C. Carvalhal[1], L. Taborda-Barata[1,2,3], S. Valente[4], C. Jácome[5,6], J. Fernandes[7], J. Almeida Fonseca[5,6,8,9]

Opinions of patients with persistent asthma regarding the use of mobile applications for disease monitoring

[1]Faculty of Health Sciences, University of Beira Interior, Covilhã, Portugal
[2]Service of Immunoallergology, Hospital Pêro da Covilhã, Cova da Beira Hospital Center, Covilhã, Portugal
[3]Clinical Academic Center of Beiras, Covilhã, Portugal
[4]Service of Pneumology, Hospital Pêro da Covilhã, Cova da Beira Hospital Center, Covilhã, Portugal
[5]Center for Health Technology and Services Research (CINTESIS), Faculty of Medicine, University of Porto, Porto, Portugal
[6]Department of Community Medicine Health Information and Decision (MEDCIDS), Faculty of Medicine, University of Porto, Porto, Portugal
[7]BloomIdea, Braga, Portugal
[8]Allergy Unit, Institute and Hospital of Porto CUF, Porto, Portugal
[9]Medicine, Education, Research, Development and Evaluation (MEDIDA), Porto, Portugal

Summary

Background. *We assessed adherence to treatment and management needs of adults with persistent asthma and their interest in using apps for asthma management. Secondarily, we explored patients' opinions about an app to assess and improve adherence to treatment.* **Methods.** *A cross-sectional study was conducted with 40 adults with persistent asthma (49.9 ± 15.8 years) recruited at outpatient clinics from a district hospital. Participants answered a survey on sociodemographic, asthma control, treatment adherence and use of mobile devices, social networks and apps. Four patients participated in a prospective extension of the study, in which they were invited to use the InspirerMundi app.* **Results**. *48% of the participants had at least ≥ 1 exacerbation in the previous year and 85% had uncontrolled asthma. Self-reported adherence to treatment showed that one in four participants had low adherence. At least daily, 55% of participants navigated on the internet with their smartphone/tablet, 35% used apps and 93% social networks. Nine (22%) participants had previously used health/fitness apps and 65% would like to use apps to improve inhaler adherence.* **Conclusions.** *Most participants had uncontrolled asthma, reported high adherence to treatment and were daily users of social networks and the internet. Only 1/4 used apps but 2/3 would like to use apps to support asthma management.*

IMPACT STATEMENT
Two-thirds of the participants with access to mobile devices would like to use an app to improve monitoring and adherence to treatment.

Introduction

Asthma affects around 235 million people worldwide (1). Regular disease monitoring and its proper management may allow a normal life (1, 2). Inhaler controller medications are the cornerstone of effective asthma treatment. However, there is low adherence to medication in patients with asthma, which leads to worse outcomes and higher disease burden (3-5).

One of the main factors contributing to the difficulty in adhering to asthma treatment is poor patients' perception of asthma, since asthma attacks are episodic, which may constitute a barrier to understanding the need of control medication (6, 7). There is a need to improve our understanding of the patterns of adherence to inhaled controller medications and to identify the specific reasons for non-adherence and other needs among patients with persistent asthma. It is also important to develop patient-centred solutions, allowing patients to be actively involved in the control of their asthma, through the implementation of self-monitoring strategies (8).

Interactive asthma monitoring tools, through the use of internet-based and social media solutions, have been associated with better outcomes in patients with asthma (9). A simple daily text message reminder was associated with increased adherence to treatment (10). In addition, most patients with asthma show a preference for using internet applications for future self-monitoring (11). However, it is important to improve our understanding of the preferences, interest and usage of web-based strategies in daily routine of people with persistent asthma, to improve adherence to treatment.

Apps can be a feasible solution, since they can be used at any time, are easily integrated into daily life, can combine mechanisms to determine treatment adherence, interactive communication and gamification that can influence patients' behaviour changes (12). In fact, the use of mobile applications made patients feel that their health care continued even outside the hospital (11). It is therefore hypothesised that an app, with gamification and peer-support elements, may improve adherence to treatment in patients with asthma. However, usefulness and acceptability by end users need to be assessed in a real-world study. The main aims of this study were to evaluate adherence to treatment and management needs of adults with persistent asthma; to assess their interest in using apps for management and adherence to treatment, and to describe the use of mobile devices, social networks and apps. The secondary aim was to investigate users' opinions about an app to assess and improve adherence to treatment.

Materials and methods

Study design and participants

A cross-sectional study with 40 adults with asthma and a pilot extension study with four of those patients were performed. Patients were recruited during 120 appointment periods of allergy and pulmonology outpatient clinics of Hospital Pêro da Covilhã, between September 2017 and June 2018. Patients were included if they had persistent asthma, were ≥ 18 years old, had an active prescription of inhaled controlled medication and had access to mobile devices (smartphone/tablet). Patients with a diagnosis of other chronic conditions with possible interference with the study aims were excluded. In the prospective extension study, patients had additionally to answer positively to the question about interest in using apps to improve inhaler adherence. All participants were informed about the study and written informed consent was obtained prior to data collection. The Ethics Committee of Hospital Pêro da Covilhã approved the study.

