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Rediscovering Allergic Rhinitis: The Use of a Novel mHealth Solution to Describe and Monitor Health-Related Quality of Life in Elderly Patients

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Keywords
Allergic rhinitis · Allergic diseases · mHealth · Quality of life · Old age

Abstract
Introduction: Allergic rhinitis (AR) is a disease characterized by IgE-mediated hypersensitivity responses akin to allergic asthma. Although common in children and young adults, AR can be particularly vexing in the elderly: several studies have underlined its impact on the patient's self-perceived health-related quality of life (HR-QoL). Available literature data on AR-affected elderly patients remain sparse and often focused on specific characteristics. mHealth solutions such as MASK-air® can be used in assessing salient clinical characteristics and unique shifts in self-perceived HR-QoL in old age people. With this pilot study, we aim to assess these variables in two cohorts of AR-affected elderly patients – one actively involved in the daily use of mHealth applications and the other having never used such a solution – by applying a widespread, validated, and standardized tool. ***Methods:*** AR-affected patients aged ≥65 years accessing the outpatient clinic of the Bari Geriatric Immuno-allergology Unit between March and July 2021 were enrolled and assigned to "mHealth" (MASK-air®) and "non-mHealth" cohorts accordingly. Each participant was given a 19-item questionnaire delivered via a custom software solution, with the EuroQoL EQ-5D-5L used to assess HR-QoL. ***Results:*** 93 patients (51 mHealth users, 43 non-mHealth users) were enrolled. AR was often either standalone or associated with asthma and conjunctivitis, and 57.4% of the participants reported a negative influence of AR on daily activities. Analysis of HR-QoL showed significantly worse scores in mobility and anxiety/depression dimensions for female patients regardless of app usage, while male non-mHealth users had worse self-care scores. Female mHealth users had worse scores for the self-care and activity dimensions, whereas female non-mHealth users showed worse scores on the pain scale. In general, mHealth

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users showed a greater degree of anxiety/depression when compared to non-mHealth users, relating to a greater awareness of their health status. ***Conclusion:*** The use of an mHealth solution, along with a concise, clinically-validated, comprehensive HR-QoL assessment toolset such as the EQ-5D, can prove beneficial in defining the unique characteristics of AR in the elderly. It can enable a detailed exploration of the impact on specific aspects of quality of life in old age. Raising patient awareness towards a health condition can improve compliance to treatment as well as follow-up. A lack of uniformity in approach, along with missing data pertaining to the general population are critical issues that require further studies. A more thorough diffusion of mHealth usage is also necessary among the geriatric population.

Background

Allergic rhinitis (AR) is an inflammation of the nasal mucosae triggered by exposure to airborne allergens characterized by IgE-mediated hypersensitivity responses. It is common in old age people [1], with a current and increasing prevalence of between 13 and 15% [2]. In this age group, symptoms include nasal congestion, rhinorrhoea, itching, and persistent sneezing, with crusting of the nasal mucosa and anosmia [3]. In the elderly, AR presents specific features owing to the anatomical and physiological changes induced by ageing (e.g., mucosal atrophy, impaired mucociliary clearance, and nasal obstruction). These are often synergic with the altered immune function and susceptibility to infectious diseases of the elderly, therefore contributing to the overall phenomenon of *inflammaging* [4].

Several studies have underlined the severe impact of AR on the patient's self-perceived health-related quality of life (HR-QoL), with affected individuals reporting an impairment of their physical capabilities and social functioning, sleep disturbances, fatigue, mood swings, and a lower academic and workplace performance [5]. However, data on quality of life in AR-affected elderly patients remain sparse and often focused on specific characteristics such as disease-related sleep disturbances, whereas it is safe to assume the AR-mediated impairment of HR-QoL to be much greater and far-reaching.

A possible solution to these issues can be offered by novel digital technologies, particularly those involving smart devices (collectively known as *mobile health* or mHealth). mHealth apps are characterized by their ease of use and an on-the-fly adaptability of the toolset with the increased adoption rate of smartphones by elderly people. mHealth can be used to methodically gather data across a large number of clinical variables and over prolonged periods of time. An added benefit is the high granularity of the information collected, defining the patient's health status and personal needs with extreme precision. The MASK-air® application [6, 7], a good practice of DG Santé on digitally enabled, patient-centred care, is one such digital toolset. It has been used since 2017 by our Centre to enable a patient-centred approach to asthma and AR. Patient-reported data regarding disease type, severity, and impact on everyday life have been used to tailor and improve the treatment regimen catering to each subject's specific needs and expectations [8]. Previous studies have validated the usage of MASK-air® in patients affected by AR, providing novel insights into aspects such as adherence to treatment and efficacy of continuous versus on-demand medication, as well as a real-world perspective on disease management [9]. With this pilot study, we aim to assess salient characteristics and self-perceived HR-QoL in two cohorts of AR-affected elderly patients – one actively involved in the daily use of mHealth applications (MASK-air®) and the other having never used such a solution – by applying a widespread and standardized tool already used in digital health platforms and toolsets.

