RESEARCH ARTICLE

F.U. Med.J.Health.Sci.
2026; 40 (1): 84 - 92
http://www.fusabil.org

Aeroallergen Sensitivity Patterns in the Central Anatolia Region and the Effects of the COVID-19 Pandemic on this Pattern

Bahar ARSLAN [1, a]
Neslihan CERRAH DEMİR [1, b]
Murat TÜRK [2, c]

[1] Kayseri City Training and Research Hospital, Department of Allergy and Immunology
Kayseri, TÜRKİYE

[2] Erciyes University, Faculty of Medicine Department of Chest Diseases, Division of Allergy and Immunology
Kayseri, TÜRKİYE

[a] ORCİD: 0000-0002-2786-8489
[b] ORCİD: 0000-0001-5102-1395
[c] ORCİD: 0000-0002-3290-2661

Objective: Aeroallergen sensitization patterns vary by ethnicity and geography; therefore, their effects on allergic diseases are likely regional.

This study aimed to determine the current aeroallergen sensitization in our region, contributing to treatment and preventive measures, and to investigate the impact of COVID-19 on this situation.

Materials and Methods: Our study included patients who presented to our hospital's immunology and allergy outpatient clinic between 2021 and 2025 with symptoms of allergic rhinitis and who had been diagnosed with at least one aeroallergen sensitivity through skin prick testing. Drops of aeroallergen extract were first applied to the forearm. The skin is then examined by puncture with a special lancet (Heinz Herenz Hamburg, Germany). Lofarma Aeroallergen Vaccine, which contains standardized aeroallergen extracts with proven efficacy, was used.

Results: Considering all individuals, the indoor aeroallergen frequency was 78.3%, while the outdoor aeroallergen frequency was 57.6%. Among all aeroallergens, the most common aeroallergens were house dust mites and grass pollen (dermatophagoides farinae (n=1135, 49.8%), dermatophagoides pterynossinus (n=1095, 48.1%), and grass pollen (n=1482, 50.2%)), and the sensitization rates to these aeroallergens were similar. The frequency of outdoor aeroallergens, particularly grass pollen, weed pollen, and olive tree pollen, was significantly lower in 2024 than in other years. The prevalence of cat aeroallergens was significantly lower in 2021 compared to the other three years (p=0.036).

Conclusion: Our study showed that indoor sensitization was higher than outdoor sensitization in the Central Anatolia region, with house dust mite (Df) sensitization being the most common indoor aeroallergen, and grass mix sensitization being the most common outdoor aeroallergen. When we examined the distribution over the years, we observed that cat allergy has increased, particularly in the post-COVID-19 period. The diversity of our findings suggests that aeroallergen protection measures can be developed based on regional sensitization differences.

Key Words: *Aeroallergen, allergic rhinitis, sensitization, COVID 19*

İç Anadolu Bölgesi Aeroallerjen Duyarlılık Paterni ve COVİD-19 Pandemisinin Bu Patern Üzerine Etkileri

Amaç: Alerjen duyarlılık paternleri etnik kökene ve coğrafyaya göre değişir; bu nedenle alerjik hastalıklar üzerindeki etkileri muhtemelen bölgeseldir.

Bu çalışmada, bölgemizin mevcut alerjen duyarlılığını belirleyerek tedavinin düzenlenmesine ve koruyucu önlemlere katkıda bulunmayı ve COVİD 19'un duyarlılık üzerine etkisini araştırmayı amaçladık.

Gereç ve Yöntem: Çalışmamıza 2021-2025 yılları arasında hastanemiz immünoloji ve alerji polikliniğine alerjik rinit semptomları ile başvuran ve deri prik testi yapılıp en az bir aeroalerjen duyarlılığı tespit edilmiş olan hastalar dahil edildi. Deri testinde öncelikle ön kola alerjen özütü damlaları uygulanır deri özel bir lansetle (Heinz Herenz Hamburg, Almanya) delinerek incelenir. Standardize edilmiş alerjen özleri içeren ve alerjenik etkinliği kanıtlanmış Lofarma Aeroallerjen Aşısı kullanıldı.

