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Detection of Active Allergens Triggering Hypersensitivity Among Residents of Basrah, Iraq

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Background: Environmental aeroallergens and dietary allergens significantly contribute to hypersensitivity reactions. Their impact in Basrah province residence remains unclear.
Objective: Understanding local allergen patterns is crucial for effective management and treatment of allergic reactions.
Materials and Methods: A total of 410 eligible participants who were clinically diagnosed with allergic conditions by certified specialists in Basrah province were recruited using an online platform questionnaire. This cross-sectional study was designed to investigate the prevalence of eight allergens: dust (house dust mites or outdoor dust), spices (hot sauce), fruits (kiwi), gluten (wheat bread), perfume (cosmetic), pollen, cleaning products (domestic hygienic products), and drug (penicillin).
Results: The study included 293 females and 117 males (aged 18–35 years). Immediate hypersensitivity reactions (52.9%) were more common than delayed reactions. Dust was identified as the leading allergen (30.73%), followed by spice (15.37%) and perfume (13.66%). Age-related

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patterns showed penicillin allergies in the oldest group, those over 31 years old, and gluten allergies in the youngest (18.7–20.7 years). Gluten triggered significantly higher symptom severity than other allergens (P = 0.001).

Conclusion: This study highlights dust as the primary allergen in Basrah. Gluten showed the highest severity despite having a low frequency in younger individuals and is associated with symptom severity. This article may help the province people with their preventive healthcare measures with the help of allergen screening.

Keywords: Allergen; dust; hypersensitivity; gluten; IgE.

1. INTRODUCTION

The pathogenesis of allergic diseases is complex and influenced by a combination of genetic, epigenetic, environmental, and immunological factors (Wang et al., 2023). The primary role of the immune system is to protect the human body against harmful antigens, including pathogens, such as bacteria, viruses, fungi, and other foreign invaders. It contains innate immunity, which provides non-specific defense, and adaptive immunity, which develops typically targeted responses to specific pathogens over time, working together to identify and eliminate potential threats (Wang et al., 2024). However, misdirected immune response towards allergens results in allergic disease reactions. Allergic diseases are considered a significant global health concern, affecting millions of individuals of all ages and massive substantial burdens on patients' quality of life and healthcare systems (Shin et al., 2023). Allergens are typically harmless substances that exist in the environment, food, or medications that do not evoke an immune response. However, susceptible individuals can trigger a cascading series of immunological events, resulting in hypersensitivity reactions (Ogulur et al., 2025). Pollens, dust mites, animal dander, insect venom, fungal spores, and certain foods, such as gluten, peanuts, shellfish, eggs, milk, and some medications, particularly penicillin, are typical examples of allergens (Shah & Grammer, 2012). In addition, chemical allergens with low molecular weights can stimulate the immune response, leading to chemical allergies, such as those caused by nano-plastics, pesticides, household cleaning materials, fragrances, and smoking (Pallardy et al., 2023). Inhalation, ingestion, and direct skin contact are the main routes of exposure to allergens, influencing the type and severity of the immune response and allergic reactions (Aldakheel, 2021). For instance, inhaled fungal spores, pollen, and house dust mite allergens primarily affect the respiratory tract, resulting in allergic rhinitis and asthma (Sharpe et al., 2016). Ingested allergens, such as food proteins, can stimulate the gastrointestinal tract and systemic reactions, while skin contact with allergens like latex or certain metals may result in contact dermatitis (Klain et al., 2024). Generally, there are four primary classifications of hypersensitivity reactions based on the immunological mechanisms and the speed of onset after exposure to the allergen. The most common type of hypersensitivity is type I, also known as immediate hypersensitivity, which is mediated by immunoglobulin E (IgE) through the activation of mast cells (Feng et al., 2024). Type I hypersensitivity includes two stages, which are sensitization, where the first exposure to an allergen leads to allergen-specific IgE production, and the effector stage, where subsequent exposure triggers IgE crosslinking on mast cells and basophils, resulting in the rapid release of inflammatory mediators, primarily histamine and prostaglandins (Aitella et al., 2025). Clinically, this manifests as symptoms ranging from mild (such as sneezing, itching, and hives) to severe and life-threatening (including anaphylaxis) (Abrams et al., 2024). Type II and III hypersensitivity reactions are mediated by the overproduction of immunoglobulin IgG or IgM, which activate the complement system, often leading to cell destruction and associated disorders such as autoimmune hemolytic anemia or immune thrombocytopenia (Chan Gomez et al., 2020). Type IV hypersensitivity (delayed hypersensitivity) is a T-cell-mediated immune response that typically initiates 48 to 72 hours after allergen exposure, triggered by the activation of CD4+ and CD8+ T cells (Knol & Gilles, 2022). The increasing trends of allergic diseases highlighted the urgent need for ongoing research into understanding the nature of allergens, their sources, and their mechanisms; this is essential for accurate diagnosis, effective management, and the development of novel therapeutic strategies. For this reason, this study was designed to investigate the nature of allergens and their sources in Basrah province especially with the increasing trend of allergic diseases during the last ten years.