Methods

Study Design

A cross-sectional observational study was carried out, assessing demographic and clinical variables, symptomatologic burden, and HR-QoL in the elderly.

Setting and Participants

All consecutive patients accessing the outpatient clinic of the University of Bari Geriatric Immuno-allergology Unit between March and July 2021 were assessed for eligibility. Inclusion criteria were (i) age of between 65 and 90 years, (ii) diagnosis of AR made by a specialist according to the current ARIA/BSACI criteria [10, 11], (iii) for the "mHealth" cohort only, active usage of the MASK-air® application. Exclusion criteria were (i) inadequate computer literacy, (ii) cognitive impairment defined as a Mini-Mental State Examination score >24, (iii) explicit refusal by the patient, or (iv) an incomplete workup of the disease. AR was diagnosed according to the patient's clinical history and presentation, positivity to skin prick tests and/or serum IgE testing as well as its concordance with the chronologic pattern of symptoms. All patients enrolled in the "mHealth" cohort had been trained in using the MASK-air® application by a physician or a nurse and/or had attended one of the brief practical workshops held twice a month at our centre by young and specially trained physicians [8].

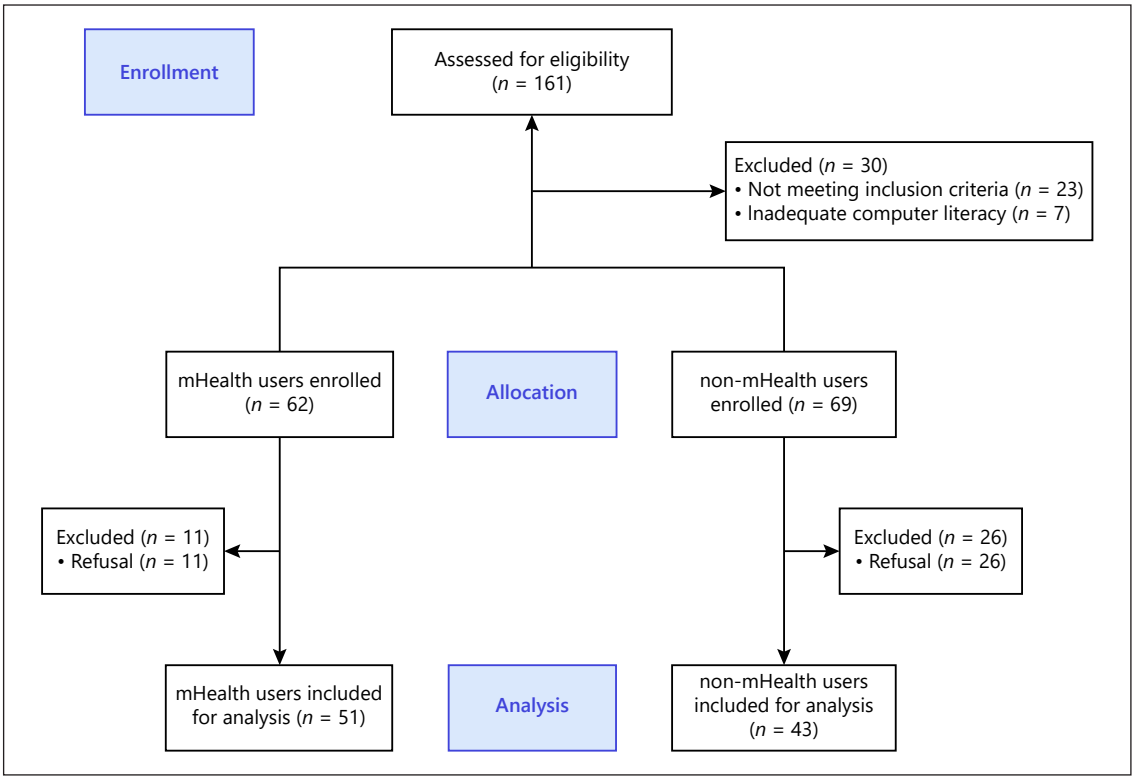

Fig. 1. CONSORT flowchart for the participants' enrolment.

Ethics

Written informed consent was obtained from each patient before enrolment, in adherence with the Declaration of Helsinki. No personally identifiable information was recorded in the study database. The study was approved by the Independent Ethics Committee of the Policlinico Hospital – University of Bari (protocol no. 707891).

Outcomes

Enrolled patients were asked to complete a questionnaire delivered via a tablet running a locally installed instance of the LimeSurvey open-source survey tool version 3.27.20 (LimeSurvey GmbH, Hamburg, Germany). Questions were divided into two sections: (i) assessment of demographic and clinical characteristics, (ii) assessment of HR-QoL.