Bulgular: Tüm bireyler dikkate alındığında iç-ortam alerjen sıklığı 78.3% iken dış-ortam alerjen sıklığı 57.6% olarak belirlendi. Tüm alerjenler içinde en sık gözlenen aeroallerjenlerin ev tozu akarı ve çim poleni (dermatophagoides farinae (n=1135,49.8%), dermatophagoides pterynossinus (n=1095, 48.1%) ve çim poleni (grass) (n=1482,50.2%) olduğu ve bu alerjenlere duyarlanma oranının birbirine benzer olduğu gözlendi. Dış-ortam alerjen sıklığının özellikle çim poleni (grass) n, yabani ot ve zeytin ağacı poleninin 2024 yılında diğer yıllardan anlamlı düzeyde daha düşük olduğu gözlendi. Kedi alerjen sıklığı 2021 yılında diğer üç yıla göre anlamlı düzeyde düşüktü (p=0.036).

Sonuç: Çalışmamızın sonucunda İç Anadolu bölgesinde iç-ortam duyarlığının dış ortam duyarlığından daha fazla olduğunu, iç-ortam alerjenlerden en sık ev tozu akarı (df), dış ortam alerjenlerden ise en sık çim poleni duyarlanmasının olduğunu gösterdik. Yıllar içindeki dağılıma baktığımız zaman kedi alerjisinin özellikle COVID 19 sonrası dönemde arttığını gözlemledik. Bulgularımızın çeşitliliği bölgesel duyarlanma farklılıklarına göre aeroalerjenlerden korunma önlemlerinin geliştirilebileceğini düşündürmektedir.

Anahtar Kelimeler: *Aeroallerjen, alerjik rinit, duyarlanma, COVID 19*

Received : 15.10.2025
Accepted : 05.01.2026

Correspondence

Bahar ARSLAN
Kayseri City Training and Research Hospital, Department of Allergy and Immunology
Kayseri, TÜRKİYE

baharozer2002@yahoo.com

Introduction

Allergic rhinitis (AR) is the most common form of noninfectious rhinitis, causing symptoms such as nasal discharge, congestion, itching, and sneezing, affecting 10-30% of all adults and 40% of children. The immunopathogenesis of allergic rhinitis involves both immediate and late-type immune responses resulting from specific immunoglobulin E antibody-mediated hypersensitivity to aeroallergens that are tolerated by normal individuals (1). Aeroallergen causing AR can include outdoor pollens (including tree, grass, and weeds, as well as ambrosia), molds, and indoor aeroallergens (e.g., house dust mites, animals, and molds) (2).

Aeroallergen sensitization patterns vary by ethnicity and geography; therefore, their impact on allergic diseases is likely regional (3). In Europe, the major aeroallergens are pollens. In tropical regions, the main aeroallergen is house dust mites (4, 5). Initial studies in our country evaluated pollen as the most common aeroallergen (6). Studies in the Marmara and Eastern Black Sea regions, including pediatric patients diagnosed with asthma and AR, was found house dust mite sensitivity as the most common in all diagnostic groups (7). Another study in the Aegean region identified weeds (54%), grass pollens (45%), olive pollen (44%), and house dust mites (38%) as the most common aeroallergens (8). A previous study in the Develi district of Kayseri province, covering both pediatric and adult age groups, showed that the most common aeroallergens were a mixture of pollens, followed by Dermatophagoides pterynossinus (dp), Bermuda grass, and olive tree pollen. House dust mite allergy is more common in patients with perennial AR; Pollen sensitivity has been found to be more common in patients with seasonal AR (9).

However, there are no data demonstrating the distribution of aeroallergens in Central Anatolia in the adult age group, nor are there data demonstrating the impact of the COVID-19 pandemic on the current aeroallergen profile.

In this study, we aimed to determine the current aeroallergen sensitivity in our region, contribute to the development of treatment and preventive measures, and investigate the impact of COVID-19 on this situation.

Materials and Methods

Research and Publication Ethics: Ethical approval was obtained from the Ethics Committee of Kayseri City Training and Research Hospital (Date: 26/09/2025, No: 597).

This retrospective study complied fully with the principles of the Declaration of Helsinki. Due to its retrospective nature, the ethics committee exempted the study from requiring informed consent from patients.