2. MATERIALS AND METHODS

2.1 Study Design and Samples

A structured questionnaire including nine questions was developed for this study to collect data about demographic information, allergic reactions, symptom severity, and sources of allergens. This study was conducted from June to December 2024 among the Iraqi population in Basrah province. A total of 410 patients participated in this study by accessing an online questionnaire. Eligible participants were adults aged 18 to 35 years residing in Basrah province with a clinically confirmed allergic condition by conducting skin prick tests and serum IgE. Diagnosis was verified by a specialist and formally documented in the registry of the Allergic and Asthma Center in Basrah, Iraq. Approval for all stages of the study was obtained from our Institutional Scientific and Ethics Committee (No. S/24/09).

2.2 The Study Process

The questionnaire was distributed electronically to populations by student groups, who were also encouraged to disseminate the questionnaire form. The electronic form was used to facilitate ease of access and participation. In this study, participation was voluntary. All participants were notified about the research purpose and their right to withdraw or cancel participation at any time without any consequences. Regular reminders were sent during the study to encourage participation and increase the response rate.

2.3 Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics (Version 25.0). Descriptive statistics summarized all relevant responses. A Chi-square goodness-of-fit test was employed to determine if observed categorical frequencies differed from expected distributions. Paired-samples t-tests with a Bonferroni correction were used to evaluate pairwise comparisons of means. A one-way ANOVA was used to assess differences in mean age across eight allergen groups, with Games-Howell for post-hoc comparisons when sample sizes and heterogeneous variances were unequal. All results are reported with 95% Confidence Intervals (95% CI), and the significance level for all tests was set at (*p*-value < 0.05).

3. RESULTS

3.1 Demographic Distribution

The age distribution of study participants revealed a predominantly young adult population, with ages ranging from 18 to 35 years (mean age = 24.53 years, median = 23 years). The study population was predominantly female (n=293, 71.5%) compared to male participants (n=117, 28.5%). The majority of patients resided in urban areas (n=234, 57.1%). Educational attainment showed that most participants held Bachelor's degrees (n=324, 79.02%), while a smaller proportion had completed high school education (n=86, 20.98%). Regarding hypersensitivity patterns, more than half of the study population exhibited immediate allergic reactions (n=217, 52.9%) compared to delayed-type hypersensitivity (n=193, 47.1%) (Table 1).

3.2 Allergen Types

A one-way ANOVA (n = 410) revealed a significant difference in mean age across eight allergen groups, $F(7, 402) = 20.38$, $P = 0.001$, with a large effect size ($\eta^2 \approx 0.23$). Dust was the most prevalent allergen (n=126, valid %= 30.73%, mean age= 23.48 years, SD = 3.91), followed by spices allergy (n=63, 15.37%, mean age= 24.97 years, SD = 4.4) and perfume allergy (n=56, 13.66%, mean age= 25.8 years, SD = 5.3). Patients with gluten allergy demonstrated the youngest mean age (n=14, valid %= 3.41%, mean age=19.71 ± 1.73 years), while those with penicillin allergy were common in the oldest (32.47 ± 2.67 years). The non-overlapping 95% confidence intervals for penicillin (31.10–33.84) and gluten (18.72–20.71) highlight robust age separation (Table 2).

3.3 Allergic Symptoms

The results of allergy symptom analysis revealed significant variations in clinical presentations, categorized into four main patterns: cutaneous/respiratory (characterized by skin rash, shortness of breath, cough, and itching), cutaneous (including rash and itching), respiratory (manifested by sneezing and cough), and gastrointestinal symptoms (Fig. 1). Multi-symptoms of allergic reactions (skin rash, shortness of breath, cough, and itching) emerged as the most common manifestation (n=158, 38.5%), followed by dermatological symptoms (rash and itching, n=150, 36.6%). Respiratory symptoms (sneezing and cough) accounted for 20.7% (n=85), while gastrointestinal complaints were notably rare (n=17, 4.1%).