In section 1, each participant was asked to specify age, sex, occupation, education level, allergic disease comorbidities, allergen sensitization, and usage of allergen immunotherapy. Patients were presented with the CARAT questionnaire, a set of ten questions pertaining to asthma and AR-related symptoms as well as their clinical impact over the last 30 days. Overall scores as well as subscores for asthma and rhinitis were used to weight overall disease burden as well as disease control [12]. The CARAT questionnaire was chosen due to its brevity and widespread use. Furthermore, it is already integrated into MASK-air©, thus improving data homogeneity between the study cohorts [13]. The participants' education level was stratified according to the 2011 revision of the International Standard Classification of Education [14].

HR-QoL was studied via the EuroQoL EQ-5D, a family of generic, standardized tools designed to describe and assess the self-perceived HR-QoL. Each toolset uses a set of five questions (or dimensions) evaluating mobility, self-care, daily activities, pain/discomfort, anxiety/depression plus a visual analogue scale. Two versions are available, with three and five possible answers (levels) per dimension, plus a third variation aimed at younger patients. For this study, we chose the five-item version (EQ-5D-5L) for its granularity in assessment while retaining its core brevity and simplicity. Each level is assigned a score ranging from 1 (no problems) to 5 (extremely significant problems). It is used to derive the population-specific social index value, a single-digit summary number ranging from 1 (perfect health) to 0 (worst possible health state), correlating the raw results obtained from the tool with the preferences of the general reference population [15]. The test results of our study cohorts have been analysed using instructions publicly provided by the EuroQoL Foundation [16]. Of note, there are currently no published valuation studies providing standard or "crosswalk" value sets for the Italian population, hence the social index score could not be calculated.

Data Analysis

Questionnaire results were processed using Microsoft™ Excel™ 365, and statistical calculations and tests were performed us-

Table 1. Demographic and clinical characteristics of the patients

	mHealth	Non-mHealth	Total
Enrolled patients			
n	51	43	94
Age*			
Range	66–93 (71.62±4.65)	67–89 (73.83±4.45)	66–93 (72.63±4.67)
Sex			
M/F	23/28	22/21	45/49
Education level **			
Primary or none	22 (43.1)	20 (46.51)	42 (44.7)
Lower secondary	10 (19.6)	9 (20.93)	19 (20.2)
Upper secondary	15 (29.41)	9 (20.93)	24 (25.5)
Bachelor's or equivalent	4 (7.84)	5 (11.62)	9 (9.6)
Comorbidities **			
None	25 (49.01)	20 (46.51)	45 (47.87)
Asthma	4 (7.84)	4 (9.3)	8 (8.51)
Conjunctivitis	9 (17.64)	11 (25.58)	20 (21.27)
Atopic dermatitis	1 (1.96)	1 (2.32)	2 (2.12)
Asthma + conjunctivitis	12 (23.52)	7 (41.86)	30 (31.91)
Sensitizations**			
Dust mite	16 (31.4)	17 (39.5)	33 (35.1)
Hazel	1 (2)	1 (2.3)	2 (2.1)
Grass	25 (49)	23 (53.5)	48 (51.1)
Cypress	21 (41.2)	20 (46.5)	41 (43.6)
Birch	1 (2)	2 (4.7)	3 (3.2)
Olive tree	17 (33.3)	17 (39.5)	34 (36.2)
Parietary	17 (33.3)	14 (32.6)	31 (33.0)
Ambrosia	1 (2)	0 (0)	1 (1.1)
Cat	3 (5.9)	2 (4.7)	5 (5.3)
Dog	4 (7.8)	3 (7.0)	7 (7.4)
Other(s)	4 (7.8)	3 (7.0)	7 (7.4)
Co-sensitivities**			
1	21 (41.2)	16 (37.2)	37 (39.4)
2	15 (29.4)	13 (30.2)	28 (29.8)
3	5 (9.8)	3 (7.0)	8 (8.5)
4	7 (13.7)	5 (11.6)	12 (12.8)
5	2 (3.9)	5 (11.6)	7 (7.4)
6	1 (2.0)	1 (2.3)	2 (2.1)
Work up**			
SPTs	38 (74.5)	32 (74.4)	70 (74.5)
RAST	2 (3.9)	1 (2.3)	3 (3.2)
Both	11 (21.6)	10 (23.3)	21 (22.3)
Allergen immunotherapy**			
Yes	24 (47.06)	21 (48.8)	45 (47.9)
No	27 (52.94)	22 (51.2)	49 (52.1)

SPTs, skin prick tests; RAST, radioallergosorbent test. * Mean ± SD; ** *n* (%).

ing EZR™ version 1.52 [17]. A copy of the patient's questionnaire is included in Online supplementary 1 (for all online suppl. material, see www.karger.com/doi/10.1159/000525595). The distribution of each variable in the dataset was tested for normality using the Shapiro-Wilk test, the results of which dictated the use of non-parametric tests ($p < 0.05$ in all cases). Where applicable, the Holm-Bonferroni method was used to account for multiplicity.

