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Original Article

Impact of allergic symptoms on work productivity in allergic rhinitis: A MASK-air direct patient data study

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ABSTRACT

Background: Allergic rhinitis may impair work productivity. This study aimed to assess (i) the differential impact of allergic rhinitis symptoms on work performance, assessed by means of Visual Analogue Scale (VAS) work; and (ii) the effect of asthma comorbidity on work productivity.

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Abbreviations:
AR, Allergic Rhinitis; ARIA, Allergic Rhinitis and its Impact on Asthma; CE, Conformité Européene; CSMS, Combined Symptom-Medication Score; GDPR, General Data Protection Regulation; IQR, Interquartile range; OECD, Organisation for Economic Cooperation and Development; SD, Standard deviation; VAS, Visual Analogue Scale; WPAI:AS, Work Productivity and Activity Impairment: Allergic Specific Questionnaire

Methods: We assessed data from the MASK-air mHealth app of patients with allergic rhinitis. We identified factors associated with the impact of allergic symptoms on work productivity through multivariable linear mixed effects models.
Results: We studied 260,378 days from 20,724 patients. In multivariable regression models, nasal symptoms showed the strongest association with VAS work (regression coefficient = 0.38 [95%CI = 0.38; 0.38]). Poor rhinitis control, measured by the combined symptom-medication score, was associated with worse VAS work (regression coefficient = 0.96 [95%CI = 0.96; 0.97]). The median VAS work in patients with probable or possible asthma (median = 9, interquartile range = 22 for probable and 23 for possible asthma) was greater than for patients with no evidence of asthma (median = 3, interquartile range = 12) (Cohen's d = 0.60). In patients with probable asthma, nasal and asthma symptoms showed a similar impact on work productivity (regression coefficient for VAS nose = 0.32 [95%CI = 0.31; 0.32]; regression coefficient for VAS asthma = 0.30 [95%CI = 0.29; 0.31]).
Conclusions: Allergy symptoms, especially nasal symptoms, are associated with worse work productivity. In addition, patients with allergic rhinitis and asthma display more impairment in work productivity than patients with allergic rhinitis alone.

Introduction

Allergic rhinitis (AR) is a highly prevalent chronic disease, affecting more than 400 million people worldwide and often presenting with comorbid conditions such as asthma.[1] Its symptoms may adversely impact quality of life[2] and daily activities, particularly academic and work performance.[3–5] In particular, previous observational studies have shown that, even despite having a low impact on absenteeism, AR has an important impact on presenteeism (i.e., productivity while working).[3] Importantly, individual AR symptoms may have a differential impact on patients. A recent systematic review has shown nasal symptoms to be the most impactful on the quality-of-life of patients with AR.[6] However, studies assessing the differential impact of specific AR symptoms on work productivity are lacking.

This gap may be addressed by studies using direct patient data, including data from mobile apps, such as MASK-air®. MASK-air® includes a daily monitoring questionnaire assessing the impact of AR and asthma by means of visual analogue scales (VASs).[7–12] One of these VASs assesses the degree to which the users' symptoms impact their work activities ("VAS work"). Previous studies based on direct patient data from MASK-air® have been published, including studies on the impact of AR on absenteeism and presenteeism,[13] as well as on the correlation between VASs measuring specific AR symptoms and VAS work.[14,15] However, these studies did not account for potential confounders or for the synergic effect of different symptoms on VAS work. Additionally, these studies did not assess the differential impact of having comorbid asthma, which has been reported as being associated with more severe forms of AR.[16,17]

In this study using MASK-air®, we aimed to assess the differential impact of specific AR symptoms (nasal, ocular, and lower respiratory symptoms) on work performance, assessed by means of VAS work. In addition, we aimed to assess the effect of asthma comorbidity on work productivity.

Methods

Study design

We performed an observational cross-sectional study based on real-world direct patient data from MASK-air®. We performed multivariable regression analyses to identify factors associated with the increased impact of allergy symptoms on work productivity. A sensitivity analysis was performed restricted to patients reporting MASK-air® data in at least three different months.