Patients who presented to the immunology and allergy outpatient clinic of our hospital between 2021 and 2025 with symptoms of allergic rhinitis and who were diagnosed with at least one aeroallergen sensitization via skin prick testing were included in this study. Age <18 years old and sensitization without symptoms were among exclusion criteria. As our hospital is one of the referral centers in allergy and immunology in Central Anatolia, patients from Kayseri, Kırşehir, Nevşehir, Yozgat, Niğde, Sivas, and Aksaray were included.

Demographic data, skin prick test results, and medical records of the patients were retrospectively reviewed.

Skin Prick Test: Skin prick testing was performed routinely by applying aeroallergen extract drops to the forearm, followed by pricking with a special lancet (Heinz Herenz Hamburg, Germany).

Standardized aeroallergen extracts with proven aeroallergenic activity (Lofarma Aeroallergen Vaccine, Lofarma S.p.A., Milan, Italy) were used. A minimum distance of 2 cm was maintained between different aeroallergen extracts. At 20 minutes, an induration size ≥3 mm greater than that of the negative control was considered positive. All skin prick tests were performed by qualified technicians.

Statistical Analysis: Statistical analysis included descriptive statistics (mean, standard deviation [SD], counts, and percentages).

Normality of sensitization wheal sizes was tested using the Kolmogorov-Smirnov test, and non-normal distributions were confirmed. Relationships between aeroallergen frequency and year, month, sex, and COVID-19 period (before vs. after) were analyzed using Pearson’s chi-square test. Since many aeroallergens were examined together, the Benjamini-Hochberg (False Discovery Rate, FDR) method was used to eliminate multiple comparison errors. Comparisons of sensitization wheal sizes among indoor and outdoor aeroallergens were performed using the Wilcoxon signed-rank test. Furthermore, individuals exposed to both indoor and outdoor allergens, and those exposed to them individually, were divided into three groups, and the changes in these groups over years, months, and genders were examined using a multiple multinomial logistic regression model. The adjusted effect sizes, odds ratios, and 95% confidence intervals were presented in tabular form. Statistical significance was set at $p<0.05$, and analyses were performed using SPSS version 29.

Results

A total of 2,964 patients with at least one aeroallergen sensitization were included. Of these, 66.4% (n=1,970) were female. The mean age of the patients was 28.2 years (range 27–32). Indoor aeroallergen sensitization was identified in 78.3% of patients and outdoor aeroallergen sensitization was identified in 57.6%. The most common aeroallergens overall were Dermatophagoides farina (Df) (49.8%), Dp (48.1%), mixed mites (52.0%), and grass pollen (50.2%). Among outdoor aeroallergens, grass pollen sensitization was most frequent, while Alternaria and Cladosporium were the least common. Among indoor aeroallergens, house dust mites (Df, Dp, Dermamix) were the most common. Among tree pollens, olive tree pollen was the most frequent, followed by mixed tree pollens and birch pollen. Grass pollen was the most common among herbaceous pollens. Detailed aeroallergen distribution is presented in Table 1.

Table 1. Frequency of All Aeroallergens

Aeroallergen	n	%
Outdoor aeroallergens	1707	57.6
Df	1135	49.8
Dp	1095	48.1
Mixed mites (Dermamix)	359	52.0
Cockroach	717	24.2
Aspergillus	58	2.3
Cat	745	25.2
Dog	238	8.0
Penicillium	34	2.6
Indoor aeroallergens	2320	78.3
Grass pollen	1486	50.2
Weed pollen	332	17.4
Mugwort (Artemisia)	200	18.9
Plantain (Plantago)	202	19.1
Tree mix	166	16.4
Birch pollen	309	15.4
Olive tree pollen	328	32.8
Alternaria	115	4.6
Cladosporium	41	2.2

Among indoor aeroallergens, the number of monosensitized patients was 946 (31.9%), and the number of polysensitized patients was 1,362 (45.9%). Among outdoor aeroallergens, the number of monosensitized patients was 825 (27.8%), and the number of polysensitized patients was 913 (30.8%). The number of monosensitized and polysensitized patients was similar for outdoor aeroallergens (90.4%, 825/913).

