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Original Article

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Asthma Management Using the Mobile Asthma Evaluation and Management System in China

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ABSTRACT

Purpose: As stated in the Global Initiative for Asthma, there are still some asthmatic patients who have not achieved asthma control. Mobile is a useful tool for asthma management. We aimed to compare the advantages of mobile management with traditional management in improving adherence and control of asthma.
Methods: In this prospective, multicentre, randomized, controlled and parallel-group study, we enrolled patients with poor adherence and uncontrolled asthma at 32 hospitals in 28 provinces in China. Patients were randomly assigned to the mobile management or traditional management groups for 12 months. The primary endpoint was the proportion of patients with good adherence (Medication Adherence Report Scale for Asthma [MARS-A] score ≥ 45) for 6 months. This study is registered at ClinicalTrials.gov (NCT02917174).
Results: Between April 2017 and April 2018, 923 patients were eligible for randomization (mobile group, n = 461; traditional group, n = 462). Dropout was 84 (18.2%) in the mobile management group and 113 (24.4%) patients in the traditional management group. The proportion of patients with good adherence was significantly higher in the mobile management group than in the traditional management group (66.0% vs. 58.99%, P = 0.048). The mobile management group showed higher mean MARS-A score (at 1, 6, 9, and 12 months) and asthma control test scores (at 6 and 9 months), and lower total lost rate to follow-up within 12 months than the traditional management group.
Conclusions: Mobile asthma management can improve adherence and asthma control compared to traditional management.

Trial Registration: ClinicalTrials.gov Identifier: NCT02917174

Keywords: Asthma; internet-based intervention; outpatient monitoring; patient adherence

INTRODUCTION

Asthma is a common airway disease with an increasing prevalence.[1] Approximately 30 million people in China suffer from it, of whom less than 30% achieve complete asthma control.[2] Asthma is influenced by genetic and environmental factors that requires long-term medication. Strategies to improve patients' adherence to treatment are essential to reduce the great health and economic burden. Traditional asthma management is laborious and time-consuming with inconvenient data storage and feedback.[3] The development of technologies has led to the concept of electronic health management including mobile management tools.[4] The Mobile applications (Apps) with asthma can regulate medication, reduce acute attacks, and decrease the frequency of emergency visits or hospitalization.[5,6] These tools improve quality of life and pulmonary function as well as accessibility and usability.[7-11] However, few studies have evaluated the Apps with usual care in asthma management; some studies have also highlighted a few shortcomings and limitations in security and cost-efficiency. Their usefulness for doctors and patients is still debated.[11] These

Trial Registration
ClinicalTrials.gov Identifier: NCT02917174

Disclosure
There are no financial or other issues that might lead to conflict of interest.

studies were limited by the uncertain quality of the Apps under investigation, small sample size, and short follow-up period.[12,16]

Currently, there is no professional App for asthma management in China. The use of Apps for a personalized asthma management needs to be further evaluated and optimized before conclusions on its usefulness can be drawn. Therefore, we designed a mobile evaluation and management system for asthmatics. This study compared the advantages of mobile management and laid the foundation for the further development of mobile asthma management systems in China. It provides a new management approach for asthma diagnosis and treatment to improve adherence and asthma control.

MATERIALS AND METHODS

Study design

This is a prospective, multicentre, randomized controlled trial aimed to evaluate the efficacy of a novel mobile App for asthma management from April 2017 to April 2018. Sixty-eight physicians and subjects in 32 third-A grade Hospitals from 28 provinces across mainland China participated in the study (**Supplementary Fig. S1**). It was registered at ClinicalTrials.gov (NCT02917174) and approved by the Ethics Committee of China-Japan Friendship Hospital (20161141). All patients signed an informed consent form. Case report forms were designed by the principal investigator. The IT team assisted in designing the WeChat subscription, Apps, and database. In order to ensure the professional and standardized conduct, a central communication system was established, which also provided a platform for unified training.

