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Telehealth to improve asthma control in pregnancy: a randomised controlled trial

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Summary at a Glance:

This study evaluated the efficacy of a telehealth program, supported by a handheld respiratory device for optimising asthma management in pregnant women. At the end of the study, participants in the intervention group showed greater improvement in asthma control and asthma-related quality of life than the control group.

Abbreviations:

APGAR, Activity Pulse Grimace Appearance Respiration; ACQ, Asthma Control Questionnaire; BMI, Body Mass Index; FEV₁, Forced expiratory volume in 1 second; FEV₆, Forced expiratory volume in 6 seconds; ICS, Inhaled corticosteroid; LABA, Long-acting beta agonist; mAQLQ, mini Asthma Quality of Life Questionnaire; MCID, Minimum clinically important difference; SABA, Short-acting beta agonist

ABSTRACT

Background and objective: Poorly controlled asthma during pregnancy is hazardous for both mother and fetus. Better asthma control may be achieved if patients are involved in regular self-monitoring of symptoms and self-management according to a written asthma action plan (WAAP). Telehealth applications to optimise asthma management and outcomes in pregnant women have not yet been evaluated. This study evaluated the efficacy of a telehealth program supported by a handheld respiratory device in improving asthma control during pregnancy.

Methods: Pregnant women with asthma (n=72) from two antenatal clinics in Melbourne, Australia were randomised to one of two groups: 1) intervention – involving a telehealth program (Management of Asthma with Supportive Telehealth of Respiratory function in Pregnancy [MASTERY[®]]) supported by a handheld respiratory device and an Android smart phone application (*Breathe-easy*[®]) and WAAP; or 2) control – usual care. The primary outcome was change in asthma control at 3 and 6 months (prenatal). Secondary outcomes included changes in quality of life and lung function, and perinatal/neonatal outcomes.

Results: At baseline, participants' mean ($\pm$ SD) age was 31.4 $\pm$ 4.5 years and gestational age 16.7 $\pm$ 3.1 weeks. At six months, the MASTERY group had better asthma control ($p=0.02$) and asthma-related quality of life ($p<0.01$) compared to usual care. There were no significant differences between groups in lung function, unscheduled healthcare visits, days off work/study, oral corticosteroid use or perinatal outcomes. Differences between groups were not significant at three months.

Conclusion: Telehealth interventions supporting self-management are feasible and could potentially improve asthma control and asthma-related quality of life during pregnancy.

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Keywords: asthma control, pregnant women, quality of life, telehealth

Running head: Telehealth for asthma during pregnancy

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INTRODUCTION

Asthma is the most common lung condition that affects and complicates pregnancy.^{1, 2} Managing asthma in pregnant women is an integral part of asthma guidelines,³⁻⁵ however, poorly controlled asthma during pregnancy still remains a major problem. It increases the risks of pre-eclampsia, foetal growth restriction, pre-term birth and need for caesarean delivery.⁶⁻⁹

Visit to medical practitioners regularly and following a written asthma action plan (WAAP) have shown better asthma control.¹⁰ Recording daily symptoms continually as a part of asthma self-management reduces unplanned hospitalizations and improves quality of life in asthma patients.¹¹⁻¹⁴

Early detection of exacerbations and better management of asthma exacerbations can be achieved by home telemonitoring.¹¹⁻¹⁴ Internet or mobile phone-based healthcare interventions have been reported to have potential benefits in adults^{11, 14} and children¹³ with asthma when compared with usual care. Mobile phone-based interventions to support asthma management have been evaluated in several studies.¹⁴⁻¹⁶ However, telehealth applications to optimise asthma management and outcomes in pregnant women have not yet been evaluated.

This study evaluated the efficacy of a telehealth program in improving asthma control during pregnancy. We hypothesised that the intervention group (Management of Asthma with Supportive Telehealth of Respiratory function in Pregnancy [MASTERY[®]]) would have better asthma control compared to usual care.