Results

Demographic Characteristics

A total of 161 subjects were assessed. 131 patients (62 mHealth users, 69 non-mHealth users) were eligible for enrolment: 94 of them agreed to take the questionnaire

Table 2. Frequency distribution for the answers to part 1 of the questionnaire pertaining to the evaluation of symptoms, drug usage, and disease burden of AR and associated comorbidities

Question	Answer	mHealth user?		*p* value
		yes, *n* (%)	no, *n* (%)	
How does allergic rhinitis influence your daily life?				
I have trouble sleeping	Yes	17 (39.5)	25 (49.0)	0.409
	No	26 (60.5)	26 (51.0)	
I feel limited in my day-to-day activities	Yes	25 (58.1)	29 (56.9)	1,000
	No	18 (41.9)	22 (43.1)	
I have trouble reading/working/tending to complex activities	Yes	13 (30.2)	13 (25.5)	0.649
	No	30 (69.8)	38 (74.5)	
I think my disease is severe	Yes	10 (23.3)	18 (35.3)	0.260
	No	33 (76.7)	33 (64.7)	
Due to your allergic rhinitis (and other allergic diseases), how often in the last 4 weeks did these symptoms occur?				
Nasal congestion	Never	27 (62.8)	30 (58.8)	0.919
	1–2 days a week	6 (14.0)	10 (19.6)	
	More than 2 days a week	7 (16.3)	7 (13.7)	
	Almost daily	3 (7.0)	4 (7.8)	
Sneezing	Never	30 (69.8)	28 (54.9)	0.512
	1–2 days a week	9 (20.9)	17 (33.3)	
	More than 2 days a week	1 (2.3)	2 (3.9)	
	Almost daily	3 (7.0)	4 (7.8)	
Itchy nose	Never	30 (69.8)	31 (60.8)	0.578
	1–2 days a week	12 (27.9)	15 (29.4)	
	More than 2 days a week	1 (2.3)	3 (5.9)	
	Almost daily	0 (0.0)	2 (3.9)	
Running nose	Never	26 (60.5)	27 (52.9)	0.806
	1–2 days a week	8 (18.6)	11 (21.6)	
	More than 2 days a week	7 (16.3)	8 (15.7)	
	Almost daily	2 (4.7)	5 (9.8)	
Shortness of breath	Never	29 (67.4)	32 (62.7)	0.769
	1–2 days a week	7 (16.3)	12 (23.5)	
	More than 2 days a week	5 (11.6)	4 (7.8)	
	Almost daily	2 (4.7)	3 (5.9)	
Wheezing	Never	34 (79.1)	41 (80.4)	1,000
	1–2 days a week	3 (7.0)	4 (7.8)	
	More than 2 days a week	5 (11.6)	5 (9.8)	
	Almost daily	1 (2.3%)	1 (2.0)	
Chest pain during physical exertion	Never	39 (90.7)	44 (86.3)	0.350
	1–2 days a week	4 (9.3)	4 (7.8)	
	More than 2 days a week	0 (0.0)	3 (5.9)	
Fatigue	Never	33 (76.7)	37 (72.5)	0.968
	1–2 days a week	6 (14.0)	7 (13.7)	
	More than 2 days a week	4 (9.3)	6 (11.8)	
	Almost daily	0 (0.0)	1 (2.0)	
Nocturnal awakenings	Never	32 (74.4)	40 (78.4)	0.901
	1–2 days a week	7 (16.3)	6 (11.8)	
	More than 2 days a week	4 (9.3)	4 (7.8)	
	Almost daily	0 (0.0)	1 (2.0)	

Table 2 (continued)

Question	Answer	mHealth user?		*p* value
		yes, *n* (%)	no, *n* (%)	
Due to your allergic rhinitis (and other allergic diseases), for how long in the last 4 weeks did you need to increase usage of your prescription drugs?				
	I don't currently take any prescription drugs	7 (16.3)	8 (17.6)	0.190
	Never	1 (2.3)	2 (3.9)	
	Less than a week	0 (0.0)	1 (2.0)	
	More than a week	1 (2.3)	8 (15.7)	

Data compared using Fisher's exact test.

and were thus included in the study (Fig. 1). Of the 51 enrolled mHealth users (out of 62 – 82.25%), 23 were males, with a mean age of 71.62 ± 4.65 years. 43 patients (out of 69–62.31%) were enrolled in the non-mHealth cohort, 22 of them males, with a mean age of 73.83 ± 4.45 years.

Global Results

International Standard Classification of Education 0 or 1 were the most common education levels in both cohorts, with a slightly higher prevalence in the non-mHealth group. Of note, nearly half of the patients suffered from rhinitis alone, while the association of AR, asthma, and conjunctivitis was particularly common (31.91% of the participants). Patients were more often sensitized against a single (39.4%) or two (29.8%) allergens, with dust mites, grass, cypress, olive tree, and *Parietaria* pollen being the more common ones. Roughly half of the patients enrolled in each cohort had either undergone or were currently undergoing allergen immunotherapy (47.6% and 48.8%, respectively). A full description of the demographic and clinical characteristics of the study cohorts is provided in Table 1.