Patients

The inclusion criteria were: (1) outpatients ≥ 18 years old; (2) diagnosed with asthma at least 3 months before admission according to the Global Initiative for Asthma (GINA) 2016 criteria[17]; inhaled corticosteroids (ICS) or ICS/long-acting β_2-agonists within the last 6 months; (3) asthma control test (ACT) score < 20 and Medication Adherence Report Scale for Asthma (MARS-A) score < 45; (4) able to use smartphones with compatible software; and (5) willing to participate in the study and signed an informed consent.

Exclusion criteria included: (1) inability to communicate because of visual impairment, hearing impairment, language barrier, with mental illness or psychological problems; (2) history of tracheal intubation or mechanical ventilation due to acute asthma attack; (3) respiratory tract infection within the last 4 weeks; (4) history of thoracic surgery; (5) comorbidities such as other/structural lung diseases (*e.g.*, chronic obstructive pulmonary disease, bronchiectasis, and lung cancer), heart disease, kidney or autoimmunity diseases, or other conditions that could potentially affect asthma control; and (6) pregnancy or planned pregnancy within 1 year.

App

The App included patient and physician modules. The patient App allows them to complete their asthma diaries and receive messages when to administer medication, doctor visits, and educational data. Patients receive feedback and suggestions according to different peak expiratory flow (PEF) values or ACT scores. The physician App allows them to monitor and be aware of any abnormalities in patient data and reminders of visits. Patients can also access the relevant updated clinical information on App.

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Randomization

A stratified block randomization method was used with randomization stratified by a center. Eligible patients were randomly allocated in a 1:1 ratio to either the mobile or traditional groups. The randomization scheme was generated using a software system and distributed to each site.

Procedures

Patients in the mobile and traditional groups were respectively trained to use App or traditional asthma diaries for self-management over 1 year. The system includes 2 parts: a patient App and a doctor App. Asthma patient can fill in an electronic asthma diary and can receive reminders of medication, follow-up, and asthma-related information in the form of articles, pictures, or videos. When a patient's PEF or ACT score is abnormal, he or she can receive real-time feedback and recommendations for action. Asthma specialists could view the patient's asthma diary online through the doctor's App, send out reminders when the patient's PEF or ACT score is abnormal, and send messages to remind patients of their visits. Additionally, specialists can learn the latest knowledge online. Treatment strategies were based on the GINA guidelines 2016. Clinical visits were arranged at 1, 3, 6, 9, and 12 months (**Fig. 1**). Accuracy of perception on asthma was assessed by the following 4 questions: (1) What kind of disease is asthma? (2) What is the first-line drug that should be used regularly every day for chronic persistent asthma? (3) Under what circumstances is the use of short-acting β_2-agonist (SABA) aerosol most reasonable? and (4) What is the goal of asthma therapy?

