



# Allergy and Its Predictive Factors in the PSAU students-Alkharj City, Saudi Arabia

Amal Alshammary <sup>1</sup>, Seba Abdo <sup>2</sup>, Talal AlMutairi <sup>3</sup>, Sultan AlSubaie <sup>3</sup>, Abdulmajeed AlKhalid <sup>3</sup>, Omar AlAnazi <sup>3</sup>, Abdullah Badawood <sup>3</sup>, Meshari AlAnazi <sup>3</sup>, Suad Alghamdi <sup>3</sup>, Abeer Alsofyani <sup>4</sup>, Rawiah Alsiary <sup>4</sup>, Shaihana Almatrrouk <sup>5</sup>, Fahad N. Alonazi <sup>5</sup>, Mona Alanazi <sup>6</sup>, Mashael Altoub <sup>1</sup>, Afaf Aldahish <sup>7</sup>, Sana Alshaikh <sup>8</sup>, Awal Zaki <sup>9</sup>, Sahar Aldosari <sup>10</sup>, Manal M. Aljohani <sup>11</sup>, Essa E. Alanazi <sup>11</sup>, Ali A Alahmari <sup>11</sup>, Awwad K. Alenezy <sup>12</sup>, Noufa Alonazi <sup>13</sup>, Adel A. Alenazi <sup>14</sup>, Talat Bukhari <sup>15</sup>, Faris Q.B. Alenzi <sup>\*3</sup>

<sup>1</sup>Dept of Clinical Laboratory Sciences, College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia.

<sup>2</sup>Dept of Biochemistry, College of Science, King Saud University, Riyadh, Saudi Arabia.

<sup>3</sup>Dept of Clinical Laboratory Sciences, College of Applied Medical Sciences, Prince Sattam bin Abdulaziz University (PSAU), Alkharj, Saudi Arabia.

<sup>4</sup>King Abdullah International Medical Research Center (KAIMRC)- WR King Saud bin Abdulaziz University for Health Sciences (KSAU-HS) Jeddah, Saudi Arabia.

<sup>5</sup>Saudi Public Health Authority, Riyadh, Saudi Arabia.

<sup>6</sup>College of Nursing, King Saud bin Abdulaziz University for Health Sciences (KSAU-HS) Riyadh, Saudi Arabia.

<sup>7</sup>Dept of Pharmacology & Toxicology- College of Pharmacy- King Khalid University Abha, Saudi Arabia.

<sup>8</sup>Maternity and Children Hospital, Dammam, Saudi Arabia.

<sup>9</sup>Dammam Regional Lab, Dammam, Saudi Arabia.

<sup>10</sup>Dept of Clinical Laboratory Sciences, College of Applied Medical Sciences, Majmaah University, Majmaah, Saudi Arabia.

<sup>11</sup>Regional Lab, KSMC, Riyadh, Saudi Arabia.

<sup>12</sup>Dept of Family and Community Medicine- Faculty of Medicine, Northern Border University. KSA.

<sup>13</sup>Dept of Paediatrics, Prince Sultan Military Medical City, Riyadh, Saudi Arabia.

<sup>14</sup>Dept of Oral and Maxillofacial surgery and diagnostic sciences, College of dentistry, Prince Sattam bin Abdulaziz University (PSAU), Alkharj, Saudi Arabia.

<sup>15</sup>Dept of Immunology, College of Medicine, Um Qura University, Makkah, Saudi Arabia.

\*Corresponding: Faris Q. Alenzi, Ph.D.; [f.alenzi@psau.edu.sa](mailto:f.alenzi@psau.edu.sa)

Received 12 January 2024;

Accepted 04 February 2024;