Data collection

First, sociodemographic and clinical (smoking habits, body mass index-BMI, age of asthma diagnosis, asthma self-monitoring and written asthma treatment plan) data were collected. To assess management needs, patients' asthma control, exacerbations and use of health care resources were collected. Clinicians reported patients' asthma clinical characteristics and control according to Global Initiative for Asthma (GINA) (13). Patients completed the Control of Allergic Rhinitis and Asthma Test (CARAT) (14). CARAT total (CARAT-T, 0-30), upper airways (CARAT-UA, 0-12) and lower airways (CARAT-LA, 0-18) scores were calculated. Scores > 24 on CARAT-T and ≥ 16 on CARAT-LA defined good disease control. Number of exacerbations (defined as episodes of progressive increase in shortness of breath, cough, wheezing, and/or chest tightness, requiring change in maintenance therapy (15), treatment with oral corticosteroids, days of work/school lost due to routine medical visits, unscheduled medical visits, hospitalizations and days of work/school lost due to asthma attacks in previous year were also assessed.

To assess inhaler adherence, patients answered the 4-item Morisky Medication Adherence Scale (MMAS-4) (16, 17). The scores range from 0 to 4 (0 indicates high adherence, 1-2 medium adherence and 3-4 low adherence). In addition, patients assessed their global adherence to inhaled controller medication for asthma during the previous week ("how would you classify your adherence to your daily inhaler during the last week?") using a Visual Analogic Scale (VAS), ranging from 0 (worst) to 100 (best) millimetres (18). Satisfaction with inhaler was assessed through a questionnaire previously used in patients with asthma (19). This questionnaire includes 4 VAS (0 worst - 100 best) questions, which evaluate patients self-perception of inhaler technique ("I perform correctly the technique of my inhaler"), satisfaction with the inhaler device ("I feel satisfied with my inhaler"), comfort with public use of the inhaler ("I feel comfortable using my inhaler in public") and perception of how his/her preferences were taken into account at the time

of inhaler's prescription ("I feel that my physician took into account my opinion and preferences when choosing my inhaler") (19). Then, the participants completed the specific Beliefs about Medicines Questionnaire (BMQ-Specific) (20). The BMQ-Specific includes a 5-item Necessity scale (score 5-25) and a 6-item Concerns scale (score 6-30). Higher scores represent greater patient's beliefs in the represented concept.

Finally, participants filled in the Smartphone Usage Scale and the General Social Media Usage Subscale of the Media and Technology Usage and Attitudes Scale (MTUAS) (21). Patients were also asked about previous use of health/fitness apps and asthma apps, if they would like to use apps to manage their asthma and, and if they would like to use apps to improve inhaler adherence. In the prospective extension study, four patients installed the InspirerMundi app on their mobile devices and were invited to use the app daily for 6 months. At the end of this time period, patients were interviewed by phone to answer a survey about the app. The survey included questions regarding satisfaction with each of the app components; suggested app improvements and also the System Usability Scale (SUS) (22). SUS score range from 0 to 100, and scores > 68 mean good system usability.

InspirerMundi App

InspirerMundi aims to transform adherence to treatment into a positive experience through immediate and enjoyable feedback (gamification), while allowing for verified inhaler adherence monitoring (12). The app, available for iOS and Android, integrates 3 main components: monitoring, gaming, and social/peer support. In the monitoring component, users can add their current medications and record performed inhalations using the image-based inhaler adherence detection tool. The mobile app allows patients to view statistics on the adherence to medications and gives alerts of scheduled medication. Patients can also record relief medication use, asthma-related symptoms and exacerbations, and can share data with their physician. In the gaming component, the aim is to increase the sphere of influence by the network of Inspirers and Warriors. The app engages patients with a customisable "Warrior" (beginner player), which can become an Inspirer (advanced player) that gives support to his/her Warriors. Points are given when users take their medication according to plan. In the social/peer support component, users can share and demonstrate their points/badges and achieve social recognition; exchange messages and alert their warriors regarding missing medication doses.

Statistical analysis

Statistical analyses were conducted with IBM SPSS Statistics v21 (Chicago, US). Categorical variables were described with absolute and relative frequencies and continuous variables with mean and standard deviation or median with interquartile range, according to data distribution. Differences between patients with or without interest in using apps were tested using the χ^2 test for categorical variables and Mann-Whitney U Test for continuous variables. Logistic regression analysis was used to explain the interest in using asthma apps. Adjusted odds ratio (OR) with 95% confidence interval (95% CI) were calculated. All variables possibly related to interest in using apps were considered. The level of significance was $\alpha < 0.05$.

Results

Participants

Forty patients (31 females) with a mean age of 49.9 ± 15.8 years participated. Most were married, had an education level ≥ 10 years and were employed. Almost two thirds of the participants had never smoked. An association between interest in using apps for asthma and age, marital/civil status, education level and BMI was observed (**table I**).