The prevalence of aeroallergens by year and the change in these prevalences over time are presented in Table 2. An examination of Table 2 reveals that the frequency of outdoor aeroallergens, particularly grass pollen, weed pollen, and olive tree pollen, was significantly lower in 2024 than in the other years. The frequency of cat aeroallergens was significantly lower in 2021 compared to the other three years (*p*=0.036).

The distribution of aeroallergens by month and the comparison results between months are presented in Table 3. When the table is evaluated, the frequency of indoor aeroallergens in June was significantly lower than in January, February, March, August, October, November, and December, and the frequency in May was also lower than in January, February, March, and December. Otherwise, the difference between months was not significant. Grass pollen aeroallergen frequency was significantly higher in June and September than in other months. Birch aeroallergen frequency was lowest in February and August and highest in July.

Table 2. Distribution of aeroallergens by year and comparison between years

	2021		2022		2023		2024		***p***
	n	%	n	%	n	%	n	%	
Indoor	132	83.0	678	78.7	549	75.4	961	79.2	0.100
Outdoor	105	66.0	546	63.3	427	58.7	629	51.8	**0.001**
Df	84	53.5	399	49.5	55	55.0	597	49.2	0.540
Dp	72	45.9	423	52.5	51	51.0	549	45.2	**0.012**
Dermamix	0	0.0	26	44.1	332	52.8	1	100.0	0.193
Cockroach	48	30.2	286	33.3	128	17.6	255	21.0	**0.001**
Aspergillus	16	10.1	9	2.0	11	1.5	22	1.8	**0.001**
Cat	27	17.1	205	23.8	185	25.4	328	27.0	**0.036**
Dog	20	12.7	37	4.3	78	10.7	103	8.5	**0.001**
Penicillium	0	0.0	0	0.0	3	2.6	31	2.8	0.667
Grass pollen	86	54.1	509	59.2	378	51.9	513	42.3	**0.001**
Weed pollen	45	28.3	187	21.7	81	11.2	19	11.7	**0.001**
Tree mix	26	16.6	140	16.4	0	0.0	0	0.0	0.906
Birch pollen	0	0.0	19	28.8	100	13.8	190	15.7	**0.012**
Olive tree pollen	1	50.0	22	33.3	273	37.6	32	15.5	**0.001**
Alternaria	31	19.6	42	4.9	9	1.5	33	3.7	**0.001**
Cladosporum	0	0.0	22	3.2	12	1.7	7	1.7	0.107

Table 3. The distribution of aeroallergens by month and the comparison results between months.