Published 10 February 2024

## Abstract

**Background:** Allergy is a widespread universal public health challenge that can result in serious complications. The incidences of allergy are continuously on the rise resulting in morbidity and mortality in all age groups. Thus, a clear knowledge of the prevalence of the spectrum of allergic diseases and the accurate identification of environmental triggers is crucial. **Aim:** The current study was conducted to determine the prevalence, types, risk factors of allergic disorders among students of Prince Sattam bin Abdulaziz University (PSAU) Saudi Arabia. This study may provide useful information for development of a strategic public health plan for optimal management of allergies. **Methods:** In this cross-sectional study, students were surveyed by an electronic questionnaires and results were analysed and compared. Five hundred adult students (330 males, 170 females) belonging to various colleges at PSAU, participated in this study. **Results:** Analysis of data from the self-administered questionnaire show that 59% of participants suffered from some type of allergy. The most prevalent type of allergy among participants was of respiratory tract (41%), followed by skin allergy (36%), Gastrointestinal tract (GIT)allergy (14%) and least number of cases were of eye allergy (9%). Fifty five percent cases of allergies were due to environmental triggers, 35% were food allergy, and 10% were animal allergy cases. For food allergy, the most common (59%) allergens were fruits, nuts and vegetables, 26% cases were of fish allergy, 10% of cases were of allergy to milk and the least number of cases (5%) were of allergy to wheat. **Conclusion:** The prevalence of allergies is high in PSAU and students. Adequate measures should be taken to reduce and manage the rising prevalence of allergies before the problem escalates any further.

**Keywords:** Allergy prevalence, self-reported, University, adults, Saudi Arabia

## Introduction

Allergies are type 2 helper T cells (Th2 cells) /immunoglobulin E (IgE) mediated type I hypersensitivity reactions against environmental factors (allergens). The influence of these environmental factors on allergic mechanisms tends to differ depending upon time of exposure as well as on immunological milieu and genetics of the host [1,2]. Several genes can contribute to allergy and thus increase susceptibility to allergic diseases. Whereas environmental and lifestyle factors modify the expression of these genes via epigenetic mechanisms. The allergic reactions manifest in different organs and the allergy spectrum includes allergic rhinitis, asthma, food allergies, urticaria, atopic eczema and anaphylaxis [2]. Rising urbanization and globalization has drastically changed the environment and increased the number of allergens. Several factors including pollution, climate change, reduction in biodiversity, urbanization, change in lifestyle and dietary habits have been attributed to significant rise in prevalence of allergies both in developed and developing countries [3]. This global outbreak of allergic diseases is a cause of considerable medical and socioeconomical burden [4]. Overall, various allergies are known to affect approximately 20% of people worldwide. Since, allergies are environment related thus allergens and risk factors differ according to various geographical locations [5,6]. Globally, asthma prevalence in adults ranges from 1 to 20%, allergic rhinitis ranges from 1 to 18%, atopic dermatitis ranges from 2 to 10% and food allergy ranges from 1% to 2% (prevalence of self-reported food allergy in adults varies from 2% to 37%) [7]. Allergic disorders are common in Saudi Arabia and asthma has been ranked as one of the most common chronic diseases in the country [7,8].

The current study was conducted to determine the prevalence, types, risk factors associated with allergic diseases among students of Prince Sattam bin Abdulaziz University (PSAU), Saudi Arabia.

## Materials & Methods

### 3.1 Study design, and participants

The present study was a population-based self-reported survey of 500 (330 males, 170 females) adult (18 to 25 years of age) students enrolled at Prince Sattam bin Abdulaziz University (PSAU), Al-Kharj, Saudi Arabia. The students from 7 colleges at PASU: Medicine, Pharmacy, CAMS, Education, Sciences,

Engineering and Administration, participated in the current study. The survey was done in form of an electronic questionnaire and was conducted between Oct-Nov 2021. The questionnaire contains 20 questions (data not shown) out of which some were open-ended questions while others were closed-ended. The questionnaire included questions about age, height, weight, gender, respiratory symptoms, asthma, allergic symptoms, use of medication, profession, and smoking habits of the participants. Body mass index (BMI) was calculated from self-reported height and weight by using the formula: BMI= [weight (kg)/height (m<sup>2</sup>)]. BMI was categorized into three groups: normal weight (18.5 to 24.9 kg/m<sup>2</sup>), overweight (25 to 29.9 kg/m<sup>2</sup>), and obese (≥30 kg/m<sup>2</sup>). The data obtained on completion of the survey was analysed and results compared with each other.

### 3.2 Data analysis

Descriptive analysis, such as percentage, was used to describe the variables. Bivariate analysis (chi-square) was used to compare categorical data. P-value < 0.05 was considered statistically significant.