Table 1. Demographic distribution of the sample population that participated in this study

Variable	Category	Number (n)	Frequency (%)
Gender	Male	117	28.5%
	Female	293	71.5%
Region	Rural	176	42.9%
	Urban	234	57.1%
Education level	High School	86	20.9%
	Bachelor's	324	79.0%
Hypersensitivity types	Immediate	217	52.9%
	Delayed	193	47.1%
Total	**410**		

Table 2. Prevalence and associated patient age demographics across different allergen types

Allergen type	Valid (%)	Mean age (year)	Std. deviation (SD)	Age (Year)		95% Confidence interval of mean
				Minimum	Maximum	
Dust	30.73%	23.48	3.91	18	35	22.79 - 24.18
Spice	15.37%	24.97	4.4	21	34	23.86 - 26.08
Perfume	13.66%	25.8	5.3	21	35	24.38 - 27.22
Pollen	11.95%	23.88	3.47	21	34	22.88 - 24.88
Cleaning products	11.46%	26.55	5.47	18	34	24.95 - 28.16
Fruits	9.27%	21.92	3.72	18	34	20.7 - 23.14
Penicillin	4.15%	32.47	2.67	24	35	31.1 - 33.84
Gluten	3.41%	19.71	1.73	18	22	18.72 - 20.71

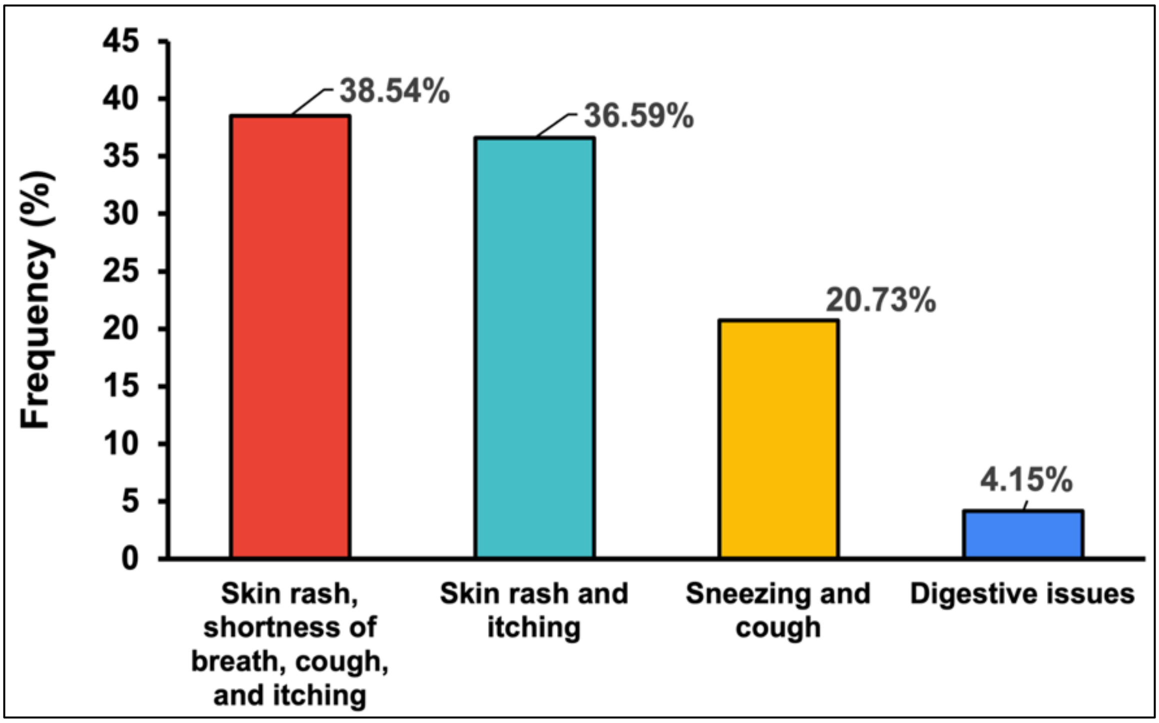

Fig. 1. The distribution of allergic symptom patterns

Table 3. Variation in allergic symptom severity across different allergen types

Allergen type	Frequency	Mean	Std. deviation (SD)	Symptoms severity (1-5)		95% Confidence interval of mean
				Minimum	Maximum	
Dust	126	2.87	0.88	1	5	2.71 - 3.02
Spice	63	2.9	0.86	1	4	2.69 - 3.12
Perfume	56	3.04	1.04	1	4	2.76 - 3.32
Pollen	49	2.78	0.8	1	5	2.55 - 3
Cleaning products	47	3.11	0.56	2	4	2.94 - 3.27
Fruits	38	3.34	0.78	2	5	3.09 - 3.6
Penicillin	17	3	0.87	2	4	2.55 - 3.45
Gluten	14	4.07	0.83	3	5	3.59 - 4.55