	Janurary		February		March		April		May		June		July		August		September		October		November		December		p**	p***
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%		
Indoor	29	16.0	32	16.7	46	16.9	49	23.0	90	24.9	87	30.2	97	25.3	53	19.2	46	25.6	42	18.9	21	19.4	51	17.8	**0.001**	**0.002**
	152	84.0	160	83.3	226	83.1	164	77.0	271	75.1	201	69.8	286	74.7	223	80.8	134	74.4	180	81.1	87	80.6	236	82.2		
Outdoor	91	50.3	106	55.2	133	48.9	96	45.1	153	42.4	87	30.2	141	36.8	108	39.1	58	32.2	87	39.2	55	50.9	141	49.1	**0.001**	**0.002**
	90	49.7	86	44.8	139	51.1	117	54.9	208	57.6	201	69.8	242	63.2	168	60.9	122	67.8	135	60.8	53	49.1	146	50.9		
Df	61	46.6	71	43.0	100	46.5	99	66.0	133	48.7	139	62.1	154	49.8	118	51.3	63	47.0	51	40.5	51	57.3	102	44.2	**0.001**	**0.002**
	70	53.4	94	57.0	115	53.5	51	34.0	140	51.3	85	37.9	155	50.2	112	48.7	71	53.0	75	59.5	38	42.7	129	55.8		
Dp	67	51.1	80	48.5	102	47.4	71	47.3	149	54.6	141	62.9	169	54.7	119	51.7	62	46.3	64	50.8	44	49.4	114	49.4	0.060	0.081
	64	48.9	85	51.5	113	52.6	79	52.7	124	45.4	83	37.1	140	45.3	111	48.3	72	53.7	62	49.2	45	50.6	117	50.6		
Dermamix	26	52.0	13	48.1	19	33.3	29	46.0	36	40.9	25	39.1	41	54.7	31	67.4	30	65.2	42	43.8	7	35.0	33	55.9	**0.006**	**0.010**
	24	48.0	14	51.9	38	66.7	34	54.0	52	59.1	39	60.9	34	45.3	15	32.6	16	34.8	54	56.3	13	65.0	26	44.1		
Cockroach	120	66.3	141	73.4	215	79.0	168	78.9	281	77.8	222	77.1	303	79.1	218	79.6	126	70.0	164	73.9	83	76.9	203	70.7	**0.008**	**0.012**
	61	33.7	51	26.6	57	21.0	45	21.1	80	22.2	66	22.9	80	20.9	56	20.4	54	30.0	58	26.1	25	23.1	84	29.3		
Aspergillus*	175	96.7	181	94.3	266	97.8	198	100.0	311	99.0	171	99.4	325	97.3	138	95.8	133	99.3	213	95.9	107	99.1	282	98.3	**0.002**	**0.004**
	6	3.3	11	5.7	6	2.2	0	0.0	3	1.0	1	0.6	9	2.7	6	4.2	1	0.7	9	4.1	1	0.9	5	1.7		
Cat	129	71.3	146	76.0	204	75.0	155	72.8	275	76.2	225	78.1	286	74.7	200	72.5	133	73.9	167	75.9	74	68.5	222	77.4	0.699	0.737
	52	28.7	46	24.0	68	25.0	58	27.2	86	23.8	63	21.9	97	25.3	76	27.5	47	26.1	53	24.1	34	31.5	65	22.6		
Dog	162	89.5	179	93.2	254	93.4	201	94.4	332	92.0	271	94.4	349	91.1	254	92.0	170	94.4	196	88.7	100	92.6	254	88.8	0.155	0.196
	19	10.5	13	6.8	18	6.6	12	5.6	29	8.0	16	5.6	34	8.9	22	8.0	10	5.6	25	11.3	8	7.4	32	11.2		
Penicllium*	91	97.8	101	100.0	157	96.9	19	95.0	203	96.2	106	98.1	251	96.5	92	97.9	0	0.0	1	100.0	63	98.4	174	97.8	0.683	0.737
	2	2.2	0	0.0	5	3.1	1	5.0	8	3.8	2	1.9	9	3.5	2	2.1	0	0.0	0	0.0	1	1.6	4	2.2		
Grass_Polen	106	58.9	119	62.0	177	65.1	109	51.2	160	44.3	102	35.4	166	43.5	130	47.1	64	35.6	104	46.8	70	64.8	168	58.5	**0.001**	**0.002**
	74	41.1	73	38.0	95	34.9	104	48.8	201	55.7	186	64.6	216	56.5	146	52.9	116	64.4	118	53.2	38	35.2	119	41.5		
Weed Mix	151	83.9	154	80.2	93	74.4	99	86.1	112	83.0	159	88.3	109	88.6	145	79.7	143	79.4	178	80.2	94	87.9	137	83.0	**0.041**	**0.050**
	29	16.1	38	19.8	32	25.6	16	13.9	23	17.0	21	11.7	14	11.4	37	20.3	37	20.6	44	19.8	13	12.1	28	17.0		
Artemisia	0	0.0	0	0.0	114	77.6	80	81.6	185	81.9	91	84.3	209	80.4	78	82.1	0	0.0	0	0.0	1	100.0	98	81.0	0.931	0.931
	0	0.0	0	0.0	33	22.4	18	18.4	41	18.1	17	15.7	51	19.6	17	17.9	0	0.0	0	0.0	0	0.0	23	19.0		
Plantago	0	0.0	0	0.0	114	77.6	76	77.6	163	72.1	92	85.2	220	84.6	81	86.2	0	0.0	0	0.0	1	100.0	106	87.6	**0.003**	**0.006**
	0	0.0	0	0.0	33	22.4	22	22.4	63	27.9	16	14.8	40	15.4	13	13.8	0	0.0	0	0.0	0	0.0	15	12.4		
Tree Mix	42	87.5	67	79.8	57	83.8	45	88.2	43	91.5	110	94.8	43	87.8	111	81.6	101	75.4	94	74.6	34	81.0	97	89.0	**0.001**	**0.002**
	6	12.5	17	20.2	11	16.2	6	11.8	4	8.5	6	5.2	6	12.2	25	18.4	33	24.6	32	25.4	8	19.0	12	11.0		
Birch Tree	113	85.0	100	92.6	176	86.3	140	87.0	263	83.8	141	82.0	261	78.1	131	93.6	38	82.6	82	85.4	56	84.8	199	84.7	**0.004**	**0.007**
	20	15.0	8	7.4	28	13.7	21	13.0	51	16.2	31	18.0	73	21.9	9	6.4	8	17.4	14	14.6	10	15.2	36	15.3		
Olive Tree	86	64.7	96	88.9	81	81.0	42	66.7	57	64.8	38	59.4	43	58.1	20	43.5	24	52.2	53	55.2	47	72.3	86	72.9	**0.001**	**0.002**
	47	35.3	12	11.1	19	19.0	21	33.3	31	35.2	26	40.6	31	41.9	26	56.5	22	47.8	43	44.8	18	27.7	32	27.1		
Alternaria	98	96.1	100	90.1	121	96.8	189	97.4	355	98.3	276	95.8	364	95.0	266	96.4	176	97.8	202	91.4	42	93.3	217	92.3	**0.001**	**0.002**
	4	3.9	11	9.9	4	3.2	5	2.6	6	1.7	12	4.2	19	5.0	10	3.6	4	2.2	19	8.6	3	6.7	18	7.7		
Cladosporum*	142	98.6	127	99.2	214	97.7	174	98.3	145	98.6	177	98.3	117	95.1	168	94.4	175	98.3	174	98.9	104	98.1	116	98.3	0.219	0.160
	2	1.4	1	0.8	5	2.3	3	1.7	2	1.4	3	1.7	6	4.9	10	5.6	3	1.7	2	1.1	2	1.9	2	1.7		