## Results

Of the total of 500 participants most of them were males (66%, n=330), the rest (34%, n=170), being females. The participants were young adults aged between 17 to 25 years (56% were 17 to 20 years old, 41% were 21 to 23 years old, 3% were aged 23 years or older). Based on BMI, it was found that 45% of participants had a normal weight, 48% were overweight and 8% were obese (Table-1). The results indicate that 59% of the total participants suffered from allergy of some type. Out of these 26% students were allergic to only one type of allergen while 74% were allergic to two or more allergens. Fifty five percent cases of allergies were due to environmental causes, 35% were food allergy, and 10% were animal allergy cases. The most prevalent type of allergy among participants was of respiratory tract (RT) (41%), followed by skin allergy (36%), Gastrointestinal tract (GIT)allergy (14%) and least number of cases were of eye allergy (9%). (Table-2). Among the cases of food allergy, the most common (59%) allergens were fruits, nuts and vegetables, 26% cases were of fish allergy, 10% of cases were of allergy to milk and the least number of cases (5%) were of allergy to wheat (Figure-1). About 74% of the students suffered allergies due to two or more allergens, while the rest had allergy due to only single allergen.

**Table 1: Demographic Characteristics of participants (n=500)**

Demographic Characteristics	n (%)	p-Value
<i>Age Groups(years)</i>		
17-20	280 (56%)	<0.005
21-23	205 (41%)	
23-25	15 (3%)	
<i>Gender</i>		
Male	330 (66%)	< 0.001
Female	170 (34%)	
<i>Body Mass Index (BMI)</i>		
< 25(normal weight)	225 (45%)	0.565
>25 (overweight)	240 (48%)	
>40 (obese)	40 (8%)	
<i>Income</i>		
High income	145 (29%)	< 0.001
Medium income	220(44%)	
Low income	115(23%)	

Note: data are presented as Number (n) (%) p value <0.05 is considered significant

**Table 2: Prevalence of different types of allergies among participants**

Allergy Type	n (%)
Allergies classified according to organ affects	
Respiratory tract	205 (41%)
Skin	180 (36%)
Gastrointestinal tract	70 (14%)
Eye	45 (9%)
Allergies classified according to type of allergen	
Environmental	275 (55%)
Food	175 (35%)
Animal	50 (10%)

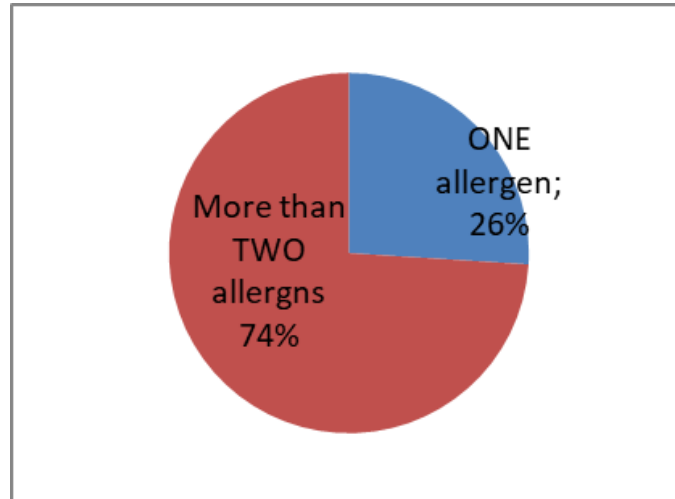


Figure 1: shows that 26% of the students had only one allergen, while most of the allergic students had 2 and more allergens.