Table 4. Distribution of psychological impacts in participants with an allergic reaction

Psychological impact	Frequency (n)	Percentage (%)	Standardized residual	Significance
Anxious only	177	43.2	3.9	*P* = 0.0001
Anxious and depressed	125	30.5	-0.32	*P* = 0.749
Cannot sleep and depressed	108	26.3	-3.58	*P* = 0.0001
Total	410	100	-	-

3.4 Symptoms Severity

Statistical analysis was performed using paired-samples t-tests with a Bonferroni correction to assess differences in mean symptom severity scores across eight allergen sources. The results revealed significant differences among several allergen comparisons. Gluten allergy showed the highest symptom severity, with a mean score of 4.07 ± 0.83 out of 5, significantly exceeding that of other allergens (*P* = 0.001). Symptoms triggered by gluten were more severe than those caused by perfume (Mean Difference [MD] = -1.04, *P* = 0.001), dust (MD = -1.21, *P* = 0.001), pollen (MD = -1.30, *P* = 0.001), cleaning products (MD = 0.97, *P* = 0.001), fruits (MD = 0.73, p= 0.006), spices (MD = 1.17, *P* = 0.001), and penicillin (MD = 1.07, *P* = 0.001). Additionally, symptoms associated with fruit allergens were significantly more severe than those from dust (MD = -0.48, *P* = 0.003) and pollen (MD = -0.57, *P* = 0.002). Dust and pollen allergies exhibited moderate severity levels (2.87 ± 0.88 and 2.78 ± 0.80, respectively), whereas cleaning product allergies showed unexpectedly high severity (3.11 ± 0.56), despite their relatively low prevalence (Table 3).

3.5 Psychological Impact

The study examined psychological impacts among the study population. The results revealed significant variations in psychological distribution. Participants most commonly reported anxiety (n=177, 43.2%), followed by combined anxiety plus depression (n=125, 30.5%), and sleep disorder with depression (n=108, 26.3%) (Table 4). By a Chi-square goodness-of-fit test analysis, there was a significant distribution (χ^2 = 24.63, df = 2, *P* = 0.0001), with post-hoc analysis showing that anxiety only was significantly overrepresented (standardized residual = +3.90), while sleep disorder with depression was underrepresented (standardized residual =-3.58).

4. DISCUSSION

The primary function of the immune system is to defend the body against harmful antigens related to microbial pathogens. However, the lack of evaluation of antigen harmfulness and immune tolerance leads to an overactive immune response, known as a hypersensitivity reaction, which is a case of immunopathology. In this study, immediate hypersensitivity reactions outnumbered delayed reactions, accounting for 52.9% of cases. This finding indicated that more than half of the population studied suffered from Type I hypersensitivity, which is mediated by IgE antibodies specific to environmental, dietary, and medication sources. A rapid allergic reaction occurs within minutes to an hour after exposure to the allergen. The production of a high level of IgE increases binding to type-I high-affinity IgE Fc-receptors (FcεRI) on the surfaces of mast cells and basophils (Anvari et al., 2019). A crosslinking of IgE and FcεRI on the same mast cells leads to the stimulation, releasing a large variety of inflammatory mediators such as histamine, prostaglandin D2, leukotriene D4, tryptase, interleukin-1 (IL-1), IL-4, IL-5, IL-13, and tumor necrosis factor (TNF) (Parente et al., 2023). As a result, anaphylaxis, asthma, and urticaria develop due to blood vessel dilation and airway constriction (Acevedo et al., 2012). Studies showed that the development of immediate hypersensitivity reactions may be influenced by a complex interplay of genetic, microbiome, and environmental factors (Jutel et al., 2023). These factors are associated either directly or indirectly with immune response dysregulation. Underscores the importance of rapid detection and management of IgE-mediated allergic responses, which is considered a critical step to reduce morbidity.

