational age at delivery, weeks	39.0 (3)
Allocated model of antenatal care	Prevalence (%)
General practitioner shared antenatal care	5.2
Hospital-based medical care	28.6
Midwifery led care	46.3
Private obstetrician care	1.6
Hospital high-risk maternity care	18.2

TABLE 3 Pregnancy complications

Pregnancy complications	Prevalence (%)
Gestational diabetes	18.4
Pre-eclampsia	4.6
Eclampsia	0.0
Hyperemesis gravidarum	3.6
Antepartum haemorrhage	4.6
Hypertension in pregnancy	13.8
Pre-term labour	3.6
Stillbirth	0.5
Postpartum haemorrhage	2.5
No complications	52.0
Other complications	
Gestational thrombocytopenia	0.5
Polyhydramnios	0.5
Septic shock	0.5
Pemphigoid gestationis	0.5
Pulmonary embolism	0.5
Cholestasis in pregnancy	0.5
Placental abruption	1.0
Pulmonary hypertension	0.5
Intrauterine growth restriction	6.0
Retained products of conception	1.5

extrapulmonary traits (range 0–7). For risk factor/behavioural traits, there was a mean of 2 ± 0.9 traits per person (range 0–5). The five most prevalent treatable traits were limited asthma knowledge (96.0% of women), inadequate inhaler technique (83.5%), no written asthma action plan (80.0%), rhinosinusitis (67.0%) and obesity (63.0%) (figure 1). The number of treatable traits per person was not related to asthma control ($r=0.08$), pregnancy complications ($r=0.05$) or perinatal complications in the fetus ($r=0.06$). This suggests that treatable traits are an independent dimension to asthma in pregnancy.

Outcome of treatable traits assessment

The outcome of the treatable traits assessment and interventions offered is shown in figure 2. Interventions for behavioural/risk factor traits, including optimisation of inhaler technique, asthma education and asthma action plan development, was delivered to 85.2% of patients. New treatment or interventions for identified comorbidities, including treatment for rhinosinusitis (18.9%), gastro-oesophageal reflux (16.8%) and vocal cord dysfunction (2.0%), was commenced in 37.7% of women. Asthma treatment was altered in 27.5% of women. On average, 3.8 ± 1.24 traits were treated per person, with a minimum of 0 and maximum of 7 traits treated.

Discussion

We describe the prevalence and pattern of treatable traits among pregnant women with asthma, and the interventions offered using a telehealth approach. Treatable traits represent a novel model of care for asthma that effectively addresses the complexity and heterogeneity of the condition [10]. Although asthma is a common issue in pregnancy, there have been no prior assessments of treatable traits in pregnancy. We conducted an audit of the prevalence and pattern of 16 treatable traits in pregnant women with asthma. We found that pregnant patients with asthma had an average of 7.5 treatable traits. This means that a comprehensive asthma management plan should address the relevant treatable traits and that a clinician would need to address several traits in each person to develop a management plan.

From the treatable traits assessed, our data indicate that traits in the behavioural/risk factor domain are most prevalent in the asthma in pregnancy population. Those traits were followed by traits in the extrapulmonary domain with most prevalent being rhinosinusitis and obesity. This pattern of trait prevalence is distinct from the severe asthma and COPD populations, as reported previously [5, 13–15]. In severe asthma populations extrapulmonary traits were most prevalent, followed by behavioural/ risk factor domain and pulmonary domain traits, respectively. Furthermore, on average more traits were identified in a severe asthma population with a mean \pm SD of 10.44 ± 3.03 traits, comprising 3.01 ± 1.54 pulmonary, 4.85 ± 1.86 extrapulmonary and 2.58 ± 1.31 behavioural risk factors [13]. Multidimensional assessment of patients with COPD identified a mean of 10.5 (95% CI 9.7–11.2) traits per participant falling into pulmonary,