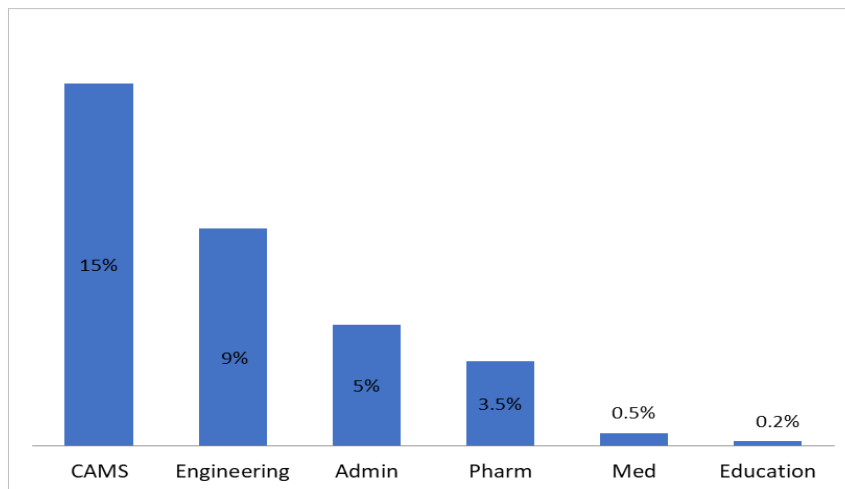


Figure 2: shows the distribution of allergic students according to their colleges: where we found that the highest incidence of allergy was among students of CAMS at 15%, followed by students of Engineering at 9%, then students of preparatory year at 6%, while the students of Education And medicine are the lowest, by 0.2 and 0.5, respectively.

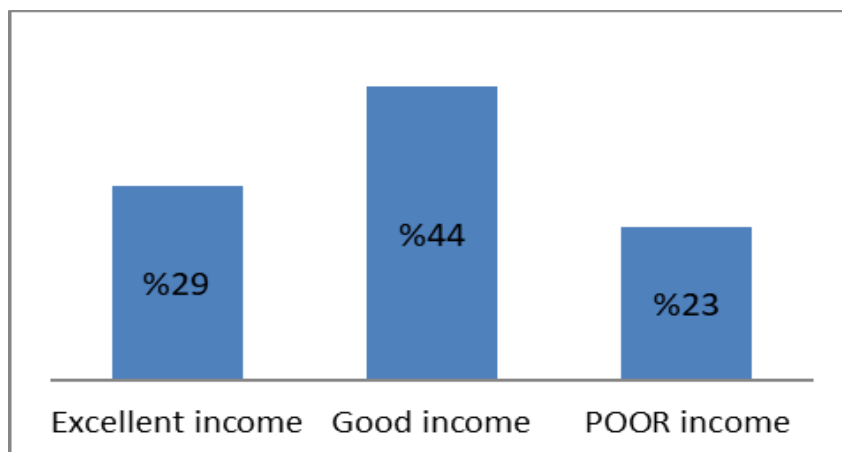


Figure 3: shows that the financial condition of the allergic students where we found that only 3% of them had poor financial income.

FINALLY, our results also indicates that only 4% of the allergic students are smokers now or one of their parents during their childhood. Our results showed that only 8% of those who received the seasonal influenza vaccine developed allergy after receiving the vaccine. (data not shown).

## Discussion

Allergies of RT include diseases such as rhinitis and bronchial asthma. Asthma is a widespread chronic inflammatory disease of the lower RT, characterized by a reversible hindrance to airflow, inflammation, persistent hyper-reactivity and airway remodeling [9,10]. Rhinitis is an inflammatory disorder of upper RT and has been associated with increased risk and severity of asthma [11]. Both these allergic diseases of RT have a high worldwide prevalence [12,13]. In Saudi Arabia itself more than 2 million people suffer from asthma [14]. The environment contains indoor (furry pets, molds, house dust mites, rodents and pests) and outdoor (molds, pollens, dust, industrial emissions and automobile exhaust) allergenic triggers. The prevalence of allergic rhinitis as diagnosed by physicians in some Middle Eastern countries including Saudi Arabia is 9% and the main outdoor trigger for this disease is reported to be dust [15]. In the present study the prevalence of respiratory tract allergies was higher (41%) than any other form of self-reported allergies among the participants. This is further supported by our finding that environmental factors were considered as the main cause (55%) of allergies by the study participants. Fur of animals is another important environmental allergen reported in Saudi Arabia, and has been implicated in respiratory tract disease such as allergic rhinitis [16]. Cat has been reported as an important indoor allergen in Saudi Arabia [17]. The present study found that 10% of participants were allergic to animals. This further justifies high prevalence of respiratory tract allergies among the participants of the study. Previously similar studies conducted in different cities of Saudi Arabia, show varied results. Saudi Arabia has an extensive territory with considerable differences in the terrain, climatic conditions, as well as degree of urbanization. Thus, regional variations in prevalence of allergic diseases is expected. However, prevalence of asthma and other allergic diseases has been observed in Hofuf, Madinah, and Najran regions, while least prevalence of these diseases has been observed in Qassim, Dammam, and Taif [18]. A study done in the year 2016-2017 at a medical college in Jeddah city found prevalence of respiratory tract allergy to be 29.5% among the students [6]. More recently a study done in the Qassim region of Saudi Arabia, reported that the prevalence of respiratory tract allergy was 28.8%, [19] among adult population. The difference in prevalence of respiratory tract allergy in different cities could be because of difference in air quality and levels of air pollution. Qassim region being further away from the capital city, Riyadh, may have better air quality and hence lower prevalence of respiratory tract allergies. Riyadh is the capital city of Saudi Arabia, and has been reported to have poor air quality index [20]. The of air pollution on respiratory system has been clearly revealed in various studies [21,22].

