

Validation of the MASK-air App for assessment of allergic rhinitis

To The Editor,

Recently, a mobile app (Allergy Diary, now MASK-air® freely available on Google Play and the Apple app store) was used to collect data on patients with allergic rhinitis (AR),^{1,2} evidencing the usefulness of this tool for assessing patient behavior in AR. Among other features, the app includes visual analog scale (VAS) measures for general, nasal, ocular, and asthma symptoms and daily medication intake.

The present prospective study aims to validate this app for the control of AR, comparing it to a written questionnaire.

Participating patients with AR (Supplementary material S1, Table S1, Figure S1) were randomly assigned to one of the two groups: (1) AR patients who were invited to use the Spanish version of the MASK-air® app at the baseline visit (app group); and (2) AR patients who were not invited to use the app were asked to use paper-based questionnaires. (non-App as control group). All patients included had a reflective total nasal symptom score (rTNSS) ≥ 8 at baseline. Patients assigned to the app group had to use the application daily to record their symptoms; patients assigned to the non-app group had to complete a written questionnaire with same items on days 1, 3, 7, 14, 21, and 28, and a final visit one week later to deliver the questionnaire to the researcher.

The usefulness of the app for rhinitis control was evaluated at baseline and at the end of the study (1 month) using the RCAT (Rhinitis Control Assessment Test) questionnaire validated in Spanish as primary objective.³ Other AR outcomes evaluated were treatment adherence as measured by the Morisky-Green-Levine questionnaire,⁴ reflective total nasal symptom score (rTNSS), ocular symptom score (rTOSS), the modified ARIA severity classification,^{5,6} a quality-of-life questionnaire (ESPRINT-15),⁷ and daily visual analog scales (VAS, 0-10 cm) for nasal,⁸ conjunctival, asthma, and global for overall allergy symptoms, and the asthma control test (ACT) for asthmatic patients⁹ at baseline and at end of study. Patient satisfaction and doctor satisfaction with the app were evaluated using a Likert scale.

The comparisons between groups were performed using the chi-square test for categorical variables and Student's *t* test for continuous variables using an intent-to-treat analysis. For analysis, only data from days 1, 3, 7, 14, 21, and 28 were considered in both groups.

A multivariable analysis was also performed using mixed linear regression models for repeated measures or logistic models,

including variables considered relevant for the model. A level of statistical significance (*P*-value) of $<.05$ was used.

A total of 267 patients were selected by 27 allergologists or otorhinolaryngologists working in 27 different major hospitals throughout Spain. Fifteen patients failed to meet the inclusion criteria (14 for rTNSS ≤ 8 and 1 for withdrawing informed consent). Therefore, the analysis included 252 patients (122 in the app group and 130 in the non-app group), 11.5% of whom were lost to follow-up (14 in the app and 15 in the non-app groups) (Figure S1 supplement). With the number of patients included, we were able to detect differences of 0.4 standard deviations in RCAT.

Patient mean age ($\pm$ SD) was 35($\pm$ 12) years (71% women). Most patients presented with persistent AR (88%), moderate 63.5%, and 36.5% severe. 35.7% patients had concomitant persistent asthma (34.4% mild, 65.6% moderate) and 60% concomitant ocular symptoms (Table S1). During the baseline visit, AR treatment was modified, according to guidelines, in 60.7% of patients, of whom 24.6% began a new therapy regimen.

At baseline, significant differences between groups were in the rTNSS (9.6 ± 1.3 non-app vs. 9.1 ± 1.1 app, $P = .0027$) (but not in individual nasal symptoms), in pet dander sensitization (22.7% non-app vs. 12.8% app, $P = .0427$), in reflective total ocular symptoms score (rTOSS) (5.4 ± 2.1 non-app vs. 5.0 ± 2.3 app, $P = .0051$), being also significantly higher for tearing ($P = .0449$) and redness ($P = .0416$) in patients without app, but not in the others (Table S1).

Regarding the usability of the app, most patients in the App group (89.5%) reported having downloaded the app on their smartphone, and 92.1% of them used the app in the study. Eight patients gave reasons for not downloading the app (3 due to smartphone problems, 3 caused by errors in the QR code, and 2 owing to a lack of time). Most app users (88.2%) reported being satisfied or very satisfied with the app. 72% of doctors stated that their patients were satisfied with the app.