Assessment of the self-reported clinical characteristics of the study population showed that 54 patients (57.4%) reported a negative influence of AR in their day-to-day activities, albeit not enough to limit their capability to perform mentally or physically demanding tasks. Furthermore, only 28 patients (29.8%) considered their disease as "severe." With regards to AR and other related comorbidities, 13 patients (13.9%) reported the need to increase their daily medication dosage to varying degrees, whereas 78 participants (82.9%) did not take any medication at all. Mean CARAT scores were suggestive of adequate disease control in both the mHealth (25.23 ± 5.25) and non-mHealth (26.16 ± 4.12) cohorts.

The Mann-Whitney U test and Fisher's exact test showed no statistically significant differences between mHealth and non-mHealth users in CARAT scores and questionnaire answers, respectively. Therefore, for further analysis, we considered disease burden to be similar in both study cohorts. A complete data summary is presented in Table 2.

Health-Related Quality of Life

Differences in EQ-5D-5L scores (Fig. 2) were investigated using the Mann-Whitney U test. No statistically significant differences were found between mHealth and non-mHealth users, except for the anxiety/depression dimension where worse scores (W 828.5; $p = 0.018$) were reported in the mHealth cohort (Table 3 and Fig. 3). With regards to gender-specific differences, females within both cohorts had worse scores in mobility (mHealth: W 424.5; $p = 0.035$ – non-mHealth: W 324.5; $p = 0.015$) and anxiety/depression (mHealth: W 437; $p = 0.016$ – non-mHealth: W 305; $p = 0.018$) scales, as well as in visual analogue scale (mHealth: W 216; $p = 0.039$ – non-mHealth: W 129.5; $p = 0.013$). On the other hand, a correlation between female sex and worse scores for the self-care (W 436; $p = 0.017$) and activity (W 425.5; $p = 0.028$) dimensions was found in the mHealth cohort only, while female non-mHealth users had significantly worse pain scores (W 323; $p = 0.014$). In assessing gender differences between the two cohorts, male non-mHealth users had worse self-care scores (W 340; $p = 0.027$), while no statistically significant differences were found in females (Table 4). A Spearman's rank-order correlation was run to study the effect of age on EQ-5D-5L scores in the study

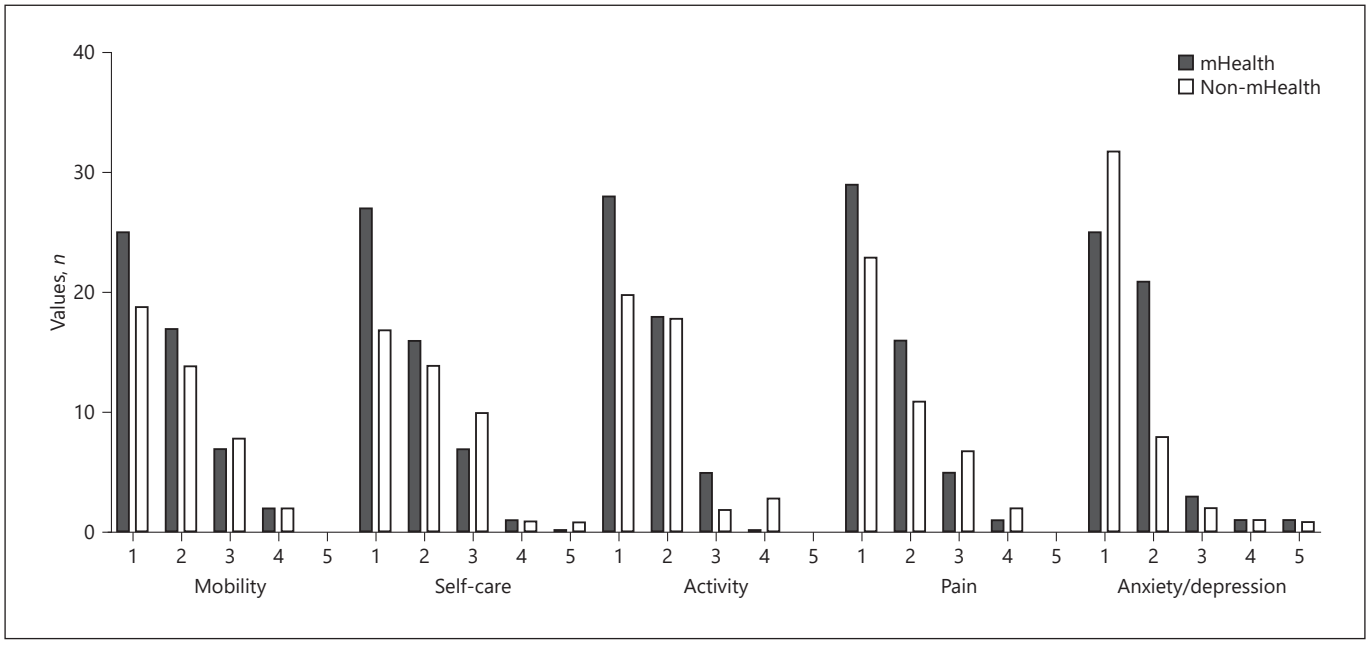

Fig. 2. Frequency distribution of EQ-5D-5L scores in the study cohorts.