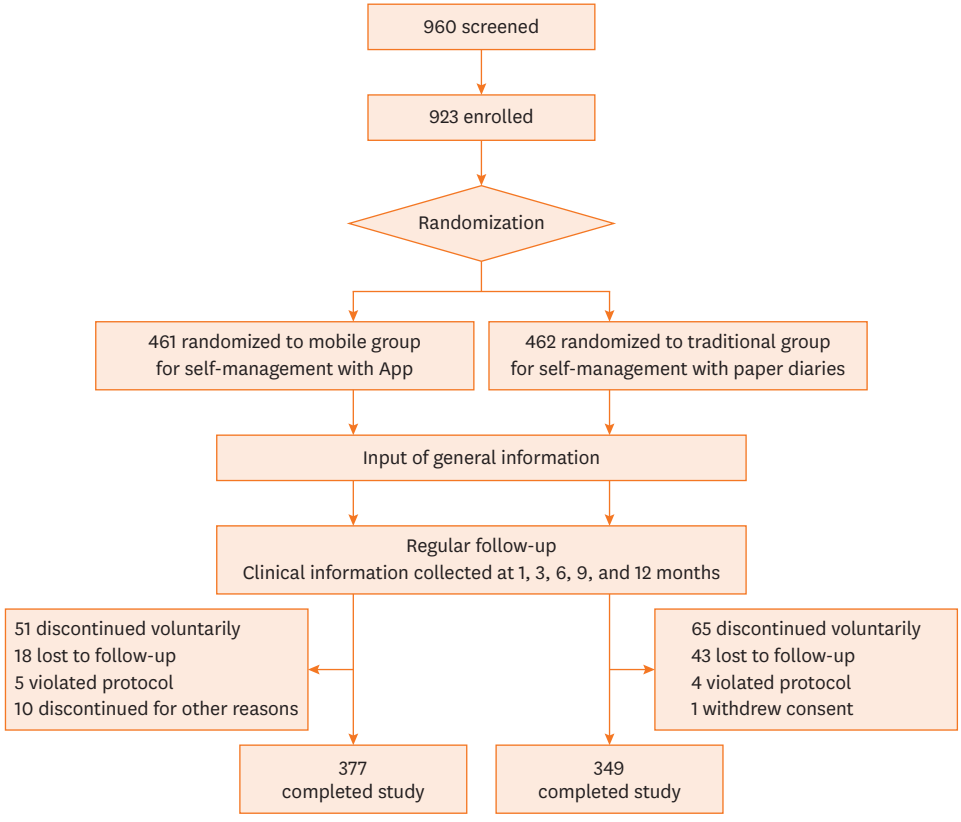

Fig. 1. Patient disposition.

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Outcomes

The primary endpoint was the proportion of patients achieving good adherence at 6 months.[18] Loss to follow-up or MARS-A score < 45 indicates poor compliance. The Secondary endpoints included: (1) ACT, (2) Mini-Asthma Quality of Life Questionnaire (Mini-AQLQ), (3) lung function (forced expiratory volume 1 (FEV1), FEV1/forced vital capacity (FVC) ratio, FVC ratio, PEF, fractional exhaled nitric oxide (FENO), and (4) number of hospitalizations or emergency visits and the rate of correct answers.

Statistical analyses

We determined sample size on the basis of 37% of patients in the control group achieving the criteria of good adherence as per the primary outcome of a MARS-A score ≥ 45,[19] with a 10% improvement after the use of App for 6 months,[20] which is considered clinically acceptable. This calculation assumed a dropout rate of 20%. The subsequent estimated sample size of 960 randomized subjects provided 80% of the power for 2-sided tests at the significance level of 0.05.

SPSS 24.0 (IBM Corp., Armonk, NY, USA) was used for analysis. Descriptive statistics (number, mean, standard deviation, *M* [*Q13, Q*], minimum and maximum for continuous variables, and frequency and percentage for categorical variables) are presented. Analysis of variance, Mann-Whitney *U* test and χ^2 test were used for comparison. The tests were 2-sided at the 0.05 significance level. Missing Data were supplemented according to the principles of intention-to-treat (ITT) analysis.

RESULTS

Primary endpoints

This study included 461 in mobile group and 462 in traditional group (**Fig. 1**). Dropout was 84 (18.2%) in the mobile management group and 113 (24.4%) patients in the traditional management group. Baseline demographics did not differ between the 2 groups (**Table 1**; all $P > 0.05$).

The proportion of patients achieving good adherence (MARS-A score ≥ 45) at 6 months was significantly different between the mobile management and traditional management groups (66.0% vs. 58.99%, $P = 0.048$). There was also a significant difference in mean MARS-A scores between the 2 groups in month 1, 6, 9, and 12 ($P = 0.022$, $P = 0.004$, $P = 0.016$, and $P = 0.008$, respectively) (**Table 2**). It also revealed that the mean MARS-A score for the mobile management group increased from month 1 ($P \leq 0.001$), decreased in month 3 ($P = 0.001$), and then was stable ($P = 0.183$, $P = 0.591$, and $P = 0.710$ for 6, 9, and 12 months, respectively). The MARS-A score of the traditional management group increased in month 1 ($P \leq 0.001$), decreased in month 3 ($P = 0.015$), decreased further in month 6 ($P = 0.016$) and then was stable ($P = 0.16$ and $P = 0.56$, respectively). Inter-group comparison showed a significant difference in MARS-A scores between the mobile management and traditional management groups in months 1, 6, 9, and 12 ($P < 0.05$) (**Fig. 2**).