Setting and participants

MASK-air® (www.mask-air.com) is a mobile app freely available in 30 countries and downloadable on the Google Play and Apple App Stores. It is a Good Practice of the Directorate-General for Health and Food Safety (European Commission) for digitally-enabled, patient-centred care in rhinitis and asthma multimorbidity.[9,18,19] It is also a Best Practice of the Organisation for Economic Cooperation and Development (OECD) for Public Health on integrated care for chronic diseases[20,21] and has been approved by the Ukrainian[22] and Polish governments.

We included the daily monitoring data of work days from MASK-air® users aged above 15 or 16 years (depending on the age of digital consent in the country[23]) with a self-reported diagnosis of AR, from May 2015 to December 2023.

Ethics

MASK-air® is Conformité Européene (CE) registered and follows the European Union General Data Protection Regulation. An independent review board approval was not required for this specific study because (i) the use of MASK-air® secondary data has been approved by an independent review board (Köln-Bonn, Germany; reference number 17–069), (ii) all data were anonymized before the study using k-anonymity and (iii) users agreed to the analysis of their data for research purposes in the terms of use for MASK-air® (translated into all languages and customized according to the legislation of each country).

Data sources and variables

MASK-air® comprises a daily monitoring questionnaire in which users report the daily impact of asthma and AR symptoms through four 0–100 symptoms VASs (with higher scores corresponding to a higher impact) (Supplementary Table 1). In addition, when users report that they worked on that day, they are asked how much their allergic symptoms affected their work performance by means of a 0 to 100 VAS ("VAS work"; higher values indicate a higher impact). In the daily monitoring questionnaire, MASK-air® users are also asked to provide their daily medication use by means of a scroll list customized for each country. The data collected from daily symptoms and medication use allow for the computation of the ARIA-EAACI Combined Symptom-Medication Score (CSMS)[24] (Supplementary Table 2).

In addition to the daily monitoring of symptoms and medication, MASK-air® users provide clinical and demographic information

when setting up their profile. Based on this baseline information, we computed the number of reported allergy symptoms presented by each patient ("baseline symptoms score") and the number of different ways in which allergy symptoms affect users (baseline impact assessed by the ARIA score, which has previously been shown to be correlated with the EQ-5D-5L and Question 9 of the Work Productivity and Activity Impairment: Allergic Specific Questionnaire [WPAI:AS][25]). Details on the computation of the "baseline symptoms" and of the ARIA scores are available in Supplementary Table 3.

Statistical analysis

When responding to the MASK-air® daily monitoring questionnaire, it is not possible to skip any of the questions, and data are saved to the dataset only after the final answer. This precludes any missing data within each daily questionnaire.

Categorical variables were described using absolute and relative frequencies, whereas continuous variables were described using medians and interquartile ranges (IQRs).

We created multivariable mixed-effects linear regression models to assess the daily impact of ocular, nasal and asthma symptoms on work productivity (outcome variable assessed by means of VAS work), setting as random effects the identification of the user, country, and month of the year (i.e., we accounted for the clustering of multiple observations by users, country, and month of the year in which the observation occurred) and adjusting for the baseline symptoms score, the ARIA score, age, and gender. We performed an additional model replacing symptoms' VASs by the CSMS.

We performed separate analyses for patients with AR alone and patients with AR + asthma. Importantly, although MASK-air® collects data on self-reported asthma, this may be prone to information biases, especially since asthma is underdiagnosed.[26,27] Therefore, we performed descriptive analyses and built regression models according to (i) self-reported asthma status and, additionally, (ii) following a classification of MASK-air® users into those with "probable asthma", "possible asthma" or "no evidence of asthma" (i.e., AR alone).[28] This classification has been previously described – in brief, *k*-means cluster analysis methods were applied to group MASK-air® users providing data on at least three different months on their probability of having asthma based on the self-reporting of asthma, asthma medication use and VAS asthma.[28] For conjunctivitis, clusters of "probable conjunctivitis", "possible conjunctivitis" and "no evidence of conjunctivitis" have not been developed. Therefore, we only performed descriptive analyses comparing patients with and without self-reported conjunctivitis. Comparisons between asthma and conjunctivitis statuses relied on effect sizes computed based on standardized differences of medians (Cohen's *d*). We assumed that values between 0.2 and 0.5 correspond to small effect sizes (differences), values between 0.5 and 0.8 to moderate differences, and values over 0.8 to large differences.[29]

We performed our main analyses using the entire MASK-air® sample. In addition, we performed sensitivity analyses restricted to patients reporting daily monitoring data in at least three different months.[28]

All analyses were performed using R (version 4.3.2; R Core Team 2023).