Table 3. Comparison of EQ-5D-5L scores in the study cohorts using the Mann-Whitney U test

	Mobility	Self-care	Activity	Pain	Anxiety/depression	VAS
mHealth	2	1	1	1	2	72.5
non-mHealth	2	2	2	1	1	77.5
W	1,170.5	1,286	1,196	1,174	828.5	1,058.5
p value	0.547	0.122	0.404	0.515	0.018*	0.772

Data presented as median. VAS, visual analogue scale. * Denotes a statistically significant difference.

population: a strong, positive correlation was found between increasing age and worse scores in the self-care dimension (ρ 0.293; $p = 0.004$). While an analogous correlation was found between age and activity scores, its statistical significance is dubious (ρ 0.201; $p = 0.052$).

Discussion

The impact of AR on the overall physical and mental well-being of patients is a component of disease burden that clinicians should consider when defining a suitable treatment strategy. Affected subjects describe AR as having a drastic impact on their life, with a direct relationship between disease severity and the degree of HR-QoL impairment [18]. The underlying aetiology of rhinitis, whether allergic or non-allergic, does not seem to play a role in the aforementioned effects [19]. AR in the geriatric population can pose a significant challenge, owing to key differences in clinical presentation, overall clinical characteristics as well as these patients' specific needs and expectations. Albeit of a lower prevalence in elderly patients when compared to younger age groups, AR tends to be under-diagnosed and under-treated. Key symptoms such as rhinorrhea [2] and conjunctivitis [20] are often misinterpreted as pointing to respiratory infections, autonomously treated by the patient on an on-demand basis by using over-the-counter medications or simply ignored al-