The proportion of patients with good adherence in the mobile management group at 1 month, 6 months, 9 months, and 12 months was 67.0%, 57.7%, 58.4%, and 57.3% respectively, which was higher than those in the traditional management group (59.1%, 48.3%, 49.6%, and 50.4%, respectively, $P < 0.05$, **Fig. 3**). Unlike the primary endpoint, which is evaluated by the per protocol set (PPS), It is based on the full analysis set (FAS). At 3 months, the adherence rate in the mobile management group was 60.6%, which was higher than that in

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Table 1. Demographic and clinical characteristics

Characteristics	Mobile group (n = 461)	Traditional group (n = 462)
Sex		
Male	198 (43)	190 (41)
Female	263 (57)	272 (59)
Age (yr)	45 (34, 54)	46 (34, 55)
Height (cm)	165.13 ± 8.23	164.32 ± 8.17
Weight (kg)	65.36 ± 13.12	64.64 ± 11.96
Disease duration (mon)	51 (21–128)	54 (18–155)
Education level		
Bachelor's degree and above	176 (38)	149 (32)
Below Bachelor's degree	285 (62)	313 (68)
MARS-A score	34 (28–40)	33 (27–39)
ACT score	16 (14–18)	16 (14–19)
Mini-AQLQ score	65 (56–74)	65 (56–75)
FEV1 (L)	2.48 ± 0.86	2.44 ± 0.87
FEV1% pred	62.35 ± 8.12	64.13 ± 7.74
FVC (L)	3.44 ± 0.96	3.41 ± 0.97
FVC% pred	78.65 ± 9.12	79.82 ± 10.34
FEV1/FVC < 0.7	183 (40)	195 (42)
PEF (L/s)	6.14 ± 2.28	6.04 ± 2.30
FENO (ppb)	46 (23–74)	41 (21–74)
No. of hospitalizations in the past year	0.31 ± 0.79	0.31 ± 0.87
No. of emergency visits in the past year	0.54 ± 1.26	0.55 ± 1.36
Correct awareness of asthma	116 (25)	127 (27)

Data are number (%), mean (standard deviation), *M* (Q_1 and Q_3), and the maximum and minimum values.
MARS-A, Medication Adherence Report Scale for Asthma; ACT, asthma control test; Mini-AQLQ, Mini-Asthma Quality of Life Questionnaire; FEV1, forced expiratory volume 1; FVC, forced vital capacity; PEF, peak expiratory flow; FENO, fractional exhaled nitric oxide.

Table 2. MARS-A, ACT, and Mini-AQLQ scores of the mobile and traditional groups over 12 months

Characteristics	Baseline	Months				
		1	3	6	9	12
MARS-A						
Mobile group	34 (28–40)	47 (43–50)	47 (41–49)	46 (42–49)	47 (42–49)	46 (44–50)
Traditional group	33 (27–39)	46 (41–49)	46 (39–49)	44 (41–49)	45 (42–49)	45 (44–49)
ACT						
Mobile group	16 (14–18)	22 (20–24)	23 (21–24)	23 (22–24)	23 (22–24)	23 (23–24)
Traditional group	16 (14–19)	22 (20–23)	23 (21–24)	22 (21–24)	22 (22–24)	23 (22–24)
Mini-AQLQ						
Mobile group	65 (55–74)	84 (74–94)	87 (75–96)	89 (78–98)	90 (79–100)	65 (55–74)
Traditional group	64 (55–75)	86 (73–95)	88 (75–97)	90 (79–99)	92 (81–100)	64 (55–75)

MARS-A, Medication Adherence Report Scale for Asthma; ACT, asthma control test; Mini-AQLQ, Mini-Asthma Quality of Life Questionnaire.