METHODS

Study design and participants

A prospective multi-centre single-blinded randomised controlled trial (RCT) was conducted in the antenatal clinics of two large maternity hospitals in Melbourne, Australia. The study was registered (ACTRN 12613000800729) and was approved by the human research ethics committees of Monash University, Mercy Hospital for Women and the Royal Women's Hospital. All participants provided written informed consent at the time of enrolment.

Pregnant women with asthma aged ≥ 18 years, up to 20 weeks gestation and able to communicate in English were approached. Those who self-reported use of any inhaled bronchodilator or anti-inflammatory agent for asthma within the previous 12 months were included. Women under specialist care for brittle/difficult asthma¹⁷ or who were not in possession of or have not used a "smart" mobile phone were excluded.

Randomisation and group allocation

The detailed protocol has been published elsewhere.¹⁸ In brief, all consenting participants were stratified by asthma severity based on their current asthma medications and symptoms into two groups: intermittent-mild or moderate-severe asthma.³ Participants were randomised to intervention (MASTERY) or control (usual care) with 1:1 allocation in random blocks of four and six using a random allocation software¹⁹ by an independent researcher. Randomisation results were concealed using the sealed opaque envelope technique. Participation of the women in the study is summarised in Figure 1.

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Intervention and control group

Intervention: MASTERY group

Participants allocated to MASTERY were provided with a COPD-6[®] (Vitalograph Ltd, Ennis, Ireland) to measure their lung function (FEV₁ and FEV₆) daily and a specifically designed *Breathe-easy*[®] application installed on a loaned “smart” mobile phone to record asthma symptoms and asthma medication usage weekly. Participants were also prompted to follow an individualised WAAP specifically developed by the study team as part of the intervention package. An automated feedback message regarding her asthma status was sent weekly based on the *Breathe-easy*[®] algorithm that was based on National Asthma Council³ and Global Initiative for Asthma (GINA) guidelines.⁵ All data were transmitted automatically to a central server to which the researchers, participants and their health professionals had secure access. Participants’ health professionals were contacted by one of the researchers, a trained asthma educator (EZ), if any medication changes or unscheduled asthma-related visits were needed.

Control: Usual care group

Control group received usual medical care from their health professionals including regular antenatal visits depending on pregnancy stage and presence of any complications. A summary of the “Asthma and Pregnancy” brochure from the NAC, which explained asthma in pregnancy, including first aid and an emergency assistance number to call for any concerns regarding asthma, was given to participants in both groups.

Outcome measures

Change in asthma control as measured by the 7-item Asthma Control Questionnaire (ACQ-7) at 3 and 6 months was the primary outcome.²⁰ Juniper's mini Asthma Quality of Life Questionnaire (mAQLQ) score,²¹ lung function (FEV₁ and FEV₆), self-reported exacerbations, asthma-related health visits, days off work/study related to asthma and oral corticosteroid use were measured as the secondary outcomes. All these measures were conducted prenatally.

Perinatal outcomes were development of any antenatal complications such as gestational diabetes, hypertensive disorders of pregnancy, postpartum haemorrhage, and foetal growth restriction, mode of delivery and gestational age of baby at delivery.

Neonatal outcomes included birth weight centile, birth length, head circumference, and Appearance Pulse Grimace Activity and Respiratory (APGAR) scores at 1 and 5 minutes after delivery. Birth weight centiles were calculated using www.gestation.net/grow-au.aspx, which adjusted for maternal characteristics including height, weight, ethnicity, parity and foetal gender.

Data collection and follow-up

At three and six months from baseline, ACQ and mAQLQ scores, asthma-related health visits, asthma-related days off work/study, oral corticosteroid use were assessed to allow comparisons. Perinatal outcomes data were collected shortly after delivery by reviewing medical records. The outcome assessors doing follow-ups at three and six months were masked to participant group allocation.

Sample size

Using a standard deviation in ACQ score of 0.66,^{22, 23} we estimated that a sample size of 28 in each arm would have 80% power with a two-sided 5% significance level to detect the minimal clinically important difference (MCID) in ACQ score of 0.5 or more between groups.²⁰ To allow for 25% attrition, 36 participants were required in each arm.