Treatment adherence and management needs

The mean age at asthma diagnosis was 29.6 ± 15.6 years. According to CARAT, 85% (n = 34) of the participants had uncontrolled disease (75% considering solely the lower airways) and almost half had exacerbations in the previous year. Yet, almost none had lost a work/school day due to asthma attacks. A relation between interest in using mobile applications for asthma and age of asthma diagnosis was observed (**table II**). The BMQ necessity score had a mean of 19.1 ± 3.3 and the BMQ concern score a mean of 15.6 ± 3.9. In terms of the 4-MMAS, most patients (55%) had medium adherence to treatment, and one fifth had high adherence. Most participants had at least one problem regarding adherence to treatment and most patients (68%) forgot to take their medication (**figure 1**). Self-perception of adherence to inhalers in the previous week was high (median 91%) as were self-evaluation of inhaler technique (median 99%), satisfaction with the inhaler device (median 99%), patient's perceived involvement in the choice of the device(s) (median 98%) and public use of the inhaler (median 100%). Association between interest in using apps for asthma and self-perception of adherence to inhalers in the previous week, self-evaluation of inhaler technique, patient's perceived involvement in the choice of the device(s) and public use of the inhalers was observed (**table II**). Participants mostly browsed the web, searched for information and used apps on their smartphone (**figure 2**). Those who used their smartphone/tablet more also showed greater interest in using apps. A relationship between interest in using mobile applications for asthma and browsing the web, listening to music, recording video, using apps, searching for information and checking Facebook page was observed. Most (93%) participants used Facebook, 22% used apps of health/fitness and only one participant had used an app for asthma (**figure 3**). However, most patients (65%) would like to use apps to improve adherence to treatment.

Table I - *Characteristics of the participants.*

Characteristics	Without interest (n = 18)	With interest (n = 22)	Total (n = 40)
Age, mean ± SD (range) years	59.6 ± 11.1	41.9 ± 14.8*	49.9 ± 15.8 (20-77)
Female, n (%)	12 (67)	19 (87)	31 (78)
Marital/Civil Status, n (%)			
Married/ Civil union	16 (89)	12 (55)*	28 (70)
Singled/Divorced	2 (11)	10 (46)*	12 (30)
Education level, n (%)			
< 10 years	13 (72)	4 (18)*	17 (43)
≥ 10 years	5 (28)	18 (82)*	23 (57)
Employment, n (%)			
Employed	7 (39)	14 (64)	21 (53)
Retired	8 (44)	2 (9)	10 (25)
Unemployed/Not working due to poor health	3 (17)	1 (3)	5 (13)
Student	0	3 (8)	3 (8)
BMI, mean±SD (range) kg/m^2	27.9 ± 2.6	25 ± 4.7*	26.3 ± 4.1 (18.5-35.1)
Smoking status, n (%)			
Non-Smokers	12 (67)	13 (59)	25 (63)
Ex-smoker	4 (22)	6 (27)	10 (25)
Current smoker	2 (11)	3 (14)	5 (12)
Passive smoking, n (%)	5 (28)	12 (55)	17 (43)

BMI: Body Mass Index; *p < 0.05.

The logistic regression model was statistically significant (χ^2 = 21.284, p < 0.001) and explained 59% (Nagelkerke R^2) of the interest in use apps for asthma. The variables use of apps (OR = 28.3; 95% CI 2.1-374.9) and the frequency of Facebook use (OR = 2.3; 95% CI 1.1-4.7) were the independent variables.

Pilot study

Four participants (1 male, 20-46 years; ≥ 10 education years) tested the InspirerMundi app. The SUS score was 65 for one participant and > 68 for the other participants (80, 82.5, 85). Concerning the monitoring component, three patients were completely satisfied/satisfied and one had no opinion. Regarding the inhaler usage detection tool, two participants were completely satisfied/satisfied and the other two had no opinion. Regarding the app gamification, two were satisfied, one had no opinion and one was unsatisfied. As for the app social network, two were completely satisfied/satisfied, one had no opinion and one was unsatisfied. All participants were globally satisfied with the app and all would recommend it to others. One participant considered that the use of the app increased his/her awareness

of the importance of adherence to medication and two stated that the app increased their motivation to adhere to it. Participants stated that the app allowed them to better control the time/doses of the medication; to register their symptoms and to have greater perception of control of their symptoms. Two participants considered that the game component should be more engaging, while another participant considered that the app stalled several times. They suggested simplifying the record of inhaled medication and the main screen presentation, with three menus: medication, CARAT and weekly/daily symptoms.

Discussion

This study contributes to the much needed knowledge about adherence to treatment, asthma management problems and about opinions on the use of apps in patients with asthma. A main finding was that two thirds of the participants with access to mobile devices would like to use apps for asthma to improve monitoring and adherence to treatment. Furthermore, insufficient control of asthma, poor monitoring between medical

*Table II - Asthma control and patients' beliefs, adherence and preferences regarding inhalers.*