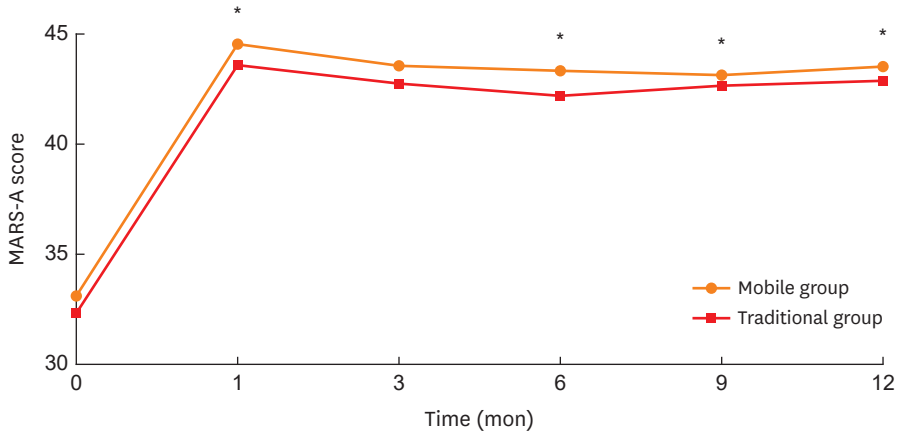

Fig. 2. Comparison of MARS-A scores between the mobile and traditional groups.
MARS-A, Medication Adherence Report Scale for Asthma.
*Inter-group *U* test, $P < 0.05$.

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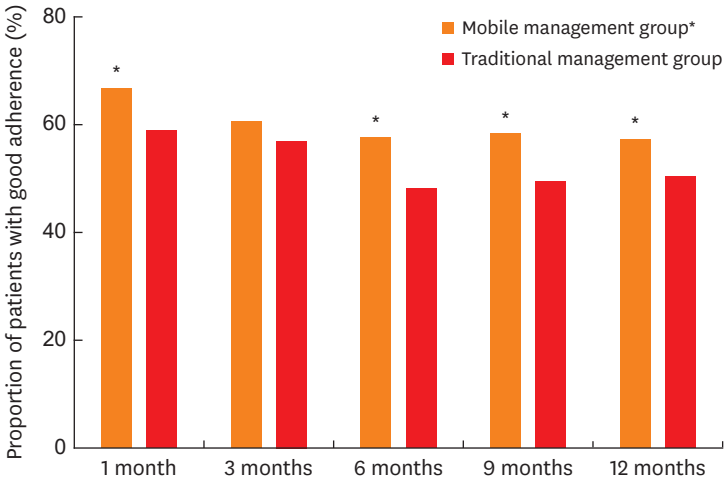

Fig. 3. Proportion of patients with good adherence.

the traditional management group (57.1%), but the difference was not statistically significant ($P > 0.05$, **Fig. 3**). The loss to follow-up in the mobile and traditional management groups were 18.22% and 24.46%; respectively, at 12 months (**Supplementary Fig. S2**).

Secondary endpoints

The ACT scores of the mobile and traditional management groups at baseline and in month 1, 3, 6, 9, and 12 are listed in **Table 2**. Inter-group comparison revealed no significant difference in ACT scores between the 2 groups at 1 or 3 months, although ACT scores were higher in the mobile management group than in the traditional management group at 6 and 9 months ($P = 0.043$ and $P = 0.023$, respectively). The difference at 12 months was not statistically significant ($P = 0.051$). Intra-group comparison revealed an increasing trend in ACT scores in both groups (**Fig. 4**).

FEV1 values at 6 and 12 months were higher in the mobile management group than in the traditional management group ($P = 0.001$ and $P \leq 0.001$). Intra-group comparison revealed an increase in FEV1 at 6 months in the mobile management group ($P \leq 0.001$) with no significant change at 12 months ($P = 0.26$). A similar pattern was observed with FEV1 values