*: Fisher-Freeman-Halton exact test, other allergens Pearson chi-square test. ****:** Unadjusted *p*-value;*****:** Adjusted *p*-value according to; Benjamini-Hochberg (False Discovery Rate)

The years were divided into 2021 COVID-19 period (during the lockdown) and the post-COVID-19 period. The distribution of aeroallergens across these periods is presented in Table 4. An examination of the table reveals that outdoor aeroallergen sensitization was significantly higher during the COVID-19 period (p=0.027), while cat aeroallergen sensitization was significantly higher after COVID-19 (p=0.016). Similarly, the frequency of dog, weed, Alternaria, and Aspergillus aeroallergens was significantly higher during the COVID-19 period.

When the induration diameters for outdoor aeroallergens were compared, grass pollen was higher than other pollen aeroallergens.

The distribution of aeroallergens by gender is shown in Table 5. When the table is examined, the frequency of outdoor aeroallergens was significantly higher in men.

Individuals with only indoor allergens and only outdoor allergens were compared to those with both allergen types, based on years, months, and genders. These factors were considered together in the model to determine their adjusted effects. (Table 6) The frequency of indoor allergens alone is significantly higher in women than in both cases; significantly higher in 2022, 2023, and 2024 than in 2021 and also significantly higher in January, February, March, April, May, October, November, and December than in June. However, no significant difference was found in other months compared to June.

Table 4. Distribution of aeroallergen frequency during and after COVID-19

	COVID 19 (2021) n (%)	**Post COVID 19 (2022-2024) n (%)**	***p***
Indoor	132 (83)	2188 (78)	0.138
Outdoor	105 (66)	1602 (57)	**0.027**
Df	84 (54)	1051 (50)	0.342
Dp	72 (46)	1023 (48)	0.562
Dermamix	0 (0)	359 (52)	0.141
Cockrach	48 (30)	669 (24)	0.071
Aspergillus	16 (10)	42 (2)	**0.001**
Cat	27 (17)	718 (26)	**0.016**
Dog	20 (13)	218 (8)	**0.026**
Penicillium	0 (0)	34 (3)	0.256
Grass pollen	86 (54)	1400 (50)	0.312
Weed mix	45 (28)	287 (16)	**0.001**
Mugwort (Artemisia)	0 (0)	200 (19)	---
Plantago	0 (0)	202 (19)	---
Tree mix	26 (17)	140 (16)	0.963
Birch pollen	0 (0)	309 (15)	0.546
Olive tree pollen	1 (50)	327 (33)	0.603
Alternaria	31 (20)	84 (4)	**0.001**
Cladosporum	0 (0)	41 (2)	0.299