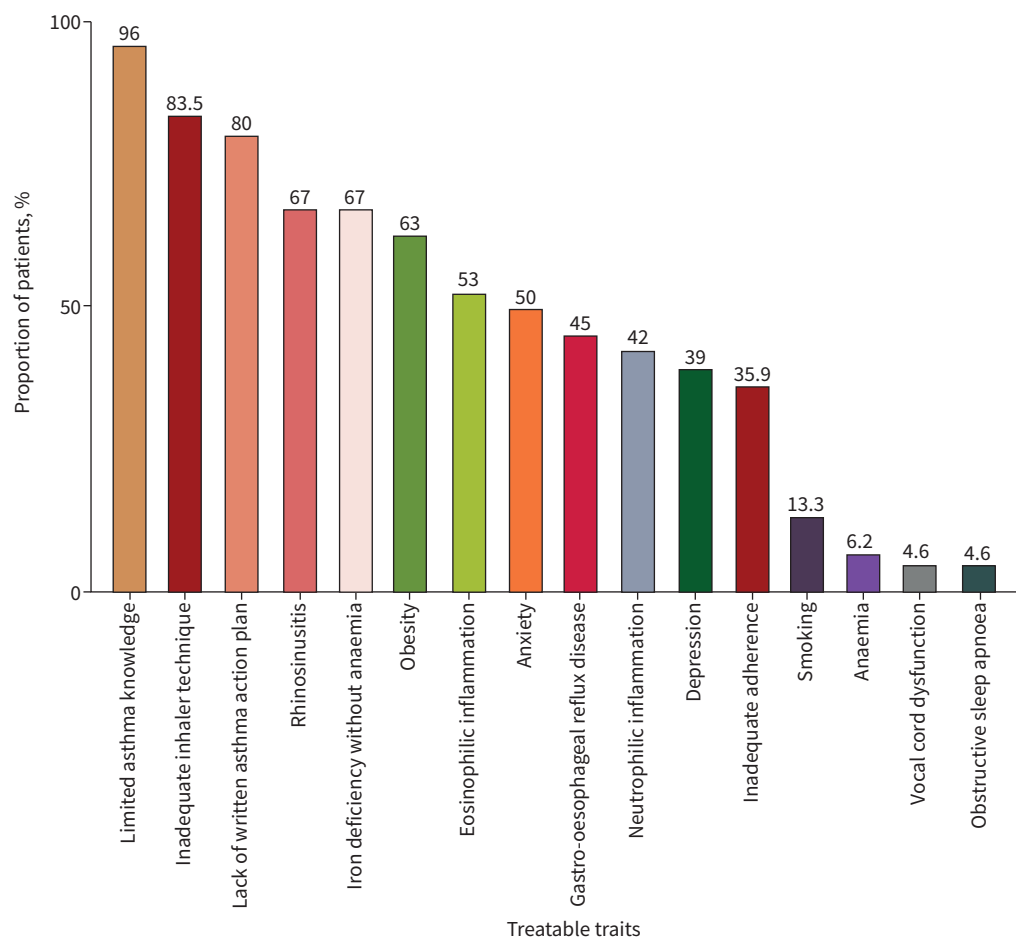


FIGURE 1 Proportion of patients with each treatable trait displayed in rank order.

comorbidity and behavioural risk factor domains. The apparent difference in the number of treatable traits per person between asthma in pregnancy and severe asthma/COPD might reflect a different population, disease severity and a different practice setting [14]. It is also important to note that the number of traits that were assessed in each domain across the studies were different, which would also contribute to the result and therefore this result needs to be interpreted with caution.

Notwithstanding the abovementioned limitation, this result is nevertheless consistent with the findings of the NOVELTY study, which revealed that, while treatable traits do not vary significantly by age, sex and geography, they do change substantially by disease severity and practice setting [15]. This is an important result, which highlights the need for individual assessment of treatable traits in order to develop personalised management plans. Identification of distinct trait patterns in different care and population settings will be useful in designing a tailored treatable traits model of care. Our data can be used to identify the trait patterns in an antenatal setting.

Our data highlight a major clinical concern, and that is the highly prevalent deficits in self-management skills in the population of pregnant women with asthma. Asthma self-management education for skills and optimisation of medications can improve asthma control and reduce asthma attacks [11]. The main challenge is therefore to provide a service that addresses these issues and which is acceptable to pregnant women with asthma and their health care providers. In this study, we implemented a virtual model of antenatal asthma care to address this issue. While our data demonstrate that assessment of a select number of treatable traits *via* virtual care is feasible, future work should evaluate the efficacy and acceptability of virtual model of antenatal asthma care. We hypothesise that this model of care might be more acceptable to pregnant women and lead to an increased availability and uptake of asthma care in pregnancy. Assessment of treatable traits *via* virtual care is novel.