The prevalence of skin allergies was found to be 36% in the present study. This result supports a previous study done in Jeddah city of Saudi Arabia, which found 33.8% prevalence of skin allergy among university students [6]. However, another study which was conducted in a university at Majma region, of Saudi Arabia found that prevalence of skin allergy was 21.9% and it was more common in males than in female participants [3]. Food allergy is defined as an adverse health effect arising from a specific immune response that occurs reproducibly on exposure to a given food. The prevalence of food allergy was reported to be 9.5% among university students in Saudi Arabia [23]. The most common self-reported food allergen were fruits and nuts, followed by fish and milk and wheat allergy was rare, which is similar to that reported previously in Saudis [24]. A nationwide study investigated prevalence of food allergy in Saudi

Arabia and reported it as 19.7% [24]. Similarly, two other studies reported prevalence of food allergy to be 10% [6] and 17% [25]. The results of this study was represented in our current study, we report a prevalence of 14% for gastrointestinal allergy among the participants. Besides the gastrointestinal tract, food allergy can also manifest in skin and respiratory tract. Thus, overall prevalence of food allergy in our study was estimated as 35%. Although there is plenty of data on ocular allergy in the medical literature globally, there is a scarcity of data on the disease in Saudi Arabia despite it affecting a wide population in the Saudi kingdom [26]. In our current study we found the prevalence of eye allergy to be 9% among the participants.

Allergic diseases are a major global public health concern that affects individuals of all ages. The prevalence of allergic diseases has increased in recent decades, with a higher incidence in developed countries than in developing countries [27]. This study investigated the prevalence of allergic diseases and their predictive factors among PSAU students in Saudi Arabia. The results established that a higher percentage of the participants had allergies, with respiratory allergy being the most common, followed by skin allergy, gastrointestinal tract, and eye allergy.

Respiratory allergies are mainly caused by exposure to pollen, dust mites, and animal dander, which trigger an immune response and cause respiratory tract inflammation. On the other hand, skin allergy results from exposure to irritants or allergens such as cosmetics, soaps, and metals. This prevalence rate depicted in the results is consistent with previous studies that established that allergic diseases are a significant public health concern in the general population. The most common primary cause of allergies in Saudi Arabia is environmental factors, followed by food and animal allergies [28]. The study established that the most common food allergens are fruits, nuts, and vegetables. A previous study established that food allergies mostly occur from allergic reactions to specific food families, such as fruits and vegetables [29]. Other factors such as genetics, age, dose of allergen, smoking, obesity, and pollution are also significant predictors of allergic diseases. Previous studies have established that these factors act as high determinants of allergic reactions among individuals [30].