Table 5. Distribution of aeroallergen frequency by gender

		Female		Male		*p**	*p***
		n	%	n	%		
Indoor	No	412	20.9	231	23.3	0.143	0.213
	Yes	1558	79.1	762	76.7		
Outdoor	No	887	45.0	369	37.2	**0.001**	**0.006**
	Yes	1083	55.0	624	62.8		
Df	No	756	50.0	386	50.5	0.842	0.842
	Yes	757	50.0	378	49.5		
Dp	No	807	53.3	375	49.1	**0.050**	0.095
	Yes	706	46.7	389	50.9		
Dermamix	No	234	50.6	98	42.8	**0.050**	0.095
	Yes	228	49.4	131	57.2		
Cockroach	No	1517	77.0	727	73.4	**0.029**	0.085
	Yes	453	23.0	264	26.6		
Aspergillus	No	1673	97.4	827	98.3	0.152	0.213
	Yes	44	2.6	14	1.7		
Cat	No	1452	73.8	764	76.9	0.062	0.107
	Yes	516	26.2	229	23.1		
Dog	No	1789	90.9	933	94.1	**0.020**	0.060
	Yes	180	9.1	58	5.9		
Penicllium	No	866	97.2	392	97.8	0.560	0.591
	Yes	25	2.8	9	2.2		
Grass_Polen	No	1042	52.9	433	43.6	**0.001**	**0.006**
	Yes	926	47.1	560	56.4		
Weed Mix	No	1062	84.2	512	79.5	**0.011**	**0.050**
	Yes	200	15.8	132	20.5		
Artemisia	No	587	82.8	269	77.5	**0.040**	0.090
	Yes	122	17.2	78	22.5		
Plantago	No	584	82.5	269	77.5	**0.050**	0.095
	Yes	124	17.5	78	22.5		
Tree Mix	No	547	84.8	297	81.4	0.157	0.213
	Yes	98	15.2	68	18.6		
Birch Tree	No	1179	86.6	521	80.4	**0.001**	**0.006**
	Yes	182	13.4	127	19.6		
Olive Oil	No	469	68.1	204	65.4	0.402	0.449
	Yes	220	31.9	108	34.6		
Alternaria	No	1586	95.7	820	94.9	0.356	0.422
	Yes	71	4.3	44	5.1		
Cladosporum	No	1217	97.5	616	98.4	0.216	0.273
	Yes	31	2.5	10	1.6		

:** Unadjusted *p*-value;*:** Adjusted *p*-value according to; Benjamini-Hochberg (False Discovery Rate)

Table 6. Results of multiple multinomial logistic regression

	Only indoor allergen / both indoor and outdoor allergen				**Only outdoor allergen / both indoor and outdoor alllergen**			
	OR	**95% CI for OR**		***p***	**OR**	**95% CI fo OR**		***p***
		Lower Bound	**Upper Bound**			**Lower Bound**	**Upper Bound**	
Intercept				<0.001				0.006
Female	1.382	1.158	1.649	**<0.001**	1.064	0.866	1.306	0.555
Male	**Referance category**							
2022	1.633	1.094	2.436	**0.016**	1.347	0.812	2.237	0.249
2023	2.153	1.436	3.227	**<0.001**	1.896	1.140	3.154	**0.014**
2024	2.937	1.969	4.380	**<0.001**	1.746	1.049	2.905	**0.032**
2021	**Referance category**							
January	1.867	1.211	2.879	**0.005**	0.591	0.348	1.004	**0.050**
February	2.701	1.744	4.182	**<0.001**	0.775	0.456	1.318	0.347
March	1.786	1.208	2.641	**0.004**	0.653	0.414	1.029	0.066
April	1.716	1.126	2.615	**0.012**	0.910	0.573	1.446	0.690
May	1.488	1.022	2.164	**0.038**	0.951	0.639	1.416	0.806
July	1.079	0.745	1.564	0.686	0.822	0.557	1.211	0.321
August	1.294	0.878	1.907	0.192	0.641	0.417	0.985	**0.042**
September	1.269	0.808	1.993	0.300	0.885	0.553	1.415	0.610
October	1.612	1.058	2.455	**0.026**	0.663	0.411	1.068	0.091
November	2.550	1.505	4.322	**0.001**	0.851	0.455	1.592	0.614
December	2.127	1.435	3.152	**<0.001**	0.755	0.479	1.189	0.225
June	**Referance category**							