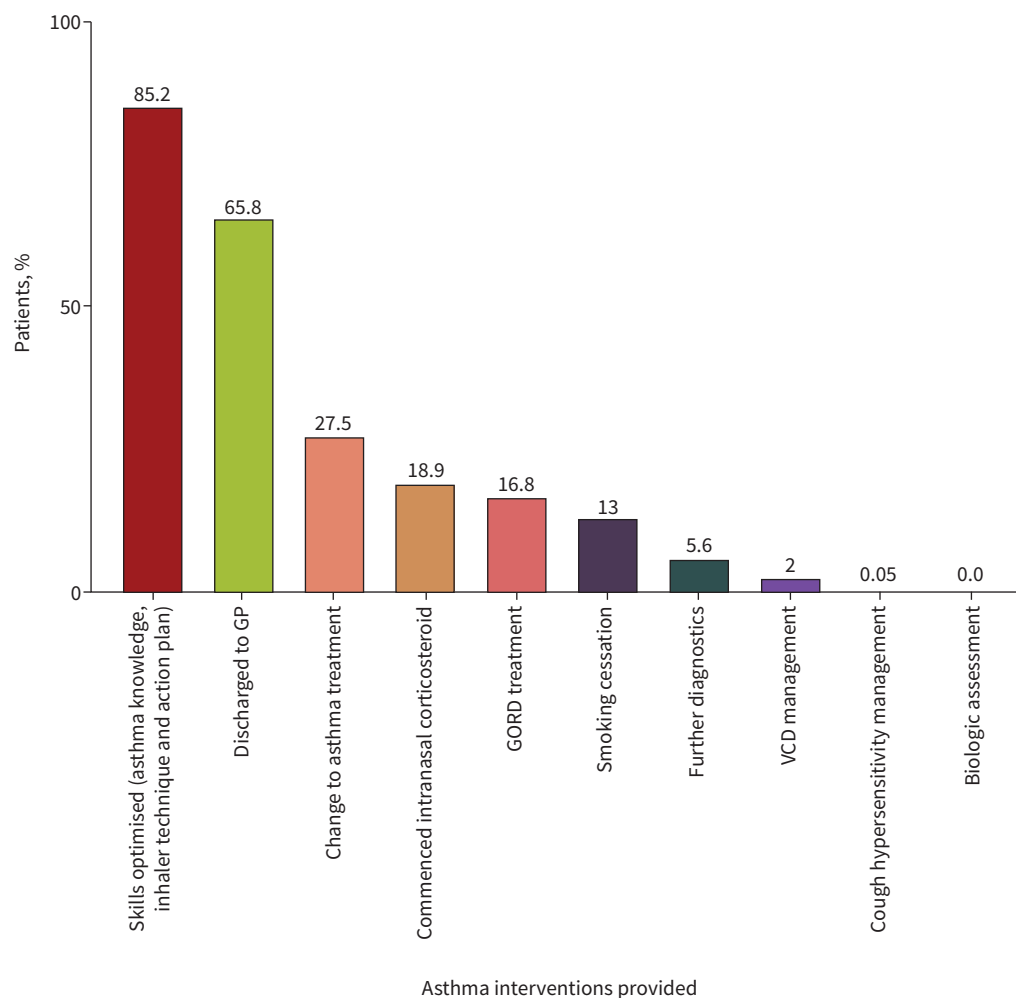


FIGURE 2 Outcome of the treatable traits assessment. GORD: gastro-oesophageal reflux disease; GP: general practitioner; VCD: vocal cord dysfunction.

Treatable traits are identified *via* a multidimensional assessment. This can occur *via* a face-to-face consultation; however, this is not the only method to identify treatable traits. McDONALD *et al.* [13] reported that treatable traits can be identified from data collected as part of a severe asthma registry in the severe asthma population. During the COVID-19 pandemic, delivery of face-to-face asthma care was limited, and this presented an opportunity to implement a treatable traits model of care *via* virtual care. In this study, we report the outcome of the assessment and delivery of treatable traits-based care; however, we recognised a number of limitations. The number of contemporaneous treatable traits that can be assessed *via* virtual care is limited. In particular, assessment of pulmonary traits including airflow limitation and bronchodilator response was not feasible during a virtual care consultation, especially during the COVID pandemic when spirometry was prohibited. While these are important components of asthma assessment, clinical history-based care with frequently available historical data, including peripheral blood eosinophil count, might be sufficient in providing effective care for people with mild asthma. Furthermore, identification and optimisation of self-management skills, the most prevalent trait in pregnant women with asthma, is feasible *via* virtual care. In the event of identification of atypical asthma symptoms and poor response to treatment, selected patients may be required to attend a face-to-face consultation for further evaluation with pulmonary function tests, fractional exhaled nitric oxide and/or blood tests.

Finally, our data disclose a discrepancy between the average number of treatable traits identified in patients with asthma who were pregnant (mean \pm SD 7.5 \pm 2.0) and the average number of interventions per person (mean \pm SD 3.8 \pm 1.24). This discrepancy might reflect the limited scope of interventions provided, targeting behavioural and risk factor management skills, the pulmonary domain and a limited number of

extrapulmonary comorbidities, such as gastro-oesophageal reflux disease, vocal cord dysfunction and rhinosinusitis. Although extrapulmonary traits such as anxiety/depression, anaemia/iron deficiency without anaemia and obesity were recorded in this clinical audit, their management did not constitute the part of the intervention in this service. These traits were managed through the obstetric clinic.