After one month, a relevant improvement on RCAT score was observed over baseline at the end of the study in both groups ($P < .001$), but there was no significant ($P = .2158$) or clinically relevant difference (being <2 points) between groups for RCAT scores. The other studied outcomes (ie, change in rTNSS, change in severity according to m-ARIA, changes in quality of life as per ESPRINT-15 questionnaire, adherence to treatment measured by Morisky-Green-Levine questionnaire)

TABLE 1 Clinical study outcomes

Outcome	Non-app group	app group	P value 1	P value 2
RCAT final				
Mean (SD)	21.26 (4.9)	22.09 (4.5)	.2158*	
RCAT score change (baseline vs final)				
Mean (SD)	6.4 (5.5)	6.2 (5.2)	.7501*	.6188**
rTNSS change (baseline vs final)				
Mean (SD)	-4.3 (3)	-4.2 (3.1)	.8947*	.3282**
mARIA severity change (baseline vs final) N (%)				
Worsening	3 (2.8)	2 (1.7)	.8028***	.7898***
No change	51 (47.2)	58 (50.4)		
Improving	54 (50.0)	55 (47.8)		
ESPRINT-15 scores change (baseline vs final)				
Mean (SD)	-1.5 (1.3)	-1.5 (1.2)	.7761*	.9329**
ACT score change (baseline vs final)				
Mean (SD)	-2.92(4.04)	-2.54(5.4)	.2269*	.8836**
Morisky-Green test change (baseline vs final) N (%)				
No change: reliable	8 (8.4)	10 (9.6)	.2700***	
No change: nonreliable	58 (61.1)	73 (70.2)		
From reliable to nonreliable	6 (6.3)	2 (1.9)		
Nonreliable to reliable	23 (24.2)	19 (18.3)		

Abbreviations: ACT, asthma control test; app, mobile application; ESPRINT, quality-of-life questionnaire; mARIA, modified ARIA classification; N, number of patients; RCAT, rhinitis control assessment test; rTNSS, reflective total nasal symptom score; SD, standard deviation.

*P: t test.