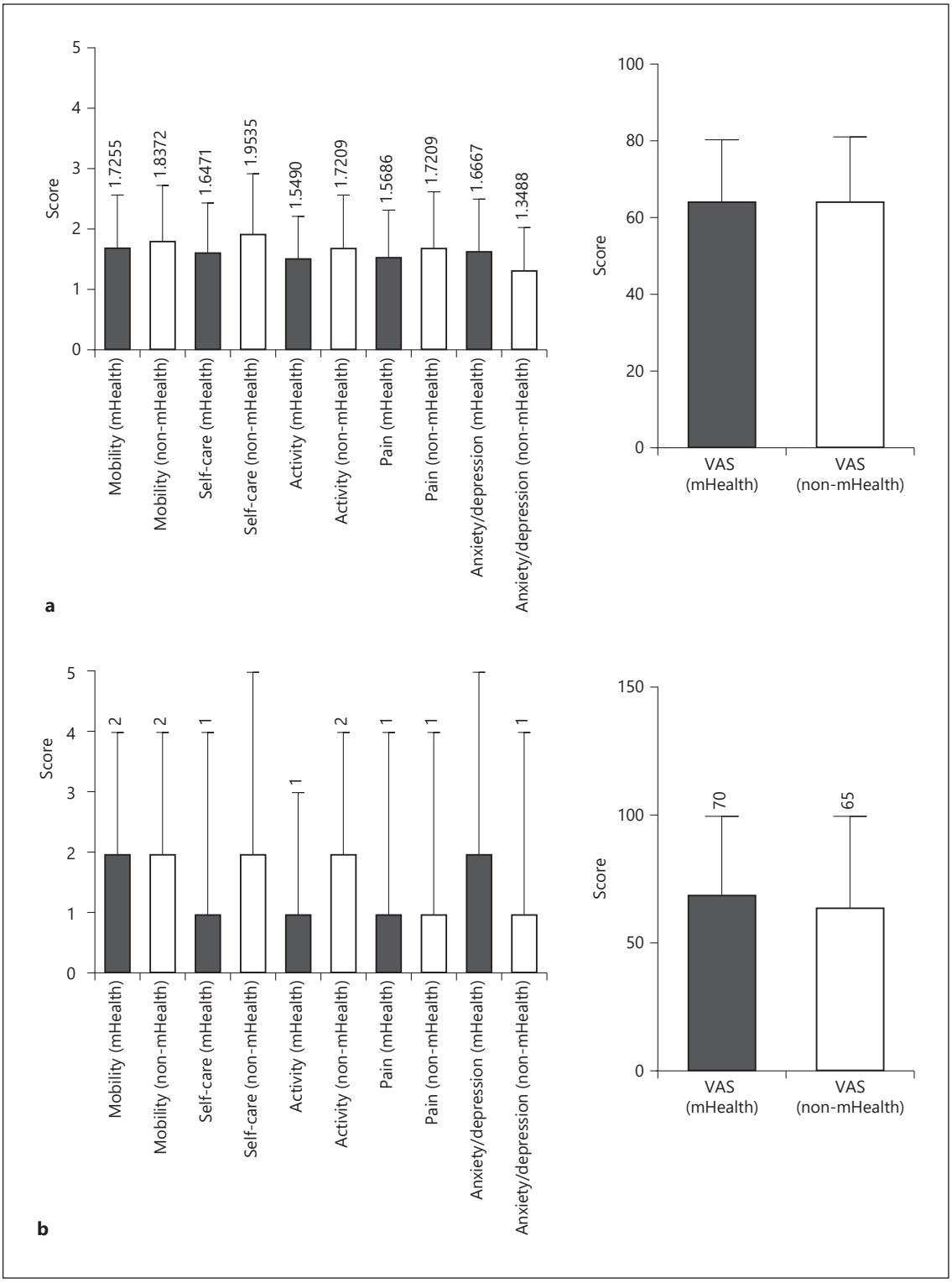

Fig. 3. Comparison of EQ-5D-5L scores between the MASK and non-MASK cohorts. **a** mean ± SD; **b** median + range.

Table 4. Comparison of EQ-5D-5L scores relative to gender in the study cohorts using the Mann-Whitney U test

	Mobility	Self-care	Activity	Pain	Anxiety/depression	VAS
mHealth						
Males	2	2	1	2	1	70
Females	2.25	2.25	2	2	2	67.5
W	424.5	436	425.5	395	437	216
p value	0.035*	0.017*	0.028*	0.121	0.016*	0.039*
Non-mHealth						
Males	1	2	1	1	1	70
Females	2	2	2	2	1	60
W	324.5	237	284	323	305	129.5
p value	0.015*	0.887	0.160	0.014*	0.018*	0.013*
mHealth versus non-mHealth (males)						
mHealth	1	1	1	1	1	70
Non-mHealth	1	2	1	1	1	70
W	266.5	340.5	294.5	249.5	192	253
p value	0.731	0.027*	0.270	0.933	0.057	1
mHealth versus non-mHealth (females)						
mHealth	2	2	2	1.5	2	67.5
Non-mHealth	2	2	2	2	1	60
W	337.5	303.5	315	348	224.5	255
p value	0.360	0.847	0.655	0.249	0.128	0.424

Data presented as median. VAS, visual analogue scale. * Denotes a statistically significant difference.

together [3]. The geriatric patient is further characterized by frailty, polypharmacy, and the psychological burden of chronic illness, often directly impacting compliance to treatment and loss to follow-up. This may lead to a vicious circle of uncontrolled disease. The clinician's attention should be focused on the weight that dimensions have on quality of life in different age groups. An individual's ability to carry out physical tasks and to take part in social responsibilities was found to be an important factor contributing to HR-QoL in old age, whereas, in younger patients, there is a greater emphasis and impact on professional and academic performance [21, 22].

The results of this pilot study aim to better understand how AR influences HR-QoL in elderly patients, defining its impact on all aspects of quality of life, and examining the influence of specific needs and non-allergic comorbidities. Patients in both cohorts did report AR as a burden to their daily activities yet did not consider their disease to be "severe" and did not describe any significant symptoms or sleep-related disturbances. Furthermore, most of them did not report usage of on-demand medication during the study timeframe, and those under treatment did not need to increase their dosage. This seems to contrast with the work of Shats in an American cohort of AR-affected patients, as most participants evaluated their disease as "severe" [23]. A plausible explanation lies in the widespread use of face masks dictated by the ongoing SARS-CoV-2 pandemic. Data published by Droor, Eisenbach, Marshak et al. [24] have shown how the usage of high-filtration face masks can significantly reduce symptomatologic burden in AR. The frequent association of AR with asthma and conjunctivitis is a notable result, confirming the known connection between different Th2-related allergic diseases known as the "atopic march" [25]. While a higher prevalence of AR is seen in females, key differences in how gender and mHealth usage affect HR-QoL in these patients emerged upon the analysis of EQ-5D scores. In females, mobility, anxiety, and overall health self-perception were impacted the most, regardless of mHealth usage, whereas MASK-air®users totalled worse scores in the dimensions pertaining to self-care and daily activity. Notably, the opposite was true for the pain descriptor, whose scores were worse in female non-mHealth users. Such findings can either be related to non-allergic comorbidities contributing to the patients' answers or to a more detailed breakdown of HR-QoL impairment by mHealth literate patients, consequent to an increased awareness of their health status, versus an otherwise more generic definition of "pain." The direct relationship between age and impairment in self-care capabilities and activity matches the findings of a previous study by our group, in which elderly participants had a

lower score in the Rhinasthma Questionnaire when compared to younger patients [26].