Statistical analysis

The primary analysis was performed according to the intention to treat (ITT) principle. Baseline group characteristics were compared using Student's t-test or Mann-Whitney U test or chi-square/ Fisher's exact test as appropriate. For the primary analysis, linear regression models were fitted to compare changes in ACQ scores at three and six months adjusting for baseline scores. We also compared the proportion of participants whose ACQ score improved more than 0.5 (MCID) over the study period, and the proportions in whom asthma remained "not well controlled" (ACQ score 1.5 or greater) or "well controlled" (ACQ score less than 1.5) at each time point.²⁴ Secondary outcomes were summarised using descriptive statistics and analyses performed as described above. All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA) and SPSS version 19.0 (IBM SPSS Statistics for Windows, Armonk, NY).

RESULTS

Seventy two pregnant women with asthma (38 and 34 from the two hospitals), mean ($\pm$ SD) age 31.4 ± 4.5 years, were enrolled in the study. The groups had similar baseline characteristics (Table 1), regardless of place of recruitment. The mean ($\pm$ SD) gestational age (in weeks) at baseline, 3 months and 6 months was 16.7 ± 3.1 , 27.4 ± 1.3 and 36.5 ± 0.6 . No significant difference in gestational age was observed between the groups. The majority had moderate to severe asthma (58%). Inhaled corticosteroid/long-acting beta agonist (ICS/LABA) combinations were the regular asthma medication for almost half of them. The mean ACQ scores, mAQLQ scores and lung function for MASTERY and usual care groups matched well.

Changes in ACQ score from baseline to 3 months (mean $\pm$ SE) for MASTERY and usual care groups were -0.01 ± 0.11 and 0.16 ± 0.09 , respectively. At six months, the changes in ACQ score in the two groups from baseline were -0.30 ± 0.11 and 0.06 ± 0.10 , respectively; and the mean difference between groups was significant ($p=0.02$) (Table 2). Participants in the MASTERY group also had clinically significant improvements ($\text{MCID} > 0.5$) in their quality of life at six months when compared with the usual care group ($p=0.002$) (Table 2). Changes in FEV_1 , $\text{FEV}_1\%$ and $\text{FEV}_1/\text{FEV}_6$ from baseline to both three and six months between the groups were not significant (Table 2).

Figures 2(A) and 2 (B) show changes in ACQ and mAQLQ scores, respectively, in the two groups between baseline and both three and six months. At six months, the MASTERY group had a higher proportion of participants with well-controlled asthma ($\text{ACQ} < 1.5$) than the control group (82% vs 58%, $p=0.03$). Compared to the control group, MASTERY group also had more participants with a clinically significant (i.e. change in

scores greater than the MCID) improvement in ACQ (39% vs 19%; $p = 0.07$) and mAQLQ scores (36% vs 19%; $p = 0.12$), but the differences were not statistically significant.

At 6 months, the MASTERY group self-reported fewer asthma symptoms requiring a reliever in the previous three months (MASTERY [$n=1$] vs control [$n=18$], $p < 0.01$). Only one control participant had an unscheduled health visit related to asthma. One participant from the MASTERY and two from the control group were prescribed an oral corticosteroid. One participant in each group reported days off work/study related to asthma.

The perinatal outcomes including neonatal outcomes, delivery data and complications at the end of the study were similar in both groups (Table 3). Differences between the groups in normal vaginal delivery (MASTERY=58%, usual care=47%; $p = 0.39$) and emergency caesarean (MASTERY=12%, usual care=17%; $p = 0.74$) did not reach statistical significance. No significant differences in neonatal outcomes or pregnancy complications were observed between the groups.

DISCUSSION

A telehealth intervention supported by a mobile application, self-monitoring device and use of an individualized WAAP improved self-management of asthma in pregnancy. Change in asthma control was statistically significant in the MASTERY (telehealth) group at 6 months, but the mean change in ACQ score failed to reach the MCID. At 6 months, better asthma-related quality of life, and fewer self-reported exacerbations were observed in the MASTERY group; however, changes in lung function between groups were not significant. This study also established the role of WAAP guided self-management in optimising asthma control in pregnancy. Assessing asthma symptoms, monitoring lung function regularly and establishing individual WAAP are components of asthma self-management according to GINA and NAC.^{3, 25} Since pregnancy may alter the severity of asthma unpredictably,²⁶ pregnant women with asthma should be encouraged to have self-management plans with close monitoring of asthma symptoms/control to prevent exacerbations during pregnancy.