Results

Characteristics of the patients

We analyzed 260,378 days from 20,724 patients (52.1 % of days reported by female patients; mean age ± SD = 39.3 ± 12.7 years) (Table 1; Supplementary Table 4 for distribution per countries), with 219,708 days reported by 6040 patients in at least three different months. Users in European countries accounted for 72.3 % of the reported days. The median VAS work was 8 (IQR = 22). The median VAS work displayed seasonality throughout the year in the Northern and Southern hemispheres (Fig. 1).

Table 1
Demographic and clinical characteristics associated with included MASK-air® observations/days and respective users.

Variable	Summary
Observations/days – *N* [*N* users]	260,378 [20,724]
Females – *N* (%)	135,574 (52.1)
Age – mean (SD)	39.3 (12.7)
European country – *N* (%)	188,209 (72.3)
Asthma – *N* (%)	
Self-reported – *N* (%)	99,756 (38.3)[†]
No evidence of asthma – *N* (%)	72,396 (33.0)[‡]
Possible asthma – *N* (%)	57,247 (26.1)[§]
Probable asthma – *N* (%)	90,056 (41.0)[¶]
Conjunctivitis	167,291 (67.0)[#]
ARIA score [‖] – median (IQR)	1.0 (3.0)
Symptoms affect sleep – *N* (%)	82,871 (33.2)
Symptoms restrict daily activities – *N* (%)	95,347 (38.2)
Symptoms restrict work/school activities – *N* (%)	72,046 (28.9)
Symptoms are troublesome – *N* (%)	147,854 (59.3)
Baseline symptoms[††] – median (IQR)	5.0 (3.0)
Rhinorrhea – *N* (%)	175,791 (70.3)
Nasal pruritus – *N* (%)	151,593 (60.6)
Sneezing – *N* (%)	186,048 (74.4)
Nasal congestion – *N* (%)	170,215 (68.1)
Red eyes – *N* (%)	106,237 (42.5)
Ocular pruritus – *N* (%)	146,130 (58.5)
Watery eyes – *N* (%)	103,645 (41.5)
CSMS – median (IQR)	9.6 (18.0)
Full control – *N* (%)	53,348 (20.5)
Good control – *N* (%)	120,483 (46.3)
Partial control – *N* (%)	36,195 (13.9)
Poor control – *N* (%)	50,350 (19.4)
VAS global – median (IQR)	
Median	11 (26)
Maximum	51 (49)
VAS eye – median (IQR)	
Median	5 (17)
Maximum	29 (53)
VAS nose – median (IQR)	
Median	12 (27)
Maximum	51 (53)
VAS asthma – median (IQR)	
Median	0 (10)
Users with a self-reported diagnosis of asthma	8 (21)
Users without a self-reported diagnosis of asthma	0 (3)
Users with no evidence of asthma	0 (0)
Users with possible asthma	2 (7)
Users with probable asthma	7 (21)
Maximum	7 (36)
Users with a self-reported diagnosis of asthma	34 (53)
Users without a self-reported diagnosis of asthma	3 (15)
Users with no evidence of asthma	2 (7)
Users with possible asthma	33 (43)
Users with probable asthma	50 (47)
VAS work – median (IQR)	
Median	8 (22)
Maximum	33 (44)

AR, Allergic Rhinitis; CSMS, Combined symptom-medication score; IQR, Interquartile Range; SCIT, Subcutaneous immunotherapy; SD, Standard deviation; SLIT, Sublingual immunotherapy; VAS, Visual Analogue Scale; WPAI + CIQ:AS, Work Productivity and Activity Impairment Questionnaire plus Classroom Impairment Questions: Allergy Specific.