The current study results demonstrate dust as the primary source of allergic reactions (30.73%). This result is consistent with global trends that showed environmental and airborne allergens are the primary causes of allergic rhinitis and asthma (Lee et al., 2023). Dust contains a complex mixture of allergenic proteins such as Der p1 and Der p2, which stimulate IgE-mediated hypersensitivity reactions leading to allergic rhinitis, asthma, and atopic dermatitis (d'Alessandro et al., 2021). Global climate change and the replacement of farms with buildings may suggest a significant increase in the rate of dust storms, resulting in an upward trend in allergic reactions among the Basrah population. Spicy foods and perfume emerged as remarkable secondary allergens in the Basrah community, which may act through either IgE-mediated or non-immunologic pathways. Spices are not well-known as standard allergy testing panels. However, studies have shown that capsaicin, carotenoids, polyphenols, and alkaloids, compounds found in spice extracts, can trigger neurogenic inflammation and pseudoallergic reactions, particularly in individuals with sensitive mucosa (Díaz-Guerrero et al., 2025). Limonene is one of the fragrance volatile organic compounds that can oxidize to form skin sensitizers, causing allergic reactions. Cleaning products were identified in the current study as active contributors to allergic reactions, including dermatitis and irritant contact dermatitis. Studies indicated that cleaning materials include (dimethyl-dimethyl) hydantoin (DMDMH), benzisothiazolinone (BIT), octylisothiazolinone (OIT), and phenoxyethanol, and also fragrances (Salonen et al., 2024). All these chemicals are common allergens and can trigger immune-mediated skin inflammation upon exposure to cause skin irritation, sensitization, redness, and itching. As a result, cleaning agents can act as allergens, causing fruit allergens to be present in the peel, pulp, and seeds of fruits, which can lead to diverse allergic reactions and clinical presentations, ranging from contact allergies to potentially life-threatening anaphylaxis. Cross-reactivity between aeroallergens and food allergens, due to structurally similar epitopes, causes a phenomenon recognized as pollen food allergy syndrome (PFAS), resulting in type I hypersensitivity through IgE production (Krikeerati et al., 2023). Our study showed that hypersensitivity to penicillin was relatively low (4.15%) among the study population. Globally, studies reported penicillin allergy rates between (8–12%) in the UK, USA, and Australia (9·9%), compared to middle-income countries in Asia (4·4%) (Luintel et al., 2025). Penicillin acts as haptens that bind to red blood cells as a carrier to be an active allergen, causing drug hypersensitivity reactions due to the release of IL-4, IL-8, IgE, and interferon-γ (IFNγ), resulting in clinical presentation of symptoms such as skin rash, vomiting, breath shortness, and anaphylaxis (Pallardy et al., 2024). The low prevalence of penicillin allergy in the Basrah community may indicate increased awareness about drug hypersensitivity or the use of a new generation of antibiotics for healthcare instead of penicillin. One of the most notable results of the current study was that allergic to gluten, with a relatively low-frequency rate (3.41%) compared to other allergens such as dust, spices, or perfumes. This result aligns with the global trend of gluten sensitivity in approximately 5% of the population (Taraghikhah et al., 2020). This finding suggests that true IgE-mediated wheat or gluten allergy is rare compared to other allergies (Sayed & Ali, 2022). In contrast, some countries reported a high prevalence of allergies to gluten, reaching approximately (10%) (Ontiveros et al., 2021). Food allergic prevalence is highly variable in different countries, which is attributed to a complex interaction between genetic variation of human leukocyte antigens (HLA-DQ2/DQ8), epigenetic factors, and environmental factors (Tham & Leung, 2018) in compare with close countries such as Turkey including the Eastern Black Sea Region and Mediterranean population reported prevalence with spices, tomatoes, and eggs as leading allergens (Duman & Dursun, 2023; Gelincik et al., 2008). The most common allergen foods were spices (15%), tomatoes (10.9%), and cow's milk (7.5%). The most common symptoms were urticaria (63.5%), gastrointestinal symptoms (30.2%), rhinitis (15.1%), and oral allergy syndrome (OAS) symptoms (11.3%). This result potentially reflects regional dietary patterns characterized by higher rice consumption, as well as social behaviors associated with food consumption and the introduction of new types of food supplemented with gluten from various countries and restaurants in Basrah province. Furthermore, Iraqi individuals have access to many countries that facilitate local food consumption, which may evoke allergic reactions in Iraqi travelers.