A limitation of this paper is the restricted number of pulmonary traits that could be assessed by telehealth. In particular, it was not possible to objectively assess lung function *via* telehealth. This is a significant limitation that could be overcome in further work by the use of home-based lung function testing. We were also not able to provide follow-up data, which would be useful to evaluate the effects of the intervention. The exacerbation rate in the population was lower than expected, likely due to the predominantly mild asthma population, the effective asthma treatment received, and the well-described reduction in airway disease exacerbations seen during the COVID-19 pandemic. There are several other limitations preventing the generalisability of our data, including this being a single-centre study as well as data derived only from patients with mild asthma in a pregnant population. We recruited women with a doctor's diagnosis of asthma that was verified by respiratory physician assessment *via* telehealth.

While to the best of our knowledge this is the first reported data on assessment and delivery of treatable traits-based antenatal asthma care *via* virtual care, more research is needed to evaluate its acceptability and efficacy when compared to a traditional face-to-face model of care.

Conclusion

Virtual antenatal asthma care is a feasible approach for assessing a select number of treatable traits in a population of pregnant women. Further research is needed to demonstrate efficacy and acceptability of this model of care. Treatable traits may then be shown to be a major step forward in improving asthma care in this and potentially other population settings.

Provenance: Submitted article, peer reviewed.

Ethics statement: The study was approved by the Hunter New England Research Ethics Committee.

Conflict of interest: K. Duszyk declares no competing interests. V.M. McDonald declares research grants or contracts from GlaxoSmithKline; and payment or honoraria from GlaxoSmithKline, AstraZeneca, Boehringer Ingelheim and Chiesi, all in the 36 months prior to manuscript submission. D. Thomas declares research grants or contracts from GlaxoSmithKline in the 36 months prior to manuscript submission. K. Steel declares no competing interests. P.G. Gibson declares research grants or contracts from GlaxoSmithKline and AstraZeneca; and payment or honoraria from GlaxoSmithKline, AstraZeneca, Chiesi and Novartis, all in the 36 months prior to manuscript submission.

References

- 1 Grosso A, Locatelli F, Gini E, *et al.* The course of asthma during pregnancy in a recent, multicase-control study on respiratory health. *Allergy Asthma Clin Immunol* 2018; 14: 16.
- 2 Murphy V, Gibson P, Smith R, *et al.* Asthma during pregnancy: mechanisms and treatment implications. *Eur Respir J* 2005; 25: 731–750.
- 3 Sawicki E, Stewart K, Wong S, *et al.* Management of asthma by pregnant women attending an Australian maternity hospital. *Aust N Z J Obstet Gynaecol* 2012; 52: 183–188.
- 4 Sarwar MR, McDonald VM, Abramson MJ, *et al.* Effectiveness of interventions targeting treatable traits for the management of obstructive airway diseases: a systematic review and meta-analysis. *J Allergy Clin Immunol Pract* 2022; 10: 2333–2345.e21.
- 5 McDonald VM, Clark VL, Cordova-Rivera L, *et al.* Targeting treatable traits in severe asthma: a randomised controlled trial. *Eur Respir J* 2020; 55: 1901509.
- 6 Duszyk K, McLoughlin RF, Gibson PG, *et al.* The use of treatable traits to address COPD complexity and heterogeneity and to inform the care. *Breathe (Sheff)* 2021; 17: 210118.
- 7 Agusti A, Bel E, Thomas M, *et al.* Treatable traits: toward precision medicine of chronic airway diseases. *Eur Respir J* 2016; 47: 410–419.
- 8 Agusti A, Gibson PG, McDonald VM. Treatable traits in airway disease: from theory to practice. *J Allergy Clin Immunol Pract* 2023; 11: 713–723.
- 9 Middleton PG, Gade EJ, Aguilera C, *et al.* ERS/TSANZ Task Force Statement on the management of reproduction and pregnancy in women with airways diseases. *Eur Respir J* 2020; 55: 1901208.
- 10 McDonald VM, Fingleton J, Agusti A, *et al.* Treatable traits: a new paradigm for 21st century management of chronic airway diseases: Treatable Traits Down Under International Workshop report. *Eur Respir J* 2019; 53: 1802058.

- 11 Murphy VE, Gibson PG, Talbot PI, *et al.* Asthma self-management skills and the use of asthma education during pregnancy. *Eur Respir J* 2005; 26: 435–441.
- 12 Codispoti CD, Greenhawt M, Oppenheimer J. The role of access and cost-effectiveness in managing asthma: a systematic review. *J Allergy Clin Immunol Pract* 2022; 10: 2109–2116.
- 13 McDonald VM, Hiles SA, Godbout K, *et al.* Treatable traits can be identified in a severe asthma registry and predict future exacerbations. *Respirology* 2019; 24: 37–47.
- 14 McDonald VM, Higgins I, Wood LG, *et al.* Multidimensional assessment and tailored interventions for COPD: respiratory utopia or common sense? *Thorax* 2013; 68: 691–694.
- 15 Agustí A, Rapsomaniki E, Beasley R, *et al.* Treatable traits in the NOVELTY study. *Respirology* 2022; 27: 929–940.