**P: mixed linear model for repeated measurements.

***Chi-square.

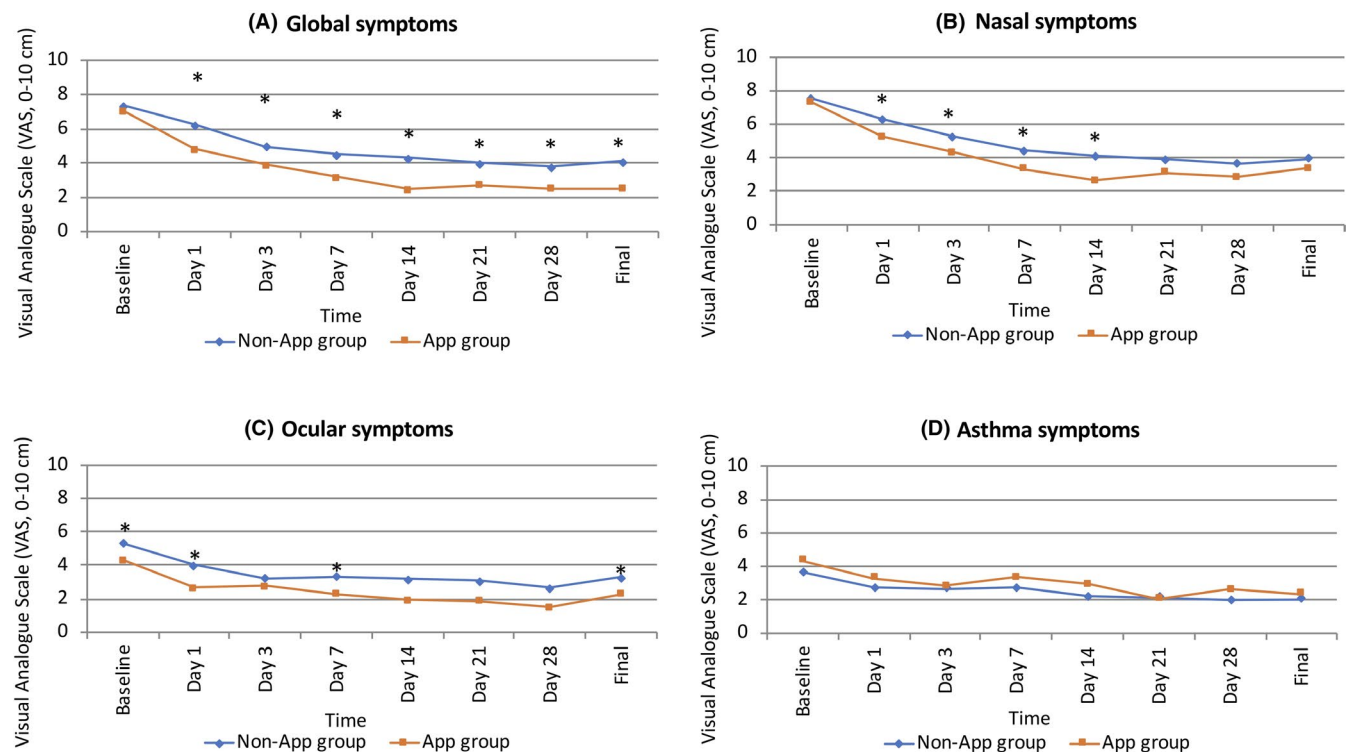


FIGURE 1 Visual analog scale (VAS) scores for global (A), nasal (B), ocular (C), and asthma (D) allergy symptoms during the 1-month period study in both the app and Non-app groups. *P < .05, between the app and the non-app groups

or VAS were not different between study groups (Table 1). The VAS comparisons between app and non-app groups along the study are shown in Figure 1. In nasal, ocular, and global VAS, improvement was reached earlier in the App group than in the non-App group (Figure 1). Moreover, there was a significant correlation between VAS of asthma and ACT score (Pearson -0.79132 , $P < .0001$) (Figure S2).

This pilot study with well-characterized patients is the first to report MASK-air results in the control of AR. It showed that after being treated in specialized centers, most of the patients were controlled after a few days, and the app contributes to the improvement of AR control as effectively as a written questionnaire. This improvement was observed earlier in the app users in either global, ocular, or nasal VAS and other outcomes (ie, AR severity and quality of life at the end of the study) when compared to the non-app group. This fact may be due to the perception that control was better by filling the symptoms daily in the app instead of every 7 days. A high correlation was observed between ACT scores and asthma VAS suggesting that both outcomes are interchangeable.

Finally, the MASK-air[®] app has shown to be practical and useful for both patients and doctors. This study reinforces the use of the app as a new eHealth tool for future epidemiological and real-life studies allowing an electronic record of clinical information that can help health professionals in decision-making and treatment.

CONFLICT OF INTEREST

JS reports having served as a consultant to Thermo Fisher, MEDA, Novartis, Sanofi, Leti, Faes Farma, Mundipharma, and GSK; having been paid lecture fees by Novartis, GSK, Stallergenes, Leti, and Faes Farma; as well as having received grant support for research from Thermo Fisher, Sanofi, and ALK. AdC reports having served as consultant to ALK and MEDA/Mylan, having been paid lecture fees from ALK, GSK, FAES Pharma, MEDA/Mylan, MSD, and Novartis, as well as having received grant support for research from Sanofi, Allakos, and Novartis. CC reports having served as a consultant to Mylan, Bial, and AstraZeneca; having been paid lecture fees by AstraZeneca, GSK, Mylan, MSD. AMN reports having served as a consultant to GSK, Mylan, and Leti; having been paid lecture fees by Chiesi, AstraZeneca, GSK, Merck, Mylan, MSD, Stallergenes and ALK. AV has served as a consultant to AstraZeneca, Novartis, Sanofi, Mylan, Mundipharma, and Leti and received lecture fees from Chiesi, Novartis, AstraZeneca, and GSK and as well as having received grant support for research from Novartis, AstraZeneca. JM is or has been member of national and international scientific advisory boards (consulting), received fees for lectures, and grants for research projects from Allakos, ALK-Abelló, AstraZeneca, Genentech-Roche, Glenmark, GSK, Hartington Pharmaceuticals, Menarini, Mitsubishi-Tanabe, MSD, MYLAN-MEDA Pharma, Novartis, Sanofi-Genzyme-Regeneron, UCB, and Uriach Group. JB: Honoraria for meeting lectures: Chiesi, Cipla, Hikma, Menarini, Mundipharma, Mylan, Novartis, Purina, Sanofi-Aventis, Takeda, Teva, Uriach. Shares in KYomed INNOV.

AUTHOR CONTRIBUTIONS

All authors participated in the conception and design of the study, analysis and interpretation of data, and drafting of the article. All approved the final version.