A Cochrane Review of self-management education and regular practitioner review has found that monitoring asthma severity and the use of WAAP could reduce the frequency of asthma exacerbations, optimise asthma medication use and decrease the cost of asthma management.¹⁰ Monitoring asthma regularly using objective measures of lung function (FEV₁) and asthma symptoms could improve asthma control and reduce exacerbations during pregnancy.²⁷ Lim *et al*²² showed that multidisciplinary care involving education and regular monitoring in pregnant women with asthma could improve maternal asthma outcomes. Our study adds further knowledge and highlights the potential role of telemonitoring of asthma in pregnancy. Automated feedback based on an individualised WAAP may identify worsening asthma control and prompt appropriate intervention, potentially preventing further

deterioration of asthma control without direct involvement of any health professional.

However, compared to the control group, the intervention group may have had additional beneficial effects from the personalised WAAP that was provided as part of the intervention.

The effect of combined mobile phone and web application/software on asthma control in adults was examined by Liu *et al*¹⁴ and Ryan *et al*.¹⁵ The intervention groups had interactive software applications installed on participants' mobile-phones which allowed recording of lung function (FEV₁) daily and asthma symptoms. Control groups were provided with a written asthma diary and WAAP. Liu *et al*¹⁴ found that at six months, the intervention group had better lung function and quality of life, fewer exacerbations and unplanned visits than the control group. However Ryan *et al*¹⁵ did not find any significant difference in outcomes between the study groups. Our trial included a much younger pregnant cohort, and excluded those who were not in possession of or have not used a "smart" mobile phone. Differences in participant characteristics (pregnant women vs ≥ 12 years) and the study settings (maternity hospitals vs primary care clinics), might explain the differences in outcomes between our study and Ryan *et al*¹⁷. Additionally, our usual care was less intensive than that of Liu *et al*¹⁴ and Ryan *et al*¹⁵ and it is possible that the observed benefits in our study resulted from the enhanced clinical care rather than the technological intervention.

Asthma self-management supported by personalised WAAP reduces severe exacerbations, unscheduled health visits and hospitalisations.²⁸ Studies to date have not provided a strong evidence base to guide clinicians or policy makers on the use of mobile phone apps for delivering asthma self-management programs.²⁹ The *Breathe-easy*[®] application encourages patients to manage asthma by monitoring their symptoms and lung function regularly and provides them with instant feedback regarding their asthma control. As

part of the Breathe-easy[®] algorithm, we also provided individualised WAAP for the MASTERY group. WAAP has been widely recommended as a component of asthma self-management rather than stand-alone intervention.^{10, 30} This study showed the importance of having an individualised WAAP as part of a self-management program for every person with asthma; however a close collaboration between patients and their health care professionals and feedback are required for full benefits.^{31, 32}

Our study had some strengths and limitations. This was the first study to investigate the role of telehealth for supporting asthma management in pregnant women. It was carried out in the antenatal clinics of two large maternity hospitals and included participants from a range of socio-demographic backgrounds and asthma severity. It was not possible to mask the intervention, which may have caused potential respondent bias, however we minimised bias by using objective assessments including spirometry (FEV₁ and FEV₆) and standardised questionnaires for the 3 and 6 months follow-ups. Exacerbations self-reported by participants might have been mild/moderate exacerbations, but no information on the amount of relievers used was collected. However, outcome assessments were performed by trained research assistants masked to group allocation.