[†] *N* distinct users = 6414 (30.9%); [‡] *N* distinct users = 2251 (37.3%); [§] *N* distinct users = 1746 (28.9%); [¶] *N* distinct users = 2035 (33.7%); [#] *N* distinct users = 10,534 (59.7%); no information for 3092 users. [‖] Computed based on the number of different ways in which allergy symptoms affect the users at baseline. [††] Computed based on the number of reported allergy symptoms at baseline.

Multivariable regression analyses

In the main regression model, adjusted for the baseline symptoms score, the ARIA score, age and sex, nasal symptoms showed the strongest association with VAS work (regression coefficient = 0.38 [95%CI = 0.38; 0.38]) (Table 2). Asthma and ocular symptoms showed a similar impact on VAS work (regression coefficient for VAS eye = 0.22 [95%CI = 0.22; 0.23]; regression coefficient for VAS asthma = 0.24 [95%CI = 0.25; 0.25]) (Table 3). When replacing all symptom VASs by the CSMS as an independent variable, the CSMS was also strongly associated with VAS work (regression coefficient = 0.96 [95%CI = 0.96; 0.97]) (Table 3).

Similar results were found in the multivariable models restricted to patients reporting daily monitoring data in at least three different months (Supplementary Table 5).

Work impact in patients with AR alone versus AR with comorbidities

Patients with self-reported asthma reported 99,756 days. The median VAS work for patients with a self-reported diagnosis of asthma was 9 (IQR = 22), while for those without asthma, it was 7 (IQR = 3) (Cohen's d = 0.17) (Fig. 2A). We additionally classified patients into those having “probable asthma”, “possible asthma” and “no evidence of asthma”. Patients with probable asthma reported 147,854 days (59.3 %) of MASK-air® use, compared to 72,046 (28.9 %) days for users with possible asthma, and 95,347 days (38.2 %) for patients with no evidence of asthma. The median VAS work for patients with probable asthma was 9 (IQR = 22), similar to that of patients with possible asthma (median VAS work = 9 [IQR = 23]). For patients with no evidence of asthma, the median VAS work was 3 (IQR = 12) (Cohen's d for probable/possible *vs.* no evidence of asthma = 0.60) (Fig. 2B). Similar results were found in sensitivity analyses restricted to patients reporting daily monitoring data in at least three different months (Supplementary Table 6). For patients with and without self-reported conjunctivitis, no differences in median VAS work were found (Supplementary Table 7).

In multivariable regression models restricted to patients with no evidence of asthma, nasal symptoms were found to have the greatest association with impact on work productivity (regression coefficient = 0.47 [95%CI = 0.47; 0.48]), followed by ocular symptoms (regression coefficient = 0.22 [95%CI = 0.21; 0.22]) (Table 4). In patients with possible asthma, nasal symptoms were also shown to have the strongest association with VAS work (regression coefficient = 0.37 [95%CI = 0.37; 0.38]), followed by ocular symptoms (regression coefficient = 0.25 [95%CI = 0.24; 0.26]) and asthma symptoms (regression coefficient = 0.22 [95%CI = 0.22; 0.23]). Finally, in patients with probable asthma, nasal and asthma symptoms showed a similar impact on work productivity