Variables	Without interest (n = 18)	With interest (n = 22)	Total (n = 40)
Age of asthma diagnosis, mean ± SD (range) years	37 ± 12.9	23.5 ± 15.1*	29.6 ± 15.6 (1-55)
Number of different inhalers, n (%)			
1	7 (39)	3 (14)	9 (23)
2	8 (44)	17 (77)	26 (65)
3	3 (17)	2 (9)	5 (12)
GINA classification of asthma control n (%)			
Well controlled	6 (33)	11 (50)	17 (43)
Partly controllled	7 (39)	5 (23)	12 (30)
Uncontrolled	5 (28)	6 (27)	11 (27)
CARAT, mean ± SD (range)	19.9 ± 6.7	17 ± 8.4	17.9 ± 7.7 (0-29)
CARAT, n (%)			
Controlled (> 24)	2 (11)	4 (18)	6 (15)
Not controlled	16 (89)	18 (82)	34 (85)
CARAT Upper Airways	7.2 ± 3,0	5.7 ± 3.6	6.4 ± 3.4
CARAT Lower Airways	11.7 ± 5.9	11.3 ± 5.8	11.5 ± 5.8
Asthma self-monitoring, n (%)	1 (6)	4 (18)	5 (13)
Days of work/school lost due to routine medical visits past 12 months, n (%)			
0	16 (89)	17 (77)	33 (83)
1-4	2 (11)	5 (23)	7 (17)
Clinician explain how to use the inhaler past 12 months, n (%)	16 (89)	20 (91)	36 (90)
Asthma written treatment plan, n (%)	15 (83)	19 (86)	34 (85)
Exacerbations past 12 months, n (%)			
0	11 (61)	10 (46)	21 (53)
1-2	7 (39)	9 (40)	16 (40)
≥ 3	0 (0)	3 (14)	3 (7)
Treatment with oral corticosteroids past 12 months, n (%)	7 (39)	8 (36)	15 (38)
Asthma unscheduled medical care past 12 months, n (%)			
Emergency department visits past 12 months	5 (28)	5 (23)	11 (27)
Hospital admissions past 12 months	1 (6)	0	1 (3)
Days of work/school lost due to asthma attacks past 12 months, n (%)			
0	17 (94)	21 (96)	39 (98)
≥ 1	1 (6)	1 (5)	1 (2)
BMQ necessity, mean ± SD (range)	19.6 ± 2.1	18.7 ± 3.9	19.1 ± 3.3 (8-25)
BMQ concern, mean ± SD (range)	15.6 ± 2.2	15.5 ± 4.8	15.6 ± 3.9 (6-27)
4-MMAS, n (%)			
High adherence	4 (22)	4 (18)	8 (20)
Medium adherence	9 (50)	13 (59)	22 (55)
Low adherence	4 (22)	5 (23)	9 (22)

⟶

Variables	Without interest (n = 18)	With interest (n = 22)	Total (n = 40)
Adherence to inhalers last week[a], Median (P25-P75)	100 (83-100)	83 (71-98)*	91 (74-100)
Preferences[a], Median (P25-P75)			
I perform correctly the technique of my inhaler	100 (97-100)	97 (98-100)*	99 (92-100)
I feel satisfied with my inhaler	100 (90-100)	98 (94-100)	99 (94-100)
I feel that my physician took into account my opinion and preferences when choosing my inhaler	100 (95-100)	93 (49-100)*	98 (67-100)
I feel comfortable using my inhaler in public	100 (99-100)	96 (90-100)*	100 (94-100)

GINA: Global Initiative for Asthma; CARAT: Control of Allergic Rhinitis and Asthma Test; *p < 0.05; BMQ: the Beliefs about Medicines Questionnaire; 4-MMAS: Morisky 4-item Medication Adherence Scale; [a]Visual analogic scale; range 0-100 (best).

**Figure 1** - *4-item Morisky Medication Adherence Scale.*
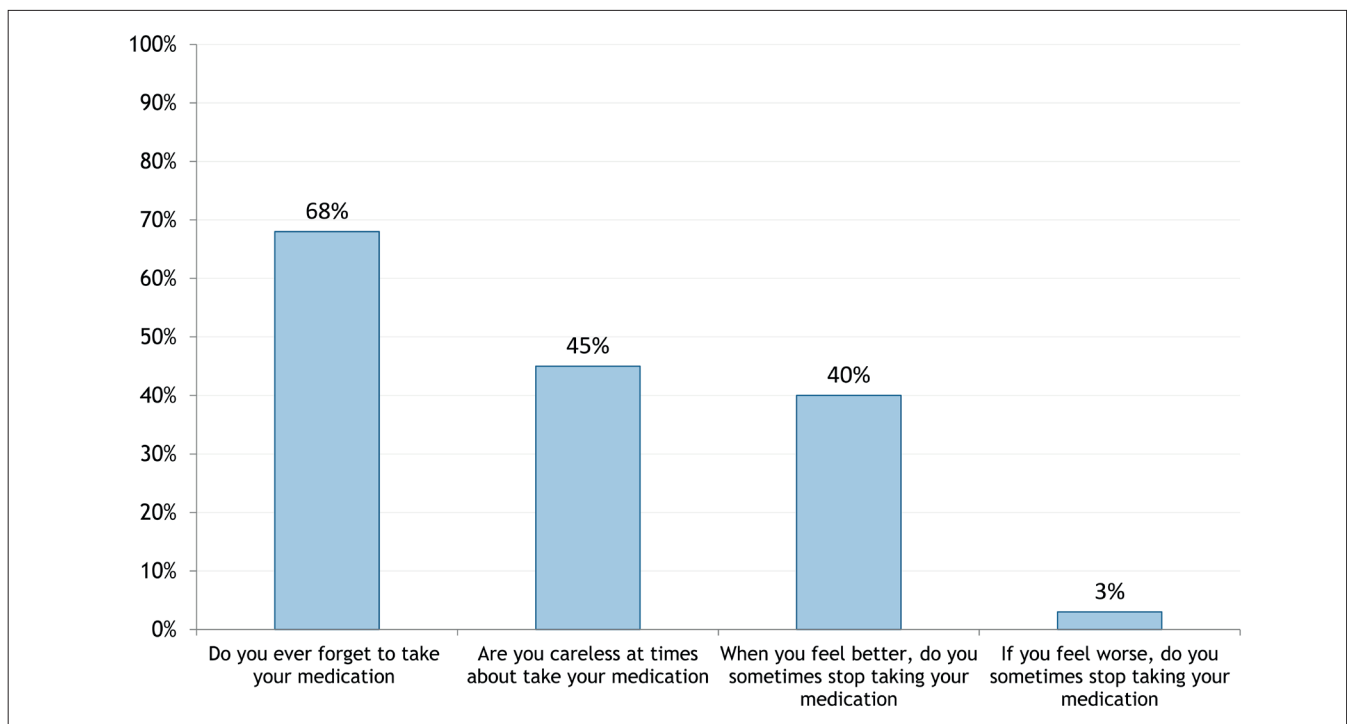
appointments and a possible overestimation of the participants regarding treatment related perceptions were observed.