The intervention was not suitable for patients with visual/hearing impairment and those unable to operate a smart mobile phone. Women's adherence to the advice provided through the app was not assessed. It is unknown to what extent general practitioners were involved in monitoring their patients' asthma. The place of mobile technology in clinical care might depend on whether it is cost effective for enhancing "usual care" to the standards recommended by guidelines. The study was not powered to assess the cost-effectiveness of the MASTERY intervention compared to usual care in the study clinics. Further studies

evaluating patient adherence to feedback provided through the app, comparative assessments of the telehealth intervention and WAAP against usual care, and cost-effectiveness analyses of telehealth interventions are warranted.

In summary, a telehealth intervention was shown to be feasible for monitoring asthma in pregnant women. The effects of Breathe-easy[®] application on asthma control, asthma-related quality of life and exacerbations should be evaluated in larger studies, other populations with asthma, and those with other chronic respiratory conditions such as COPD.

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Disclosure statement

MA and JG have held investigator-initiated research grants from Pfizer and Boehringer Ingelheim for unrelated research. MA has undertaken an unrelated consultancy for AstraZeneca and received assistance with conference attendance from Boehringer-Ingelheim and Sanofi. CMcD has participated in advisory boards and educational meetings for AstraZeneca, Boehringer Ingelheim, GSK and Novartis. This research was previously presented at the TSANZSRS **Annual** Scientific Meeting 2015.

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REFERENCES

- 1 Sawicki E, Stewart K, Wong S, Leung L, Paul E, George J. Medication use for chronic health conditions by pregnant women attending an Australian maternity hospital. *Aust N Z J Obstet Gynaecol.* 2011; **51**: 333-8.
- 2 Clifton VL, Engel P, Smith R, Gibson P, Brinsmead M, Giles WB. Maternal and neonatal outcomes of pregnancies complicated by asthma in an Australian population. *Aust N Z J Obstet Gynaecol.* 2009; **49**: 619-26.
- 3 National Asthma Council Australia. Australian Asthma Handbook - Quick Reference Guide, version 1.0. National Asthma Council Australia, Melbourne, 2014. Available from [<http://www.asthmahandbook.org.au>]. Accessed 30 July 2015.
- 4 Busse WW. NAEPP Expert Panel Report: Managing Asthma During Pregnancy: Recommendations for Pharmacologic Treatment—2004 Update. *J Allergy Clin Immunol.* 2005; **115**: 34-46.
- 5 Managing asthma with comorbidities and in special populations In: Global Strategy for Asthma Management and Prevention, From the Global Strategy for Asthma Management and Prevention, Global Initiative for Asthma (GINA), 2015 Update. Available from [<http://www.ginaasthma.org/>]. Accessed 30 July 2015.
- 6 Namazy JA, Murphy VE, Powell H, Gibson PG, Chambers C, Schatz M. Effects of asthma severity, exacerbations and oral corticosteroids on perinatal outcomes. *European Respiratory Journal.* 2013; **41**: 1082-90.
- 7 Murphy VE, Wang G, Namazy JA, Powell H, Gibson PG, Chambers C, Schatz M. The risk of congenital malformations, perinatal mortality and neonatal hospitalisation among pregnant women with asthma: a systematic review and meta-analysis. *BJOG.* 2013; **120**: 812-22.
- 8 Rejño G, Lundholm C, Gong T, Larsson K, Saltvedt S, Almqvist C. Asthma during Pregnancy in a Population-Based Study - Pregnancy Complications and Adverse Perinatal Outcomes. *PLoS One.* 2014; **9**: e104755.
- 9 Mendola P, Laughon SK, Mannisto TI, Leishear K, Reddy UM, Chen Z, Zhang J. Obstetric complications among US women with asthma. *Am J Obstet Gynecol.* 2013; **208**: 127 e1-8.