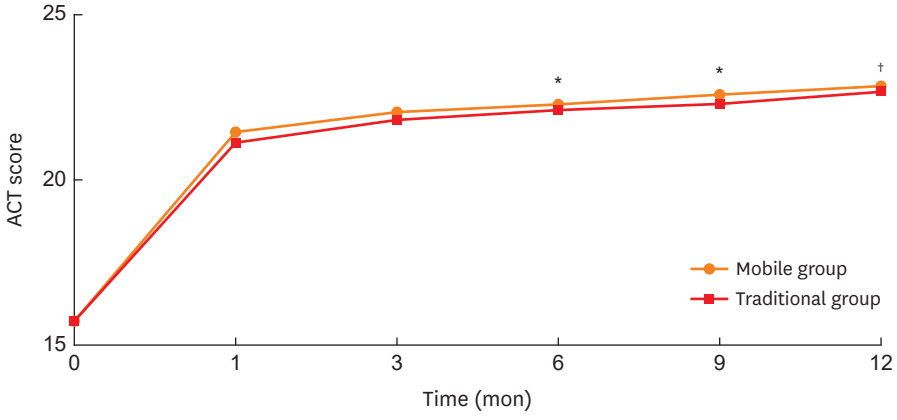

Fig. 4. Comparison of ACT scores between the mobile and traditional group.
ACT, asthma control test.
*Inter-group *U* test, $P < 0.05$; †Inter-group *U* test, $P = 0.051$.

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Table 3. FEV1 and FVC in the mobile and traditional groups at 6 and 12 months (403 and 349 subjects, respectively)

Groups	FEV1 (L)			FVC (L)		
	Baseline	6 mon	12 mon	Baseline	6 mon	12 mon
Mobile group	2.48 ± 0.86	2.67 ± 0.75	3.61 ± 0.93	3.44 ± 0.96	3.61 ± 0.93	3.53 ± 0.79
Traditional group	2.44 ± 0.87	2.53 ± 0.76	3.47 ± 0.89	3.41 ± 0.97	3.47 ± 0.89	3.40 ± 0.77

FEV1, forced expiratory volume 1; FVC, forced vital capacity.

in the traditional management group, with an increase at 6 months ($P \leq 0.001$), and no significant change at 12 months ($P = 0.13$) (**Table 3** and **Supplementary Fig. S3**).

The FVC values at 6 and 12 months were also higher in the mobile management group than in the traditional management group ($P = 0.030$ and $P = 0.013$). Intra-group comparison revealed that FVC values increased at 6 months in the mobile management group ($P = 0.007$), but no statistically significant difference was found at 12 months ($P = 0.088$). However, FVC was shown to increase at both 6 and 12 months ($P = 0.003$ and $P = 0.043$, respectively) in the traditional management group (**Table 3** and **Supplementary Fig. S3**).

Similarly, the PEF values at 6 and 12 months were higher in the mobile management group than in the traditional management group ($P = 0.001$ and $P < 0.001$ for 6 and 12 months, respectively). Intra-group comparison showed the PEF values of mobile management group increased at 6 months ($P < 0.001$) with no significant difference at 12 months ($P = 0.69$). The mean PEF of traditional management group also increased at 6 months ($P < 0.001$) with no significant change at 12 months ($P = 0.62$) (**Table 4** and **Supplementary Fig. S3**).

The proportion of patients with FEV1/FVC < 0.7 in mobile management group was 27.73% at 12 months and 38.02% in traditional management group ($P = 0.005$) (**Supplementary Fig. S4**). The proportions of patients with FEV1/FVC < 0.7 in the 2 groups at 12 months were both significantly lower than baseline (both $P < 0.001$).

There was no significant difference in FENO values between the 2 groups at 6 and 12 months (both $P > 0.05$). It showed an increase in FENO values at 6 months in the mobile management and traditional management groups (both $P < 0.05$) (**Table 4**).

There was no difference in the Mini-AQLQ scores of the 2 groups at any time points over 12 months (all $P > 0.05$), although intra-group comparison showed an increase in Mini-AQLQ from 3 to 12 months for both groups (all $P < 0.05$) (**Table 2**).

The number of hospitalizations and emergency visits in the mobile and traditional management groups decreased after 12 months. There was no significant difference in the frequency of hospitalizations or emergency visits between the 2 groups ($P > 0.05$) (**Supplementary Table S1**).

Table 4. PEF and FENO in the mobile and traditional groups at 6 and 12 months (403 and 349 subjects, respectively)

Groups	PEF (L/s)			FENO (ppb)		
	Baseline	6 mon	12 mon	Baseline	6 mon	12 mon
Mobile group	6.14 ± 2.28	6.80 ± 1.92	6.73 ± 1.83	46 (23–74)	30 (19–53)	27 (18–53)
Traditional group	6.04 ± 2.30	6.37 ± 2.01	6.29 ± 1.81	41 (21–74)	28 (18–49)	30 (17–51)

PEF, peak expiratory flow; FENO, fractional exhaled nitric oxide.