These results give significant implications to different entries such as parents, educators, and policymakers, who take different roles in shaping the health and consumption of the population. The results suggest that parents should be able to take proactive measures to minimize environmental exposures of their children to allergens, especially in their homes [31]. To the policymakers, this implies that they should be able to develop and implement measures that reduce air pollution and improve air quality, as this stands out as a significant risk factor for the development of allergies [32]. To educators, this implies they should promote general awareness of the risk factors and allergies to students, teachers, and parents. This will contribute to high chances of reduced exposure to risk factors of allergens at school, at home, and in the country in general. On the other hand, healthcare providers should focus more on educating patients and families on the potential risks of obesity, smoking, and age-related changes in immune function in the development of allergic diseases [33]. The high prevalence of allergic diseases among PSAU students highlights the need for increased awareness and education about allergies and their management.

Allergies can be a significant health challenge in the country based on the findings of this study. With environmental factors such as dust, pollen, and mold, which can trigger allergic reactions in susceptible individuals, there is a need to implement potential solutions to such problems in the population [34]. Addressing these allergies requires a comprehensive approach, including prevention and treatment strategies. Therefore, to successfully address these allergic challenges, a research study proposed avoidance of allergens as one of the possible solutions [35]. This involves identifying and



avoiding common allergens such as pollen, dust mite, and mold. Several medications can be used to address allergies, including antihistamines, decongestants, and nasal corticosteroids. These medications can help alleviate sneezing, runny nose, and itchy eyes [28]. Another potential solution is the use of immunotherapy. In addition, increased awareness of common allergens and how to manage allergy symptoms can also be helpful. This can include providing information about common triggers, such as dust and pollen, and offering tips for managing symptoms, such as avoiding outdoor activities during high pollen count days.

## Conclusion

This study provides important insights into the prevalence and predictive factors of allergic diseases among PSAU students in Saudi Arabia. The findings highlight the need for increased awareness and education about allergies and their management and further research and interventions to prevent and manage allergic diseases. The study also underscores the importance of prioritizing environmental and public health initiatives to reduce exposure to allergens and pollutants. These findings can be used to develop effective prevention and management strategies to mitigate the burden of allergic diseases in the population. Future research should aim to replicate these findings and investigate additional factors that may contribute to the development of allergic diseases. Introduction of various strategies that can adequately prevent occurrence of allergies and create awareness about causes of allergic diseases and its triggering factors, may help to reduce the prevalence of this disease.

## Conflict of Interest

There was no conflict of interest.

## Funding Statement

The entire financial burdens were borne by the researchers.

## Data Availability

Data would be available upon reasonable request by corresponding author.