- 10 Gibson PG, Powell H, Coughlan J, Wilson AJ, Abramson M, Haywood P, Bauman A, Hensley MJ, Walters EH. Self-management education and regular practitioner review for adults with asthma. *Cochrane Database Syst Rev*. 2003; CD001117.
- 11 Rasmussen LM, Phanareth K, Nolte H, Backer V. Internet-based monitoring of asthma: A long-term, randomized clinical study of 300 asthmatic subjects. *J Allergy Clin Immunol*. 2005; **115**: 1137-42.
- 12 Willems DCM, Joore MA, Hendriks JJE, Wouters EFM, Severens JL. Cost-effectiveness of self-management in asthma: a systematic review of peak flow monitoring interventions. *Int J Technol Assess Health Care*. 2006; **22**: 436-42.
- 13 Chan DS, Callahan CW, Sheets SJ, Moreno CN, Malone FJ. An Internet-based store-and-forward video home telehealth system for improving asthma outcomes in children. *Am J Health Syst Pharm*. 2003; **60**: 1976-81.
- 14 Liu WT, Huang CD, Wang CH, Lee KY, Lin SM, Kuo HP. A mobile telephone-based interactive self-care system improves asthma control. *Eur Respir J*. 2011; **37**: 310-7.
- 15 Ryan D, Price D, Musgrave SD, Malhotra S, Lee AJ, Ayansina D, Sheikh A, Tarassenko L, Pagliari C, Pinnock H. Clinical and cost effectiveness of mobile phone supported self monitoring of asthma: multicentre randomised controlled trial. *BMJ*. 2012; **344**: e1756.
- 16 Van der Meer V, Bakker MJ, van den Hout WB, Rabe KF, Sterk PJ, Kievit J, Assendelft WJ, Sont JK, Group SS. Internet-based self-management plus education compared with usual care in asthma: a randomized trial. *Ann Intern Med*. 2009; **151**: 110-20.
- 17 Asthma Australia. 2015. Asthma with a difference. Available at: http://www.asthmaaustralia.org.au/onAIR/Asthma_with_a_difference.aspx. Accessed July 2015.
- 18 Zairina E, Abramson MJ, McDonald CF, Li J, Dharmasiri T, Stewart K, Walker SP, Paul E, George J. Study protocol for a randomised controlled trial evaluating the efficacy of a telehealth program - management of asthma with supportive telehealth of respiratory function in pregnancy (MASTERY). *BMC Pulm Med*. 2015; **15**: 84.
- 19 Saghaei M. Random allocation software for parallel group randomized trials. *BMC medical research methodology*. 2004; **4**: 26.

- 20 Juniper EF, O'Byrne PM, Guyatt GH, Ferrie PJ, King DR. Development and validation of a questionnaire to measure asthma control. *Eur Respir J*. 1999; **14**: 902-7.
- 21 Juniper EF, Guyatt GH, Cox FM, Ferrie PJ, King DR. Development and validation of the Mini Asthma Quality of Life Questionnaire. *European Respiratory Journal*. 1999; **14**: 32-8.
- 22 Lim AS, Stewart K, Abramson MJ, Walker SP, Smith CL, George J. Multidisciplinary Approach to Management of Maternal Asthma (MAMMA): a randomized controlled trial. *Chest*. 2014; **145**: 1046-54.
- 23 Goeman D, Jenkins C, Crane M, Paul E, Douglass J. Educational intervention for older people with asthma: a randomised controlled trial. *Patient Educ Couns*. 2013; **93**: 586-95.
- 24 Juniper EF, Bousquet J, Abetz L, Bateman ED. Identifying 'well-controlled' and 'not well-controlled' asthma using the Asthma Control Questionnaire. *Respir Med*. 2006; **100**: 616-21.
- 25 Braman SS. The global burden of asthma. *Chest*. 2006; **130**: 4S-12S.
- 26 Schatz M, Harden K, Forsythe A, Chilingar L, Hoffman C, Sperling W, Zeiger RS. The course of asthma during pregnancy, post partum, and with successive pregnancies: A prospective analysis. *J Allergy Clin Immunol*. 1988; **81**: 509-17.
- 27 Zairina E, Stewart K, Abramson MJ, George J. The effectiveness of non-pharmacological healthcare interventions for asthma management during pregnancy: a systematic review. *BMC Pulm Med*. 2014; **14**: 46.
- 28 Pinnock H, Thomas M. Does self-management prevent severe exacerbations? *Curr Opin Pulm Med*. 2015; **21**: 95-102.
- 29 Marcano-Belisario JS GG, Huckvale K, Gunn LH, Car J. . Smartphone and tablet self-management apps for asthma (Protocol). 2012.
- 30 Gibson PG, Powell H, Coughlan J, Wilson AJ, Hensley MJ, Abramson M, Bauman A, Walters EH. Limited (information only) patient education programs for adults with asthma. *Cochrane Database Syst Rev*. 2002: CD001005.
- 31 Gibson PG. Asthma action plans: use it or lose it. *Primary Care Respiratory Journal*. 2004; **13**: 17-8.