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The proportion of patients who answered all the questions correctly in the mobile management group increased from 38.2% to 66.6% after 12 months. A similar pattern was observed in the traditional management group with an increase from 24.9% to 62.2%. However, no significant difference between the 2 groups was observed ($P > 0.05$). After 12 months' education, the accuracy rate of perception on asthma increased from 70.1% to 89.1%. The accuracy rate of perceptions on first-line medication and SABA were increased from 55.3% to 83.2% and from 81.6% to 86.5%, respectively. The accuracy rate of perceptions on treatment goals increased from 70.0% to 89.4%. The mean MARS-A score of patients with the correct perception of asthma at 12 months was 48 (43–50), which was higher than that of patients with the incorrect perception (47 [35–50]; $P = 0.041$). After 1 year of follow-up and education, the MARS-A score of patients with a correct perception of asthma increased by 11 (6–18), which was higher than that of those with an incorrect perception (8 [2–18]) ($P = 0.006$). At 12 months, 83.48% of the mobile management group patients indicated that they would like to continue using the mobile tool for self-evaluation and management of asthma.

DISCUSSION

This prospective, multicentre, randomized controlled trial of 923 adult asthma patients is one of the largest studies to evaluate mobile management for asthma with a 12 months follow-up in China. Both mobile and traditional management were shown to effectively improve adherence, asthma control, quality of life, and pulmonary function. In addition, the implementation of mobile management tools decreased times of hospitalizations and emergency visits as well as optimized asthma knowledge. We demonstrated that mobile management improves medication adherence and markers of asthma control to a certain degree.

As technologies develop rapidly, the mobile management tools are increasing. Johnson et al.[21] conducted a 3-week study evaluating a short messaging service (SMS)-based management for 46 asthmatics and found that patients managed by SMS recorded better adherence and quality of life than traditional management. In a 12-week study of 88 children with asthma, Jan et al.[22] found that asthma management using websites can reduce symptoms, improve PEF and medication adherence, enhance asthma perception, and improve quality of life. Similarly, Farooqui et al.[23] found that medication adherence and asthma knowledge had both improved after using an App in a 30-day study among 21 children. In addition, 20 out of 21 patients found it more acceptable. Asthma management via an App was also shown to improve patients' ICS adherence in a 10 children aged 11–16 years.[24] An asthma mobile App with a reminder and asthma action plan was also evaluated in a study, involving 98 children and teenagers aged from 6 months to 21 years who were followed up for 6 months.[25] App-based asthma management tool reduces the frequency of emergency visits and hospitalizations.[25] These studies conducted in children and teenagers all indicate that asthma management via SMS, websites, or Apps can improve compliance, asthma control, quality of life, perception of asthma and overall decrease healthcare burden. However, their sample sizes were small (n = 10–98) and follow-up duration was short (3 weeks–6 months). Furthermore, most of the studies did not compare with traditional management.[25]

Similar results were found in adult patients. A 4-month study of 16 asthmatic patients demonstrated lower PEF variability and higher FEV1 with SMS management.[26] Cook et al.[27] evaluated mobile App management for 4 months in 60 patients with poorly controlled asthma, and found that ACT and FEV1 increased and that patients were highly satisfied. In