The strength of our approach to patient evaluation and follow-up is twofold. Multiple studies have assessed the impact of AR on HR-QoL using disease-specific toolsets, such as the Rhinosinusitis Disability Index [27], the Rhinoconjunctivitis Quality of Life Questionnaire, and the Rhinasthma Questionnaire. Despite their coherence, widespread use, and clinical validation, the results obtained via these toolsets cannot be directly compared with each other. Furthermore, these questionnaires are often focused on specific AR-correlated HR-QoL dimensions versus the EQ-5D-5L's more global evaluation of the patient. In the same vein, general-scope HR-QoL toolsets such as the Short-Form 36 and 15D questionnaires are available and also widely used in assessing AR [28]. However, a high number of items could reduce patient compliance, especially in the geriatric population and particularly with long-term use. The EQ-5D-5L has shown to be ideal in this context, due to its robustness and brevity: the average completion time for the questionnaire was approximately 7 min in the mHealth cohort and 11 min in non-mHealth literate subjects. It should be noted that the usage of an mHealth solution can be helpful in improving patient compliance and adherence to treatment: there was a significantly greater participation in the study among MASK-air® users than among mHealth-naïve patients.

Several critical issues remain. While the data collected contribute to a unique perspective of AR in the elderly, the sample size is relatively small. The specific timeframe of the study along with the usage of face masks does not enable a proper account of the full effect of fluctuations in disease burden during different times of the year, acting as a confounding factor in the evaluation of symptoms. Comorbidities represent another possible bias in correctly interpreting EQ-5D results: as the elderly patient is often aggravated by multiple concurrent diseases, their effects on HR-QoL might conceal the specific contribution of AR or even counterbalance them. A possible solution to this issue is represented by the inclusion of an appropriate stratification parameter, such as the Charlson Comorbidity Index [29].

On the other hand, the role of mHealth in the assessment of AR, although of proven efficacy, is limited by its dependency on adequate cognitive performance and particularly on continued usage by the patient. There is no clear solution to these issues, taking into account how cognitive impairment is itself an effect of AR [22]. However, they can be remedied by proper training and a patient-centred approach [8]. Furthermore, the lack of a control group limits the potency of the EQ-5D-5L toolset: as the specific weight of each dimension in determining the overall self-perceived health status (and subsequently each specific social index value) depends on the unique characteristics of each population, a quantitative measure of the decline of HR-QoL in disease-affected subjects depends on the future availability of the said data or a "crosswalk" matrix.

Conclusion

All data considered, the use of an mHealth solution such as MASK-air®, along with a concise, clinically validated, comprehensive HR-QoL assessment toolset such as the EuroQoL 5D, can prove beneficial in defining the unique characteristics of AR in the elderly patient: it can pinpoint the peculiarities in presentation, disease progression, and correlation with other comorbidities, as well as explore in detail its impact on specific aspects of quality of life as perceived in old age. The modular nature of MASK-air® along with the shift in paradigm towards a patient-centred approach can be beneficial in raising patient awareness towards his/her health condition. It can strengthen the doctor-patient relationship and improve compliance to treatment and follow-up while gathering real-world data to tailor the clinician's approach and the very toolset used in a swift and effective manner. A lack of uniformity in the approach, along with missing data pertaining to the general population are critical issues that require further studies. A more thorough diffusion of mHealth usage among the geriatric population is also necessary, a task that has already been proven to be viable and fruitful.

Statement of Ethics

Written informed consent was obtained from each patient before enrolment, in adherence with the Declaration of Helsinki. No personally identifiable information was recorded in the study database. The study was approved by the Independent Ethics Committee of the Policlinico Hospital – University of Bari (protocol no. 707891).

Conflict of Interest Statement

Professor Jean Bousquet declares membership in advisory boards, consultations, and/or honoraria for meeting lectures for Chiesi, Cipla, Hikma, Menarini, Mundipharma, Mylan, Novartis, Sanofi-Aventis, Takeda, Teva, and Uriach, as well as shares in Kyomed. None of the other authors have any conflicts of interest to declare.

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Author Contributions

Antonio Francesco Maria Giuliano: conceptualization, methodology, investigation, software, data curation, and writing – original draft. Rosalba Buquicchio, Vincenzo Patella, Anna Bedbrook, and Gianenrico Senna: writing – review and editing. Jean Bousquet: supervision, validation, and writing – review and editing. Maria Teresa Ventura: conceptualization, project administration, investigation, and writing – original draft. Antonio Francesco Maria Giuliano and Maria Teresa Ventura contributed equally to this manuscript.

Data Availability Statement

All data analysed during this study are included in this article and/or its supplementary material files. Further enquiries can be directed to the corresponding author.

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