32 Gibson PG, Powell H. Written action plans for asthma: an evidence-based review of the key components. *Thorax*. 2004; **59**: 94-9.

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Figure legends

Figure 1. CONSORT diagram of participant flow

*ITT analysis: participants who had at least one follow-up were included in the primary analysis

Figure 2. (A) Changes in ACQ scores (B) Changes in mAQLQ scores.
Data are expressed as mean $\pm$ SE

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Table 1. Demographic, maternal and clinical characteristics of the study population at baseline

	MASTERY group (n=36)	Usual care group (n=36)
Demographic characteristics		
Race		
Caucasian	30 (84)	30 (84)
Asian	3 (8)	3 (8)
Other	3 (8)	3 (8)
Australian/New Zealander	30 (83)	30 (83)
Married	27 (75)	29 (81)
Full time employment	17 (47)	18 (50)
Health care/concession card holder	5 (14)	4 (11)
Possessed current asthma action plan	2 (5)	1 (3)
Level of education		
High school graduate	5 (14)	4 (11)
University graduate	6 (16)	11 (31)
Postgraduate or advanced degree	15 (42)	13 (36)
Other	10 (28)	8 (22)
Smoking status		
Never	25 (69)	23 (64)
Quit pre-pregnancy	8 (22)	11 (30)
Quit during pregnancy	1 (3)	1 (3)
Currently smoking	2 (5)	1 (3)
Maternal characteristics		
Age (years) ¹	31.1 ± 4.7	31.8 ± 4.3
Height ¹	164.0 ± 5.4	161.7 ± 7.1
Weight (kg) ¹	78.9 ± 21.6	70.8 ± 11.1
BMI (kg/m ²) ¹	29.3 ± 7.4	27.6 ± 3.9
Gestational age (weeks) ¹	16.5 ± 2.9	16.2 ± 2.9
Primigravid	16 (44)	15 (42)
Other medical conditions		
Anxiety/depression	10 (28)	10 (28)
Thyroid disorder	4 (11)	2 (6)
Clinical characteristics		
Duration of asthma [years] ²	26.5 [20.50 – 30]	25.5 [20 – 30]
Asthma severity		
Intermittent to Mild	15 (42)	15 (42)
Moderate to Severe	21 (58)	21 (58)
Asthma medications		
SABA only	15 (42)	15 (42)
ICS + SABA	3 (8)	2 (6)
ICS/LABA + SABA	18 (50)	19 (52)
FEV ₁ in litres ³	2.7 ± 0.1	2.9 ± 0.1
FEV ₁ % predicted ³	89.1 ± 2.3	91.6 ± 0.1
FEV ₁ /FEV ₆ (%) ³	80.1 ± 1.1	81.5 ± 1.0
ACQ score ³	1.1 ± 0.1	1.2 ± 0.1
mAQLQ score ³	5.5 ± 0.2	5.5 ± 0.2

ACQ, Asthma Control Questionnaire; BMI, Body Mass Index; mAQLQ, mini Asthma Quality of Life Questionnaire; FEV₁, Forced expiratory volume in 1 second; FEV₁%, FEV₁ expressed as a percentage of the predicted value; FEV₆, Forced expiratory volume in 6 seconds; ICS, inhaled corticosteroid; LABA, long-acting beta agonist, SABA, short-acting beta agonist. Values are

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Table 2. Mean ($\pm$ SE) change of ACQ, mAQLQ score and lung function from baseline to 3 and 6 months and the difference in mean change between groups adjusted for baseline.