The main management needs identified were the high proportion of patients with insufficient asthma control, the lack of self-monitoring between medical visits and the mismatch between clinical outcomes and patients' perceptions about their management. Near half of the patients had an asthma exacerbation in the previous year; however, patients reported very few days of missed work/school and very high levels of written treatment plans. In addi-

tion, perceptions of their adherence and inhaler technique were also very high. Therefore, there is a disassociation between patients' perceptions and clinical outcomes. Most of the participants reported a high satisfaction with the inhaler device, were confident about the correctness of their inhaler technique and about using their inhaler in public and considered being involved by the physician in the choice of the device. Our results on inhaler technique are apparently much better than those obtained by Chorão *et al.* (19), but this difference may reflect the different methods used. In the

Figure 2 - *Smartphone usage scale (9 items) and General social media usage subscale (1 item) of Media and Technology Usage and Attitudes Scale.*
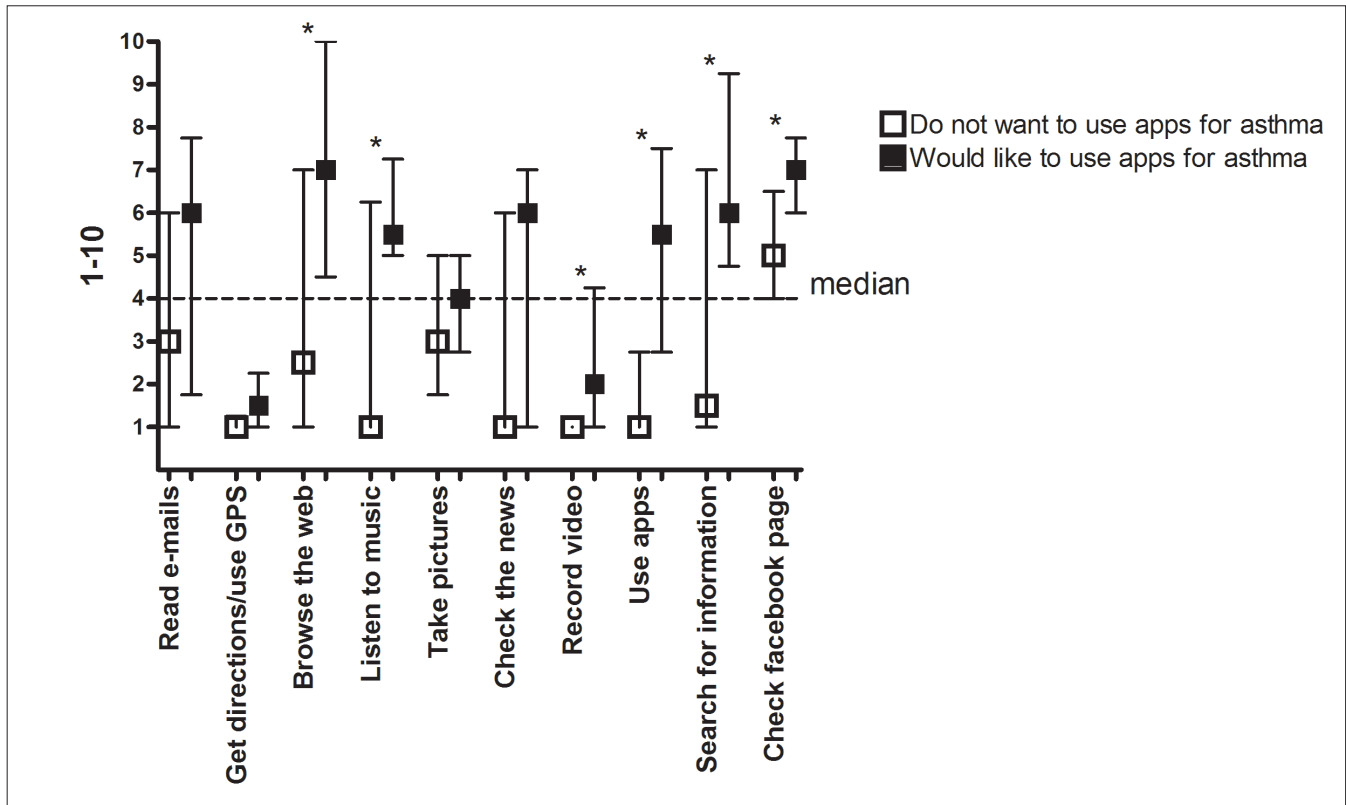