## References

- [1] Murrison, Liza Bronner, Eric B. Brandt, Jocelyn Biagini Myers, and Gurjit K. Khurana Hershey. "Environmental exposures and mechanisms in allergy and asthma development." *The Journal of clinical investigation* 129, no. 4 (2019): 1504-1515
- [2] Gilles, Stefanie, Cezmi Akdis, Roger Lauener, Peter Schmid-Grendelmeier, Thomas Bieber, Georg Schäppi, and Claudia Traidl-Hoffmann. "The role of environmental factors in allergy: A critical reappraisal." *Experimental dermatology* 27, no. 11 (2018): 1193-1200.
- [3] Aldahash, Bader Ahmed, Syed Meraj Ahmed, Kawther Abdulla Alsadady, Fahad Salman Alshabab, and Ibrahim Mohammad Almutairi. "A Study on the Prevalence of Allergic Skin Disorders among Students Of Majma'ah University, Majmaah, Saudi Arabia."
- [4] Ogulur, Ismail, Yagiz Pat, Ozge Ardicli, Elena Barletta, Lacin Cevhertas, Ruben Fernandez-Santamaria, Mengting Huang et al. "Advances and highlights in biomarkers of allergic diseases." *Allergy* 76, no. 12 (2021): 3659-3686.
- [5] Caraballo, L., J. Zakzuk, B. W. Lee, N. Acevedo, J. Y. Soh, and M. Sánchez-Borges. "Particularities of allergy in the tropics." *World Allergy Organ J.* 2016; 9: 20."
- [6] Ibrahim, Nahla Khamis, Abeer Ali Alghamdi, Mayar Majed Almeahmadi, Asma Abdulwahed Alzahrani, Asraa Khairallah Turkistani, and Khalid Alghamdi. "Allergy and related clinical symptoms among medical students and interns." *Pakistan Journal of Medical Sciences* 35, no. 4 (2019): 1060.
- [7] Dierick, Boudewijn JH, Thys van der Molen, Bertine MJ Flokstra-de Blok, Antonella Muraro, Maarten J. Postma, Janwillem WH Kocks, and Job FM van Boven. "Burden and socioeconomics of asthma, allergic rhinitis, atopic dermatitis and food allergy." *Expert review of pharmacoeconomics & outcomes research* 20, no. 5 (2020): 437-453.
- [8] Musharrafieh, Umayya, Hani Tamim, Rana Houry, and Fadia AlBuhairan. "A nationwide study of asthma correlates among adolescents in Saudi Arabia." *Asthma research and practice* 6 (2020): 1-8.
- [9] Resende, E. P., A. Todo-Bom, C. Loureiro, A. Mota Pinto, B. Oliveiros, L. Mesquita, and H. C. Silva. "Asthma and rhinitis have different genetic profiles for IL13, IL17A and GSTP1 polymorphisms." *Revista Portuguesa de Pneumologia (English Edition)* 23, no. 1 (2017): 10-16.
- [10] Bateman, Eric D., Suzanne S. Hurd, Peter J. Barnes, Jean Bousquet, Jeffrey M. Drazen, Mark FitzGerald, Peter Gibson et al. "Global strategy for asthma management and prevention: GINA executive summary." *European Respiratory Journal* 31, no. 1 (2008): 143-178.
- [11] Bousquet, Jean, Nikolai Khaltayev, Alvaro A. Cruz, Judah Denburg, W. J. Fokkens, A. Togias, Torsten Zuberbier et al. "Allergic rhinitis and its impact on asthma (ARIA) 2008." *Allergy* 63 (2008): 8-160.
- [12] Network, Global Asthma. "The global asthma report 2018." (2018).
- [13] Savouré, Marine, Jean Bousquet, Jouni JK Jaakkola, Maritta S. Jaakkola, Bénédicte Jacquemin, and Rachel Nadif. "Worldwide prevalence of rhinitis in adults: A review of definitions and temporal evolution." *Clinical and translational allergy* 12, no. 3 (2022): e12130.
- [14] Alharbi, Saleh A., Sumayyah AN Kobeisy, Suzan A. AlKhatir, Adel S. Alharbi, Mansour M. Alqwaiee, Faisal N. Alotaibi, Khalid A. Alawam et al. "Childhood asthma awareness in Saudi Arabia: five-year follow-up study." *Journal of Asthma and Allergy* (2020): 399-407.
- [15] Abdulrahman H, Hadi U, Tarraf H, Gharagozlou M, Kamel M, Soliman A, Hamad WA, Hanna KM, Mostafa BE, Omrani M, Abdelmotal A, Moukarzel N: Nasal allergies in the Middle Eastern population: results from the "Allergies in Middle East Survey". *Am J Rhinol Allergy.* 2012, 26: 3-23.
- [16] Al Anazy, Fatma Homood, and Siraj Mustafa Zakzouk. "The impact of social and environmental changes on allergic rhinitis among Saudi children: A clinical and allergological study." *International journal of pediatric otorhinolaryngology* 42, no. 1 (1997): 1-9.
- [17] Almogren, Adel. "Airway allergy and skin reactivity to aeroallergens in Riyadh." *Saudi Med J* 30, no. 3 (2009): 392-6.
- [18] Mohamed Hussain, Shalam, Syeda Ayesha Farhana, and Sulaiman Mohammed Alnasser. "Time trends and regional variation in prevalence of asthma and associated factors in Saudi Arabia: a systematic review and meta-analysis." *BioMed research international* 2018 (2018).
- [19] Almatroudi, Ahmad, Ayman M. Mousa, Divya Vinnakota, Adil Abalkhail, Ameen SS Alwashmi, Saleh A. Almatroodi, Fahad A. Alhumaydhi, Russell Kabir, and Ilias Mahmud. "Prevalence and associated factors of respiratory allergies in the Kingdom of Saudi Arabia: A cross-sectional investigation, September–December 2020." *PLoS One* 16, no. 6 (2021)