Change in outcome	Change within group			Difference between groups adjusted for baseline	
	<i>MASTERY</i> group (n=33)	Usual care group (n=36)	Mean difference	95% CI	p value
ACQ					
3 months	-0.01 $\pm$ 0.11	0.16 $\pm$ 0.09	-0.17 $\pm$ 0.14	-0.45 to 0.12	0.26
6 months	-0.30 $\pm$ 0.11	0.06 $\pm$ 0.10	-0.36 $\pm$ 0.15	-0.66 to -0.07	0.02
mAQLQ					
3 months	0.09 $\pm$ 0.14	-0.17 $\pm$ 0.13	0.27 $\pm$ 0.19	-0.09 to 0.64	0.15
6 months	0.51 $\pm$ 0.16	-0.22 $\pm$ 0.15	0.72 $\pm$ 0.22	0.29 to 1.16	0.002
FEV₁					
3 months	0.12 $\pm$ 0.05	0.08 $\pm$ 0.05	-0.03 $\pm$ 0.06	-0.16 to 0.09	0.63
6 months	0.11 $\pm$ 0.06	0.07 $\pm$ 0.05	-0.04 $\pm$ 0.08	-0.19 to 0.11	0.57
FEV₁%					
3 months	6.04 $\pm$ 1.69	1.75 $\pm$ 1.57	-4.29 $\pm$ 2.32	-8.84 to 0.25	0.07
6 months	4.27 $\pm$ 1.86	1.54 $\pm$ 1.72	-2.72 $\pm$ 2.54	-7.71 to 2.27	0.29
FEV₁/FEV₆					
3 months	3.43 $\pm$ 1.17	0.14 $\pm$ 1.09	-3.29 $\pm$ 1.61	-6.44 to 0.14	0.05
6 months	1.53 $\pm$ 1.07	-0.56 $\pm$ 0.98	-2.08 $\pm$ 1.46	-4.94 to 0.78	0.16

ACQ, Asthma Control Questionnaire; mAQLQ, mini Asthma Quality of Life Questionnaire; FEV₁, Forced expiratory volume in 1 second; FEV₁%, FEV₁ expressed as a percentage of the predicted value; FEV₆, Forced expiratory volume in 6 seconds. Values are presented as mean $\pm$ SE. Decreased (negative) ACQ score suggests asthma control improved from baseline. Increased (positive) mAQLQ score suggests QoL improved from baseline.

Table 3. Perinatal outcome data and the comparison between the groups

	MASTERY group (n=33)	Usual care group (n=36)
Outcome		
Neonatal Data		
Male	16 (49)	21 (58)
Birth weight (g) ¹	3434 ± 555	3447 ± 547
Length ¹	49.9 ± 2.7	50.3 ± 2.3
Head circumference ¹	34.3 ± 1.7	34.8 ± 2.8
APGAR score ²		
At 1 minute	9 [8-9]	9 [7.25 – 9]
At 5 minutes	9 [9-9]	9 [9-9]
Gestational age (weeks) ¹	39.1 ± 1.4	39.3 ± 1.2
Admission to NICU or SCN	1 (3)	2 (6)
Premature (< 37 weeks)	1 (3)	2 (6)
Low birth weight (<10 th centile for gestational age)	4 (12)	7 (19)
Delivery Data		
Mode of Delivery		
Vaginal delivery	19 (58)	17 (47)
Assisted delivery	4 (12)	7 (19)
Elective caesarean	6 (18)	6 (17)
Emergency caesarean	4 (12)	6 (17)
Complications		
Gestational diabetes	3 (9)	6 (17)
Hypertensive disorders of pregnancy	2 (6)	2 (6)
Postpartum haemorrhage	1 (3)	2 (6)
Macrosomia	2 (6)	5 (14)
IUGR	1 (3)	0 (0)
<i>APGAR, Activity Pulse Grimace Appearance, Respiration; NICU, Neonatal Intensive Care Unit; SCN, Special Care Nursery; IUGR, Intra Uterine Growth Restrictions.</i> <i>Values are presented as numbers (percentages) unless specified. ¹mean ± SD, ² median [interquartile range]</i>

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