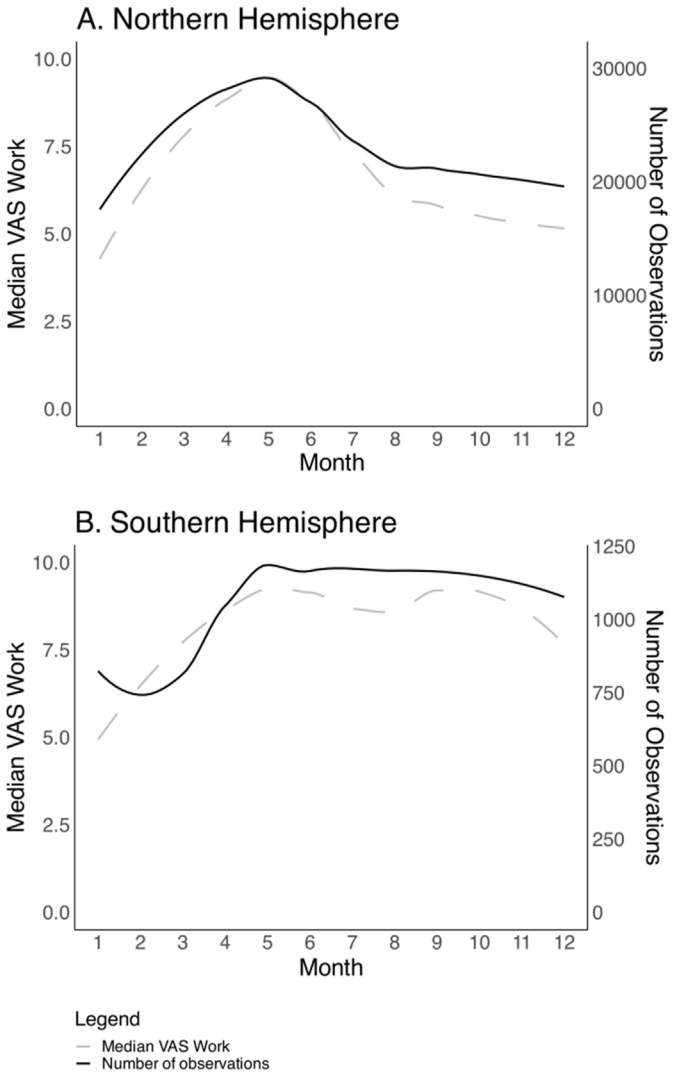

Fig. 1. Monthly median Visual Analogue Scale (VAS) work levels.

Table 2
Multivariable mixed-effects linear regression model on the association between Visual Analogue Scale (VAS) work and symptom VASs.

	Association with VAS Work		
	Regression coefficient	95 % CI	*p*-value
Baseline symptoms†	−0.31	−0.39; −0.23	<0.001
ARIA score‡	1.21	1.06; 1.36	<0.001
Male gender	−0.68	−1.03; −0.33	<0.001
Age	−0.03	−0.04; −0.01	<0.001
VAS eye	0.22	0.22; 0.23	<0.001
VAS nose	0.38	0.38; 0.38	<0.001
VAS asthma	0.24	0.24; 0.25	<0.001

This model was obtained by multilevel mixed effects linear regression. Coefficients and their 95 % confidence intervals take into account the clustering of observations by users, by countries, and by time of the year.
ARIA, Allergic Rhinitis and its Impact on Asthma; CI, Confidence Interval; VAS, Visual Analogue Scale.
† Computed based on the number of reported allergy symptoms at baseline.
‡ Computed based on the number of different ways in which allergy symptoms affect the users at baseline.

Table 3
Multivariable mixed-effects linear regression models on the association between Visual Analogue Scale (VAS) work and the Combined Symptom-Medication Score (CSMS).

	Association with VAS Work		
	Regression coefficient	95 % CI	*p*-value
Baseline symptoms†	−0.30	−0.38; −0.22	<0.001
ARIA score‡	1.11	0.97; 1.26	<0.001
Male gender	−0.25	−0.59; 0.09	0.144
Age	−0.04	−0.05; −0.03	<0.001
CSMS	0.96	0.96; 0.97	<0.001

This model was obtained by multilevel mixed effects linear regression. Coefficients and their 95 % confidence intervals take into account the clustering of observations by users, by countries, and by time of the year.
ARIA, Allergic Rhinitis and its Impact on Asthma; CI, Confidence Interval; VAS, Visual Analogue Scale.
† Computed based on the number of reported allergy symptoms at baseline.
‡ Computed based on the number of different ways in which allergy symptoms affect the users at baseline.