The results of this study showed distinct patterns between age-related distribution and allergen sensitivities, with penicillin allergies occurring predominantly in older adults over 31 years. These findings are consistent with broader epidemiological trends indicating that drug hypersensitivity reactions, particularly to penicillin, are more commonly reported in adults due to increased lifetime exposure and healthcare encounters (Copaescu et al., 2025). The relatively narrow age range suggests that these reactions may be more likely to occur in individuals with prior sensitization through repeated antibiotic use during childhood illnesses. In contrast, in this study, gluten sensitivity was reported primarily among individuals younger than 20 years. This finding is consistent with the younger age range observed by other studies. For example, gastrointestinal symptoms associated with gluten allergy were most frequently reported in younger individuals in Italy (Brindicci et al., 2024).

Gluten stands out as the most triggering allergen, with significantly higher allergic symptom severity (4.07±0.83 out of 5) compared to all other allergens, including perfume, dust, pollen, fruits, spicy foods, and penicillin, despite its low frequency. This finding aligns with studies showing more severe systemic manifestations in gluten-related disorders compared to other food allergies (Sapone et al., 2012) and reflects its substantial impact on gluten intolerance and presentations of allergic disease, which often involve significant gastrointestinal and systemic symptoms (Jansson-Knodell & Rubio-Tapia, 2024). Among the study samples, the results showed a high prevalence of combined cutaneous/respiratory symptoms, including skin rash with breath shortening, cough, and itching (38.54%), skin rash with itching alone (36.59%), sneezing with cough (20.73%), and digestive issues (4.15%). These symptoms indicated a spectrum of allergic manifestations involving multiple organ systems. Studies have reported a high prevalence of a combination of skin irritation and respiratory symptoms among the student population (Ibrahim et al., 2019). The combination of symptoms is potentially due to anaphylaxis, severe allergic reactions, which are characteristically associated with two or more organ systems simultaneously, including the skin and respiratory tract (Cardona et al., 2020). These symptoms result from the activation of mast cells and basophils, which is associated with the crosslinking of IgE on FcεRI, leading to the immediate release of histamine (Peavy & Metcalfe, 2008). The skin is the largest immune organ, supported by a complex mixture of immune cells, particularly mast cells, which are mainly located in the dermis and orchestrate the defense mechanisms. Mast cells play a pivotal role as the first line of defense against microbial antigens, and they contain a large number of proinflammatory mediators within their cytoplasmic secretory granules, primarily histamines (Banafea et al., 2022). Histamine triggers an itch sensation on the skin, prompting the desire to scratch. Skin irritation, including itching, pruritus, and rashes, is a common hallmark of allergic reactions due to histamine release, reflecting the complex immune mechanisms triggered by allergen exposure (Umehara et al., 2021). Accordingly, cutaneous symptoms are the predominant signs observed in the population studied. An inflammatory immune response may also develop, leading to hypersensitivity reactions triggered by allergens, which are typically characterized by skin redness and swelling, such as contact dermatitis and atopic dermatitis. Conversely, digestive symptoms are presented less commonly, which aligns with the recognized gastrointestinal effects of food allergies, where immune-mediated responses lead to symptoms such as abdominal pain, nausea, or vomiting (Brown-Whitehorn & Spergel, 2020). This pattern of symptoms emphasizes the complex interaction and involvement of the skin, respiratory tract, and gastrointestinal organs in the immune system during allergic reactions. From a clinical perspective, these results point out the importance of identifying specific allergens to draw certain strategies for preventing or avoiding severe allergic reactions that require urgent medical attention, particularly in Basrah province. This study had several limitations. Firstly, a small sample size of participants may be considered one of these limitations. Second, the definitions of allergy symptoms collected from questionnaire choices may not represent the actual symptoms, and the conclusions obtained may be biased.

5. CONCLUSION

These findings reveal that dust-contaminated air is identified as the predominant environmental trigger, followed by spicy foods, perfume, pollen, cleaning products, fruits, penicillin, and gluten. Gluten emerges as the most potent active allergen in younger individuals and is associated with the highest symptom severity. Developing strategies to mitigate exposure to dust, pollen, and particularly gluten can enhance allergy management and medical support services. Further research is needed to address and reduce the impact of allergic diseases in this area.

CONSENT

As per international standards or university standards, Participants' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

Approval for all stages of the study was obtained from the Institutional Scientific and Ethics Committee (No. S/24/09).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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