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REFERENCES

1. Bédard A, Basagaña X, Antó JM, et al. Mobile technology offers novel insights on control and treatment of allergic rhinitis. The MASK study. *J Allergy Clin Immunol*. 2019;144(1):135-143.
2. Bousquet J, Devillier P, Arnavielhe S, et al. Treatment of allergic rhinitis using mobile technology with real-world data: the MASK observational pilot study. *Allergy*. 2018;73(9):1763-1774.
3. Del Cuvillo A, Sastre J, Colás C, Navarro Am, Mullol J, Valero A. Adaptation to Spanish and validation of the Rhinitis Control Assessment Test (RCAT) questionnaire. *J Investig Allergol Clin Immunol*. 2020;30(3).<https://doi.org/10.18176/jiaci.0420>
4. Morisky DE, Green LW, Levine DM. Concurrent and predictive validity of a self-reported measure of medication adherence. *Med Care*. 1986;24(1):67-74.
5. Valero A, Ferrer M, Sastre J, et al. A new criterion by which to discriminate between patients with moderate allergic rhinitis and patients with severe allergic rhinitis based on the Allergic Rhinitis and its Impact on Asthma severity items. *J Allergy Clin Immunol*. 2007;120:359-365.
6. Valero A, Ferrer M, Baró E, et al. Discrimination between moderate and severe disease may be used in patients with either treated or untreated allergic rhinitis. *Allergy*. 2010;65(12):1609-1613.
7. Valero A, Alonso J, Antépara A, et al. Health-related quality of life in allergic rhinitis: comparing the short form ESPRINT-15 and MiniRQLQ questionnaires. *Allergy*. 2007;2007(62):1372-1378.
8. del Cuvillo A, Santos V, Montoro J, et al. Allergic rhinitis severity can be assessed using a visual analogue scale in mild, moderate and severe. *Rhinology*. 2017;55(1):34-38.
9. Vega JM, Badia X, Badiola C, et al. Validation of the Spanish version of the Asthma Control Test (ACT). *J Asthma*. 2007;44:867-872.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

Supplementary material

Allergists and otolaryngologists from twenty-seven different referral hospitals throughout Spain participated in the study. Physicians were not allowed to include more than 4 patients per month, up to a total of 15 patients per investigator. All patients signed an informed consent to participate in the study. Patients assigned to app group were invited to download the application in the doctor's office for training while those assigned to non-app group were trained in how to fill the written questionnaires. Each Investigator included a similar number of patients in both groups.

Inclusion criteria were as follows: ≥ 18 years of age with a diagnosis of moderate to severe allergic rhinitis (AR) following the severity criteria of the modified ARIA (mARIA) guidelines (mild: no affected items; moderate, 1, to 3 affected items; and severe: 4 affected items) (5, 6), and with a reflective total nasal symptom score (rTNSS, $0-12$) ≥ 8 , where the range from 0 to 12 represents the sum of individual nasal symptom scores of nasal congestion/obstruction, nasal itching, rhinorrhea, and sneezing (0, no symptom; 1, mild symptom; 2, moderate symptom; and 3, severe symptom). Patients had to download the application during their outpatient visit and the doctor/researcher should verify the application was properly functioning. Patients assigned to the app group had to use the application daily to record their symptoms while subjects assigned to the Non-app group had to complete a questionnaire at baseline and at days 1, 3, 7, 14, 21, and 28 after the baseline visit and deliver the questionnaire to the researcher during the follow-up visit. The study was carried out from November 2015 to October 2016 in Spain.

The collected data included in the study were the following:

1) Diseases associated with AR: asthma, conjunctivitis, otitis media, chronic rhinosinusitis with/without nasal polyps, lymphoid hypertrophy (adenoids and tonsils), urticaria, angioedema, atopic dermatitis, contact dermatitis, food and drug allergy.

2) Other concomitant diseases: hypertension, anxiety/depression, kidney disease, liver disease, neoplasia, cardiovascular disease, musculoskeletal disease, diabetes mellitus.

There was no statistical difference in the presence of any concomitant diseases between both study's group

3) Data related to AR: date of diagnosis, age at onset of symptoms, predominant symptoms, presence of concomitant eye symptoms, smoking habit, , and etiology of IgE-sensitizations to allergens (seasonal or perennial and class specification).

4) Current and/or previous treatments for AR (only at the baseline visit).

5) Treatment for the AR prescribed at baseline and agreement of the previous treatment to the current clinical practice guidelines (evaluation carried out by the researcher) and changes during treatment. The app or written questionnaires do not contain any mention to change treatment.

Excluded patients were those participating in clinical trials or patients diagnosed with obstructive septal deviation, chronic rhinosinusitis with/without nasal polyps. All patients provided written, informed consent to participate in the study.

The study was approved by the Ethics Committee for Clinical Research of the Hospital Clínic de Barcelona. The study was carried out from November 2015 to October 2016. Demographics characteristics are described in Table E1. In figure E1 is shown the flow-chart of the study.

The mean elapsed time ($\pm$ SD) between the date of AR diagnosis and the study was 6.3 ($\pm$ 9.7) years.