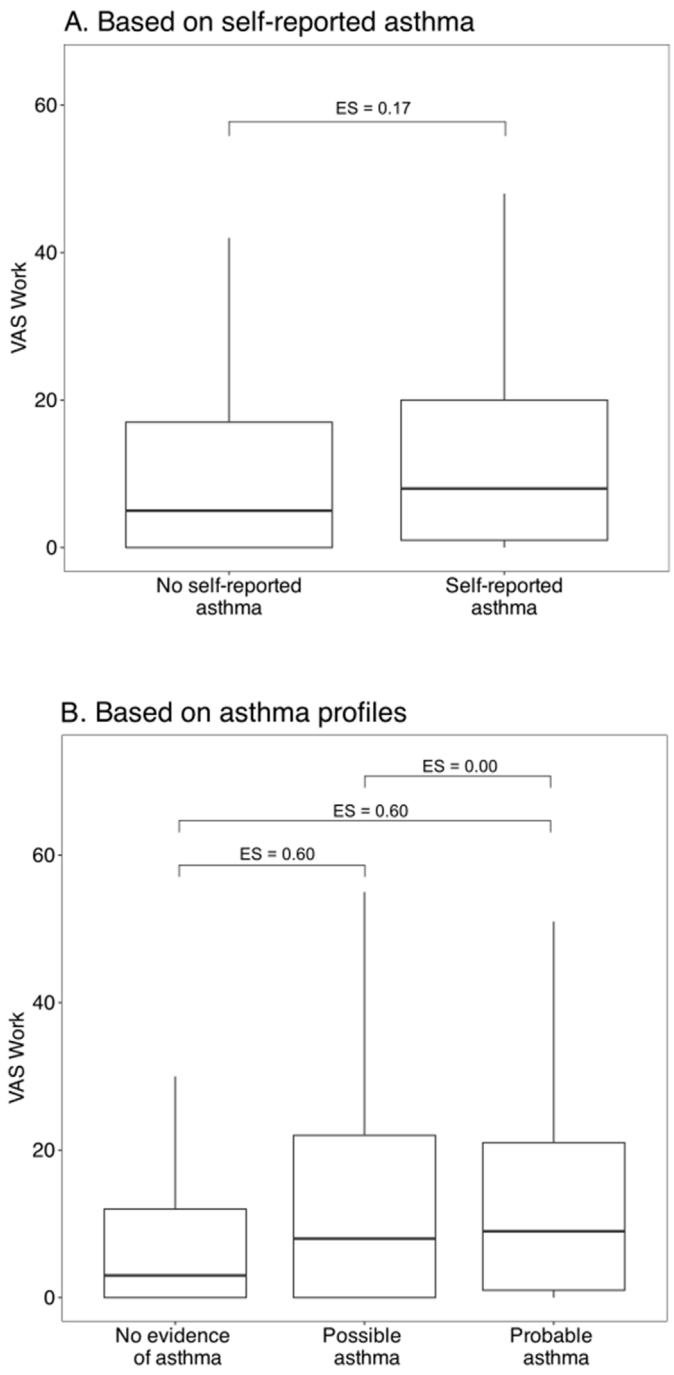

Fig. 2. Distribution of values of visual Analogue Scale (VAS) work in patients with allergic rhinitis alone versus allergic rhinitis + asthma, with asthma classified based on **(A)** self-reporting and **(B)** profiles created by k-means clustering. ES, Effect size, calculated based on Cohen's d; VAS, Visual Analogue Scale.

(regression coefficient for VAS nose = 0.32 [95%CI = 0.31; 0.32]; regression coefficient for VAS asthma = 0.30 [95%CI = 0.29; 0.31]). Similar results were found in the multivariable models restricted to patients reporting daily monitoring data in at least three different months (Supplementary Table 8).

Discussion

In this study, we assessed the impact of specific AR symptoms on work performance, as well as the effect of having comorbid asthma on work productivity. Our results indicate that (i) nasal symptoms are the main set of symptoms associated with impaired work productivity (alongside asthma symptoms in patients with AR + asthma); and (ii) the impact of AR on work productivity is greatest in patients with AR + asthma compared to AR alone.