study by Chorão *et al.*, the inhaler technique was observed by the researcher and included patients with asthma and with chronic obstructive pulmonary disease (19). Thus, opinions and preferences of patients concerning their inhaler device may be over-estimated. One of the most relevant management needs may be to improve patients' awareness of the importance of inhaler technique, adherence and involvement in treatment decisions. In fact, overestimation of disease control by patients was apparent in a study by Sá-Sousa *et al.* (23), in which 88% of patients with uncontrolled asthma considered their asthma to be under control.

The majority of participants had uncontrolled asthma, with CARAT scores similar to those observed in other studies. A similar situation was also observed in both elderly and non-elderly asthmatic patients from the region of Beira Interior (24). A study carried out in 224 participants recruited in pharmacies located in the same district of this study obtained similar results of CARAT (mean 17.8; 87% uncontrolled asthma) (25). In another study, involving 200 patients with a mean age of 33.6 ± 12.3 years, of which 86 had allergic rhinitis and asthma, 86% had uncontrolled asthma (26). There is a high percentage of patients

with uncontrolled asthma, which is a cause for concern and calls for measures to be taken to improve these outcomes. The availability and use of tools to support asthma self-monitoring may be one of the measures to improve asthma management.

We observed high values of treatment with oral corticosteroids in the previous year (38%) and visits to the emergency department (27%), and relatively few hospitalisations (3%). A study by Price *et al.*, with 8000 patients with asthma from 11 European countries showed similar results in the percentage of treatment with oral corticosteroids (44%) and of emergency department visits (24%), but reported more hospitalisations (12%) (27). These differences may be explained by the fact that in the European study, participants were recruited by an online survey which means that a broader spectrum of patients was represented, whereas in the present study participants were regularly followed up by a clinician at secondary care. It was observed that in the present study, according to GINA, 43% of the participants had well controlled asthma and, according to 4-MMAS, approximately half of them had medium adherence to treatment while in the European study only 20% had well controlled asthma and many with

Figure 3 - *Use of social networks and apps and interest in using apps for asthma.*
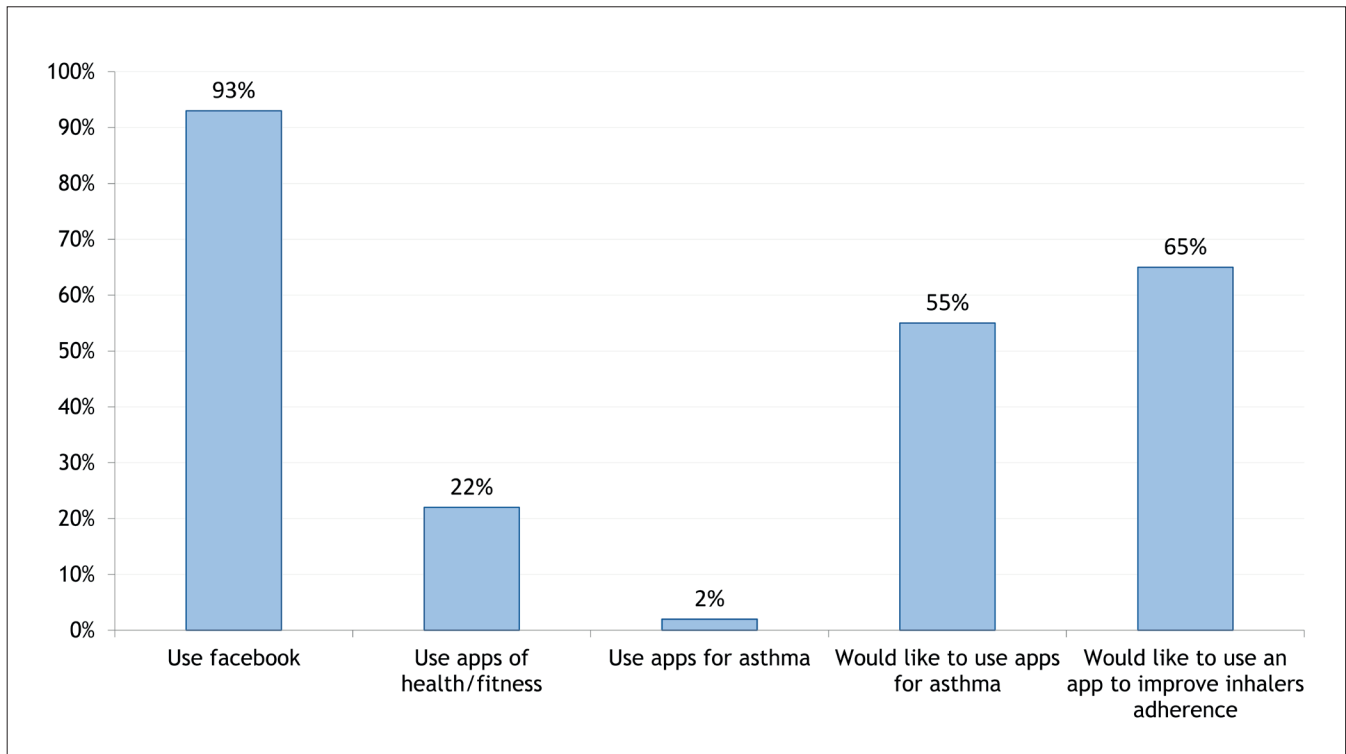
low adherence to therapy. In our case this factor may contribute towards reducing hospitalizations but adherence to treatment remains an important issue and we need objective data to confirm the high levels of self-reported adherence observed.