51 Only for the subgroup with app, patient's and doctor's satisfaction was evaluated using
52 a Likert scale with 7 response options: very satisfied, quite satisfied, somewhat
53 satisfied, neither satisfied nor dissatisfied, something dissatisfied, quite dissatisfied,
54 very dissatisfied.

55 Adherence/compliance:

56 For the primary objective (RCAT) the compliance for app group was 87.6% (114/130)
57 and for non-app 86.8% ($p=0.2158$). Other variables had similar compliance and none
58 with statistical significance between groups.

Table E1. **Demographic characteristics of the Allergic Rhinitis (AR) patients at baseline.**

Group		app	Non-app	P value
Patients, n (%)		130 (100)	122 (100)	
Age, yr, mean (SD)		35.2 (12.2)	34.2 (11.9)	0.5076
Gender, female, %		66.2	76.0	0.0780
BMI, , mean (SD)		24.6 (4.0)	25.4 (5.2)	0.4293
Non smokers, %		76.2	67.3	0.0606
Duration of AR, years mean (SD)		6.9 (10.1)	5.7 (9.3)	0.2973
Asthma, %		66.2	60.3	0.5229
Conjunctivitis, %		23.8	18.9	0.3343
Allergy sensitization, %	Pollen – seasonal	92	94	0.5510
	Pollen perennial	8	6	0.5496
	HDM	63.2	64.7	0.8066
	Animal dander	12.8	22.7	0.0427
	Fungi	4.8	4.2	0.8219
	Other inhalants	15.1	9.5	0.1269
	Polysensitized	59.2	62.4	0.6110
RCAT, mean (SD)		15.8 (3.9)	14.0 (3.9)	0.0663
rTNSS, mean (SD)		9.1 (1.1)	9.6 (1.3)	0.0027
m-ARIA severity, %	Intermittent moderate	10.0	9.8	0.6143
	Intermittent severe	2.3	1.6	
	Persistent moderate	56.9	60.0	
	Persistent severe	30.8	38.5	
ESPRINT-15 score, mean (SD)		3.4 (1.1)	3.8 (1.1)	0.0032
Morisky-Green Good compliance, %		10.2	15.8	0.2022
ACT, mean (SD)		18.0 (5.3)	18.0 (5.2)	0.9482
Medications at the beginning of study, %	OAH	51.0	55.7	>0.05
	INCS	48.0	50.8	>0.05
	MP-AzeFlu	31.5	27.0	>0.05
	OAH + INCS	56.2	59.8	>0.05

ACT, asthma control test; BMI, body mass index; HDM, house dust mites; INCS, intranasal corticosteroids; m-ARIA, modified-ARIA severity classification; RCAT: rhinitis control questionnaire, TNSS: total nasal symptoms score, ESPRINT: rhinitis quality of life questionnaire, MP-AzeFlu: azelastine + fluticasone intranasal formulation; OAH, oral H₁-antihistamines; SD, standard deviation.

Figure E1. Flow-chart of the study

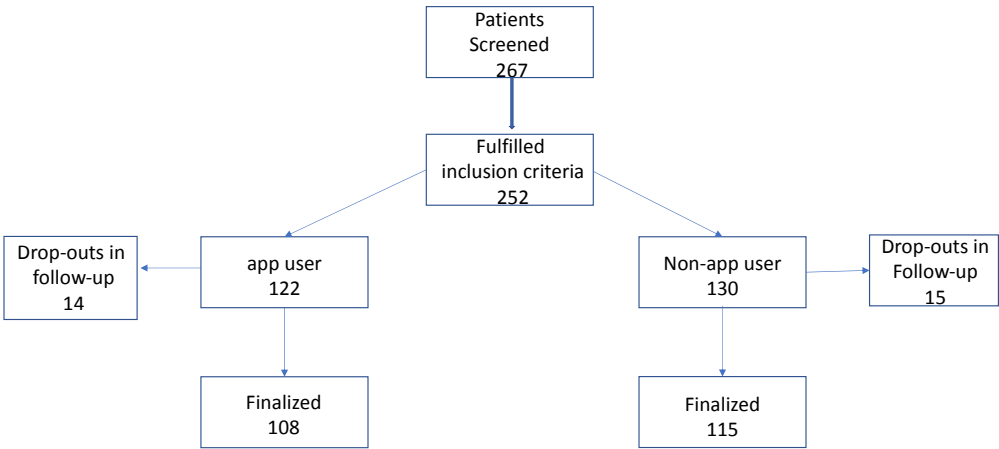


Figure E2. Correlation between Asthma Visual Analogue Scale and Asthma Control Test.