- [20] Hassan, R., M. Rahman, and A. Hamdan. "Assessment of air quality index (AQI) in Riyadh, Saudi Arabia." In IOP Conference Series: Earth and Environmental Science, vol. 1026, no. 1, p. 012003. IOP Publishing, 2022.
- [21] Gül, Hülya, Eftade O. Gaga, Tuncay Döğeroğlu, Özlem Özden, Özkan Ayvaz, Sevda Özel, and Günay Güngör. "Respiratory health symptoms among students exposed to different levels of air pollution in a Turkish city." International journal of environmental research and public health 8, no. 4 (2011): 1110-1125.
- [22] Rajper, Sohail Ahmed, Sana Ullah, and Zhongqiu Li. "Exposure to air pollution and self-reported effects on Chinese students: A case study of 13 megacities." PloS one 13, no. 3 (2018): e0194364.
- [23] Hassan, Ali, Amna Alsaihati, Malak Al Shammari, Haitham Alaithan, Wejdan Al-Johani, Nouf AlShamlan, and Salman Aljubran. "Food allergy among university students: uncharted territory." Allergy, Asthma & Clinical Immunology 16, no. 1 (2020): 1-6.
- [24] Althumiri, Nora A., Mada H. Basyouni, Norah AlMousa, Mohammed F. AlJuwaysim, Nasser F. BinDhim, and Saleh A. Alqahtani. "Prevalence of self-reported food allergies and their association with other health conditions among adults in Saudi Arabia." International journal of environmental research and public health 18, no. 1 (2021): 347.
- [25] Ibrahim, Nahla Khamis, Abeer Ali Alghamdi, Mayar Majed Almeahmadi, Asma Abdulwahed Alzahrani, Asraa Khairallah Turkistani, and Khalid Alghamdi. "Allergy and related clinical symptoms among medical students and interns." Pakistan Journal of Medical Sciences 35, no. 4 (2019): 1060.
- [26] Bazuhair, Muaz S., Hamzah H. Alsabban, Kasim H. Alsabban, Khalid A. Alzahrani, Ali A. Alattas, Abdullah M. Khinkar, and Emad M. Salawati. "Knowledge and awareness of ocular allergy among Jeddah population." Journal of Family Medicine and Primary Care 11, no. 4 (2022): 1502.
- [27] Achilova D, Amonov R, Sharipova LK, Yomgurova O, Rustamov B. Clinical, immunological and medico-social aspects of allergic diseases in children. Annals of the Romanian Society for Cell Biology. 2021:6736-40.
- [28] Haahtela T, Alenius H, Lehtimäki J, Sinkkonen A, Fyhrquist N, Hyöty H, et al. Immunological resilience and biodiversity for prevention of allergic diseases and asthma. Allergy. 2021;76(12):3613-26.
- [29] Alqahtani JM. Atopy and allergic diseases among Saudi young adults: a cross-sectional study. Journal of International Medical Research. 2020;48(1):0300060519899760.
- [30] Alotiby AA, Alrashidi HE. Prevalence of Food Allergy and Common Food Allergen Among Saudi Adults in Makkah Region, Saudi Arabia. Journal of Asthma and Allergy. 2022:1851-9.
- [31] Patel G, Saltoun C. Skin testing in allergy. Allergy Asthma Proc. 2019;40(6):366-8.
- [32] Alsharairi NA. Diet and food allergy as risk factors for asthma in the Arabian Gulf region: current evidence and future research needs. International Journal of Environmental Research and Public Health. 2019;16(20):3852.
- [33] Kabesch M, Tost J. Recent findings in the genetics and epigenetics of asthma and allergy. Semin Immunopathol. 2020;42(1):43-60.
- [34] Abdelaziz MH, Abdelwahab SF, Wan J, Cai W, Huixuan W, Jianjun C, et al. Alternatively activated macrophages; a double-edged sword in allergic asthma. Journal of translational medicine. 2020;18:1-12.
- [35] Asayama K, Kobayashi T, D'Alessandro-Gabazza CN, Toda M, Yasuma T, Fujimoto H, et al. Protein S protects against allergic bronchial asthma by modulating Th1/Th2 balance. Allergy. 2020;75(9):2267-78.



**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <https://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2024