The mean scores for the Necessity and Concerns subscales are comparable to the study by Salgado *et al.*, carried out in 300 outpatients of several illness groups (19.9 for Necessity and 17.7 for Concerns), which indicates that patients with asthma perceive necessity and concerns similarly to patients with other chronic diseases (20). The BMQ results are associated with poor medication adherence and highlight the importance of addressing patients concerns during medical visits.

Mobile devices can be an instrument that helps asthma self-monitoring because they are part of people's daily lives, allow the users to request data wherever they are, allow more timely health monitoring and can associate personal and social contact (28). We verified that most of the participants used Facebook daily and that browsing the web, searching for information and using apps were daily used on their smartphone. We observed that one third of the participants had already used apps of health/fitness and despite the fact that only one participant had used an app for asthma, more than half of the patients showed interest in

using apps to improve inhaler adherence. Fonseca *et al.* reported that patients with moderate-to-severe asthma and with access to mobile phones had interest in using it for self-monitoring asthma (91%) and for information about medication (88%) (29). The designs of the studies and the 14-year difference in data collection do not allow direct comparisons, but there may be differences in the interest of patients in using apps for different asthma related purposes. As apps become instrumental in providing health care measures, further research is needed to prove the importance of these tools. In addition, it is believed that the development of apps grounded in research will probably have a role in increasing patients' interest in using these tools.

As an early pilot study, four patients reported on the use of the InspirerMundi app. The participants liked the app and reported that it allows them to have better understanding of the medication/symptoms. The gamification and the social network were the components with less positive opinions from the users, but all components need to be improved in app future versions. Also, more studies with larger samples are needed to further evaluate the app feasibility and validity.

This study has some limitations. First, the selection bias related to the inclusion criterion of having access to mobile devic-

es, since the site of recruitment has a high proportion of older patients. Another limitation is the small sample size, especially of the pilot study. Nevertheless, we report relevant information regarding asthma management issues and new approaches to improve them. Third, adherence was assessed using subjective measures (4-MMAS and VAS), which are known to overestimate of real adherence. Future studies should combine subjective and objective measures of adherence. A fourth limitation involves the fact that most patients had self-management asthma plans and their inhalation technique was regularly checked, a situation which is not often found in other settings where patients are seen and which may hinder generalization. Future studies will need to recruit a larger sample with participants from several healthcare units with greater socio-economic and clinical variety.

Conclusions

Two-thirds of the participants with access to mobile devices would like to use an app to improve monitoring and adherence to treatment. Participants had a high daily usage of their mobile devices, and social networks but only one third used other apps. The self-reported measures about treatment adherence and perceptions had high scores which contrast with poor asthma control. Improvements in self-monitoring between medical appointments are asthma management needs that are apparent from this study and apps can be important tools.

References

1. World Health Organization. Asthma 2017. Available at: http://www.who.int/news-room/fact-sheets/detail/asthma. Last access date: 10/15/2021.
2. Direcção Geral da Saúde Comissão de coordenação do Programa Nacional de Controlo da revisto em Novembro de 2007. Manual de Boas Práticas na Asma. Available at: https://nocs.pt/manual-de-boas-praticas-na-asma-2/. Last access date: 10/15/2021.
3. Barbosa JP, Ferreira-Magalhães M, Sá-Sousa A, Azevedo LF, Fonseca JA. Cost of asthma in Portuguese adults: A population-based, cost-of-illness study. Rev Port Pneumol 2017;23:323–30.
4. Ferreira de Magalhães M, Amaral R, Pereira AM, et al. Cost of asthma in children: A nationwide, population-based, cost-of-illness study. Pediatr Allergy Immunol 2017;28:683–91.
5. World Health Organization. Adherence to long-term therapies: Evidence for action. Geneva 2003:pp 3-47. Available at: https://apps.who.int/iris/handle/10665/42682. Last access date: 10/15/2021.
6. Horne R. Compliance, adherence and concordance. Chest 2006;130:65S–72S.
7. Horne R, Weinman J. Self-regulation and self-management in asthma: Exploring the role of illness perceptions and treatment beliefs in explaining non-adherence to preventer medication. Psychol Heal 2002;17:17–32.
8. Guimarães T, Faísca V. Adesão à terapêutica e controlo da doença na asma: papel das perceções de doença. 2013; Available at: https://repositorio.ipl.pt/handle/10400.21/3518. Last access date: 10/15/2021.
9. Al-Durra M, Torio MB, Cafazzo J. The Use of Behavior Change Theory in Internet-Based Asthma Self-Management Interventions: A Systematic Review. J Med Internet Res 2015;17: e89.
10. Strandbygaard U, Thomsen SF, Backer V. A daily SMS reminder increases adherence to asthma treatment: A three-month follow-up study. Respir Med 2010;104:166–71.