Interpretation of the data

This MASK-air® study assessed the impact of AR on work productivity. First, we found seasonality in the impact of AR on work productivity, with a higher impact in the Spring season in the Northern and Southern hemispheres. Although we observed an overall low impact of AR on work productivity (median VAS work = 8), our results suggest that a substantial amount of individual users report occasional days with a moderate or large impact of AR on work productivity (median maximum VAS work = 33). We found nasal symptoms to have the greatest impact on work productivity, especially in patients without asthma. The impact of nasal symptoms *vis-à-vis* other symptoms had previously been recognized[3,30] in other contexts. A systematic review of the values and preferences of patients with AR had previously shown nasal symptoms to be the ones displaying the greatest impact.[6] A previous MASK-air® study had also identified nasal symptoms as those associated with the greatest impact on academic productivity.[4] In the specific context of work productivity, two previous studies had shown a strong correlation between VAS nose and VAS work.[14,15] However, these studies did not assess whether such an association would still be observed if adjusted for other allergic symptoms experienced by the patients. Importantly, in patients with probable asthma, the impact of nasal symptoms on work productivity was found to be similar to that of asthma symptoms, underscoring the importance of controlling both upper and lower respiratory symptoms in patients with AR + asthma.

We found the impact of AR on work productivity to be higher in patients with AR + asthma compared to those with AR alone. This aligns with previous results suggesting that the impact of AR on work productivity is greater in patients with comorbid AR and asthma.[31] These data also support the ARIA-MeDALL hypothesis, which postulates that AR alone and AR + asthma may be two distinct clinical entities.[16] Indeed, a previous study using direct patient data had found that patients with AR + asthma tend to display more severe ocular symptoms and report a higher frequency of AR symptoms than those with AR alone.[16,17]

Strengths and limitations

This study presents some limitations. First, there is a possibility of selection biases in mHealth studies due to an overrepresentation of younger patients, patients with more access to health care and patients who are more concerned about their health. In addition, among MASK-air® patients, less well-controlled days may tend to be more frequently reported.[32,33] However, this is less of a concern in our study because we were interested in assessing how specific AR symptoms impact work productivity rather than in providing estimates for the general population on the overall impact of AR on work productivity. Another possible concern is that of information biases, considering that, although some clinicians recommend the app to their patients, some patients in the MASK-air® app have started using the app by themselves. Due to privacy concerns, we are not able to distinguish patients who have started using the app by themselves or after diagnosis by a physician. Therefore, we rely on self-reported diagnosis of allergic rhinitis. Importantly, the reported symptoms and medication use patterns of MASK-air® users resemble those of the general population with rhinitis,[34] suggesting that most patients have rhinitis and that the impact of information

Table 4
Multivariable mixed-effects linear regression models on the association between Visual Analogue Scale (VAS) work and symptom VASs for patients with probable asthma, possible asthma, and no evidence of asthma.

	Association with VAS Work		
	Probable asthma − Coefficient (95%CI) [*p*-value]	Possible asthma − Coefficient (95%CI) [*p*-value]	No evidence of asthma − Coefficient (95%CI) [*p*-value]
Baseline symptoms[†]	−0.16 (−0.31; −0.01) [0.036]	−0.38 (−0.56; −0.20) [<0.001]	−0.19 (−0.32; −0.05) [0.006]
ARIA score[‡]	0.58 (0.33; 0.83) [<0.001]	1.04 (0.71; 1.38) [<0.001]	0.85 (0.61; 1.09) [<0.001]
Male gender	−0.90 (−1.54; −0.26) [0.006]	−1.56 (−2.35; −0.77) [<0.001]	−0.68 (−1.25; −0.12) [0.018]
Age	0.00 (−0.02; 0.02) [0.780]	−0.01 (−0.03; 0.02) [0.719]	−0.02 (−0.04; 0.01) [0.913]
VAS eye	0.21 (0.20; 0.21) [<0.001]	0.25 (0.24; 0.26) [<0.001]	0.22 (0.21; 0.22) [<0.001]
VAS nose	0.32 (0.31; 0.32) [<0.001]	0.37 (0.37; 0.38) [<0.001]	0.47 (0.47; 0.48) [<0.001]
VAS asthma	0.30 (0.29; 0.31) [<0.001]	0.22 (0.22; 0.23) [<0.001]	0.09 (0.06; 0.13) [<0.001]