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a larger randomized controlled trial, Lv et al.[28] assigned 150 adults with asthma to 3 groups: the SMS group, traditional diary management and oral education group. Patients in SMS group were shown to have improved mental health and quality of life and a lower rate of loss to follow-up over 12 weeks. FEV1 and the frequency of emergency visits were also shown to improve in all 3 groups. Another study showed that 49% of patients using App-based management reported an ACT score > 19 at 3 months compared with only 22% of patients using traditional management.[11] Mobile management improved clinical outcomes compared with traditional management, including PEF and FEV1 and quality of life as well as a lower frequency of asthma attack and emergency visits in a 6-month study of 43 patients.[14] In contrast to these studies, Prabhakaran et al.[29] conducted a 12-week study investigating SMS management in 60 adult asthmatic patients and found no significant improvement in ACT or the frequency of emergency visits and hospitalizations compared with traditional management. These studies in adult patients indicate that SMS or App-based management tools can improve clinical outcomes, such as asthma control, pulmonary function, and then reduce the healthcare burden. It suggests that novel management tools may be superior to traditional management tools in improving clinical outcomes. However, again, these were small studies (n = 16–160) and the duration of follow-up was short (12 weeks–6 months). Furthermore, most studies did not evaluate adherence to medication or effectiveness of mobile management vs. traditional management.[13] Consequently, the longer-term findings from our study provide more robust evidence supporting the use of mobile management technologies. Recently, many Asia countries have taken less action in the management of asthma. However, they have made many attempts in the field of innovation. Asthma management will advance toward intelligence and individualization.

Previous studies have indicated that medication adherence gradually declines over time.[30] Our study also showed a gradual decline in patients' medication adherence from baseline to 12 months. This trend was not significant in the mobile management group at 3 months, whereas the decline in adherence was significant in the traditional management group until 6 months. Such trends suggest that mobile asthma management may delay the decline in adherence over time compared with traditional management.

Our study also provided insight into the long-term utility of standardized asthma management in improving key clinical outcomes. For example, the ACT and Mini-AQLQ score of patients in both groups showed an increasing trend at 12 months, indicating that standardized asthma management can have a long-term effect on improving asthma control and quality of life. The FEV1, FVC, PEF and FENO of patients in both groups all improved at 6 months. This suggests that standardized asthma management can improve clinical outcomes and reduce airway inflammation. Standardized asthma management can also reduce the potential healthcare burden in terms of hospitalization and emergency visits. In our study, most patients did not require hospitalization (93.9%) or emergency visits (94.5%) within 12 months.

Patients' perceptions on asthma are related to asthma control.[27] As reported, asthmatic patients in urban areas have a more accurate perception than those in suburban areas.[31] In our study, the accuracy rate of patients' perceptions to the questionnaire at enrolment was lower than what has previously been reported, it may be related to the enrolment criteria being limited to patients with poor adherence and uncontrolled asthma. After 12 months of follow-up, the accuracy rate of patients' perceptions significantly increased. This suggests that both mobile management and traditional management can effectively improve patient perception. Interestingly, the mean MARS-A score of patients who had correctly answered all 4 questions

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was higher than that of those who had answered incorrectly, suggesting that patients with the correct perception of asthma had higher adherence.

In this study, the overall loss to follow-up rate was 21.3%, which may be related to the enrolment criteria being limited to patients with poor adherence and the long follow-up duration. However, the per-protocol analysis was fully consistent with the ITT (full analysis set) analysis results in demonstrating no significant differences between either group in terms of clinical outcomes, healthcare burden, and perception of disease.

Using mobile Apps for asthma management is promising. The design and implementation of mobile Apps have substantial influence on self-management and the current quality of mobile Apps in the market varies. We encourage asthma specialists to provide professional suggestions for the design and establish a standardized assessment system. For elderly asthmatic patients, traditional asthma management tools are still an appropriate method. However, the restriction of mobile phones in some schools and colleges may limit the application of mobile Apps for children with asthma.

In conclusion, we consider mobile asthma management using App provides meaningful improvements in medication adherence and asthma control. Future studies are needed to further promote these tools within specific groups.

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SUPPLEMENTARY MATERIALS

Supplementary Table S1

Number of hospitalizations and emergency visits in the mobile and traditional groups in the past year

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Supplementary Fig. S1

Schematic diagram of geographical distribution the Mobile Asthma Evaluation and Management System.

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Supplementary Fig. S2

Lost to follow-up rate of mobile management and traditional management groups over 12 months.

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Supplementary Fig. S3

Comparison of FEV1, FVC, and PEF between the mobile and traditional management groups.

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Supplementary Fig. S4

Proportion of patients with FEV1/FVC < 0.7 in the mobile and traditional management groups at 12 months.

Click here to view

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