11. 1Wang J, Wang Y, Wei C, et al. Smartphone Interventions for Long-Term Health Management of Chronic Diseases: An Integrative Review. Telemed e-Health 2014;20:570–83.
12. Jácome C, Guedes R, Almeida R, et al. mINSPIRERS – Estudo da exequibilidade de uma aplicação móvel para medição e melhoria da adesão à medicação inalada de controlo em adolescentes e adultos com asma persistente. Rev Port Imunoalergologia 2018;26:47–61.
13. Bateman ED, Hurd SS, Barnes PJ, et al. Global strategy for asthma management and prevention: GINA executive summary. Eur Respir J 2008;31:143–78.
14. Fonseca JA, Nogueira-Silva L, Morais-Almeida M, et al. Validation of a questionnaire (CARAT10) to assess rhinitis and asthma in patients with asthma. Allergy 2010;65:1042–8.
15. Loymans RJ, Ter Riet G, Sterk PJ. Definitions of asthma exacerbations. Curr Opin Allergy Clin Immunol 2011;11(3):181–6.
16. Morisky DE, Green LW, Levine DM. Concurrent and predictive validity of a self-reported measure of medication adherence. Med Care 1986;24:67–74.
17. Tan X, Patel I, Chang J. Review of the four item Morisky Medication Adherence Scale (MMAS-4) and eight item Morisky Medication Adherence Scale (MMAS-8). Inov Pharm 2014;5:165.
18. Jonsdottir H, Opjordsmoen S, Birkenaes AB, et al. Medication adherence in outpatients with severe mental disorders: relation between self-reports and serum level. J Clin Psychopharmacol 2010;30(2):169-75.
19. Chorão P, Pereira AM, Fonseca JA. Inhaler devices in asthma and COPD - An assessment of inhaler technique and patient preferences. Respir Med 2014;108:968–75.
20. Salgado T, Marques A, Geraldes L, Benrimoj S, Horne R, Fernandez-Llimos F. Adaptação transcultural do Beliefs about Medicines Questionnaire para o Português. Sao Paulo Med J 2013;131:88–94.

21. Costa JJM, Matos AP, Pinheiro MR, Salvador MC, Vale-Dias ML, Zenha-Rela M. Evaluating Use and Attitudes Towards Social Media and ICT for Portuguese youth: the MTUAS-PY scale. Eur Proc Social Behav Sci 2016:99–115.

22. Martins AI, Rosa AF, Queirós A, Silva A, Rocha NP. European Portuguese Validation of the System Usability Scale (SUS). Procedia Comput Sci 2015;67:293–300.

23. Sá-Sousa A, Amaral R, Morais-Almeida M, *et al*. Asthma control in the Portuguese National Asthma Survey. Rev Port Pneumol 2015;21:209–13.

24. Freitas Ferreira E, Pascoal A, Silva P, *et al*. Inhaler training and asthma knowledge are associated with a higher proportion of patients with correct inhaler technique in young but not in elderly asthmatic patients. J Asthma 2019:1-11.

25. Lourenço O, Calado S, Sá-Sousa A, Fonseca J. Evaluation of Allergic Rhinitis and Asthma Control in a Portuguese Community Pharmacy Setting. J Manag Care Pharm 2014;20:513–22.

26. Pereira PR, Lopes C. A cross sectional assessment of allergic rhinitis and asthma control at an Immunoallergology outpatient hospital setting using CARAT10 questionnaire. Rev Port Pneumol 2013;19:163–7.

27. Price D, Fletcher M, Van Der Molen T. Asthma control and management in 8,000 European patients: The REcognise Asthma and LInk to Symptoms and Experience (REALISE) survey. NPJ Prim Care Respir Med 2014;24:14009.

28. Currie M, Philip LJ, Roberts A. Attitudes towards the use and acceptance of eHealth technologies: A case study of older adults living with chronic pain and implications for rural healthcare. BMC Health Serv Res 2015;15:162.

29. Fonseca JA, Costa-Pereira A, Delgado L, Fernandes L, Castel-Branco MG. Asthma patients are willing to use mobile and web technologies to support self-management. Allergy 2006;61:389–90.