These models were obtained by multilevel mixed effects linear regression, by varying the set independent variables selected. Coefficients and their 95 % confidence intervals consider the clustering of observations by users, by countries, and by month of the year.
ARIA, Allergic Rhinitis and its Impact on Asthma; CI, Confidence Interval; VAS, Visual Analogue Scale.
[†] Computed based on the number of reported allergy symptoms at baseline.
[‡] Computed based on the number of different ways in which allergy symptoms affect the users at baseline.

biases is small. In addition, we built multivariable regression models adjusting for symptom severity. Finally, although factors such as individual sensitizations and exposure to allergens may lead to different patterns of rhinitis throughout a year, we do not expect the impact of symptoms on work productivity to differ between patients with the same levels of symptoms.

This study also has important strengths. We assessed direct patient data from a large cohort of AR patients across 30 different countries, with the structure of MASK-air® precluding the existence of missing data within each daily questionnaire. MASK-air® VASs and the CSMS are both allergy-specific measures that have been validated in previous studies.[35,36] We developed multivariable mixed-effects models in which we clustered observations by patients, and adjusted for key clinical and demographic variables to reduce confounding. Our findings were consistent across various models in sensitivity analyses, underscoring the robustness of our results.

Conclusion

In patients with AR, AR-related allergy symptoms, especially nasal symptoms, were found to be associated with worse work productivity (higher VAS work). In addition, patients with AR + asthma displayed more impairment in work productivity than patients with AR alone. These findings underline the impact of the control of AR on the impairment of work productivity. These findings can inform policy makers on the importance of effective AR management in improving work productivity and reducing associated costs. Furthermore, these results support the feasibility of mHealth studies and underscore the value of digital health tools in assessing the impact of AR on work and enabling continuous monitoring.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.alit.2024.12.007.

Conflict of interest

JB reports personal fees from Cipla, Menarini, Mylan, Novartis, Purina, Sanofi, Teva, Uriach, other from KYomed-Innov, other from Mask-air-SAS. STS reports personal fees from AstraZeneca, personal fees from ALK-Abelló, personal fees from GSK, personal fees from Sanofi, personal fees from Clario, personal fees from Orion Pharma, grants from GSK, grants from Sanofi. OP reports grants and/or personal fees and/or travel support from ALK-Abelló, Allergopharma, Stallergenes Greer, HAL Allergy, Bencard Allergie, Leti, GlaxoSmithKline, ROXALL Medizin, Novartis, Sanofi, Med Update Europe, streamedup! Pohl-Boskamp, Inmunotek, John Wiley and Sons/AS, Paul-Martini-Stiftung (PMS), Regeneron., RG Aerztefortbildung, Institut für Disease Management, Springer, AstraZeneca, IQVIA Commercial, Ingress Health, Wort&Bild Verlag, Verlag ME, Procter&Gamble, Altamira, Meinhardt Congress, Deutsche Forschungsgemeinschaft, Thieme, Deutsche AllergieLiga e.V., AeDA, Alfried-Krupp Krankenhaus, Red Maple Trials, Königlich Dänisches Generalkonsulat, Medizinische Hochschule Hannover, Expro&Conference Management, Technical University Dresden, Lilly, Japanese Society of Allergology, Forum für Medizinische Fortbildung, Dustri-Verlag, Pneumolive, ASIT Biotech, Lofarma, Almirall, Paul-Ehrlich-Institut, outside the submitted work; and he is Vice President of the EAACI and member of EAACI Excom, member of ext. board of directors DGAKI;

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Authors' contributions

RJV designed the study, performed the statistical analysis and interpretation of the results, and wrote the manuscript. LFA, JAF, JB and BSP designed the study, interpreted the results, and critically reviewed the manuscript. All other authors contributed to data collection and critically reviewed the manuscript. All authors read and approved the final manuscript.

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