Discussion

Our study showed that indoor sensitization is higher than outdoor sensitization in the Central Anatolia region, with house dust mite (Df) sensitization being the most common indoor aeroallergen, and grass mix sensitization being the most common outdoor aeroallergen. When we examined the distribution over the years, we observed that cat allergy has increased over the years, especially in the post-COVID-19 period.

Climate, geography, and vegetation influence atmospheric aeroallergen content (3). An evaluation of 2,554 plant samples collected on Mount Erciyes between 1996 and 2002 identified 1170 species and subspecies taxa (1116 species, 31 subspecies, 23 variants) belonging to 89 families and 433 genera. The largest families in terms of the number of species and subspecies taxa are Asteraceae, Fabaceae, and Poaceae (10).

Poaceae pollen (grass pollen) is currently among the leading aeroallergens worldwide and is the primary cause of pollen allergy in most developed countries, particularly in North America and Europe (11). Consistent with global data, we observed the highest rate of sensitization to grass pollen among outdoor aeroallergens.

Olea europaea pollen is a significant cause of respiratory allergic diseases in the Mediterranean region; olive pollen is a significant cause of pollinosis in Spain, Southern Italy, Greece, and Türkiye (12). Although Kayseri is not located in a coastal area, olive tree sensitization is significantly common (9). Our patients experienced sensitization in 32.8% of those tested with olive aeroallergen.

Previous studies have shown an increase in the prevalence of both cat ownership and cat allergy during the COVID-19 period (13, 14). Our study did not compare pre-COVID-19 with those during or after COVID-19, but consistent with the literature, we observed that the upward trend in cat sensitization continued even after the COVID-19 pandemic lockdowns ended.

Moreover, the frequency of outdoor aeroallergens was found to be higher in the pre-COVID-19 period, likely due to the impact of curfews, and this was similar to other studies conducted during the COVID-19 period (15, 16). The frequency of Dp aeroallergens was found to be significantly lower in 2024 and 2021 compared to 2022.

When evaluated monthly, the frequency of indoor aeroallergens in June was significantly lower than in January, February, March, August, October, November, and December, and the frequency in May was lower than in January, February, March, and December. Several studies of allergic patients have reported higher rates of IgE sensitization to pollen or higher specific IgE (sIgE) levels during or after the pollen season (17). At the regional level, evidence suggests that sIgE for both grass and birch pollen varies seasonally (higher levels in spring and potentially higher levels in summer than winter) (18). Similarly, in our study, grass pollen aeroallergen sensitization peaked in June and birch aeroallergen sensitization peaked in July.

The overall outdoor environment encompasses factors such as climate, biodiversity, and urban, social, and economic conditions that shape human interactions with the natural world (19). One notable health impact is the increase in allergic respiratory diseases triggered by increased atmospheric carbon dioxide and higher temperatures. These factors increase the concentration and aeroallergenicity of airborne particles such as pollen and fungal spores, leading to more severe symptoms (20). Higher temperatures before the pollen season have been associated with earlier pollen release (21). Furthermore, rain, wind, and sun may have contributed to the extension of the pollen season (22). There are studies indicating that grass and birch pollen seasons may be altered due to climate change, starting earlier and producing greater amounts (23, 24). However, despite these findings, we have not found any evidence demonstrating the effect of changes in pollen release timing on the sensitization profile. Studies spanning many years are likely necessary to observe this effect.

In patients with pollen monosensitization, symptoms persist only in the spring, while in patients with polysensitization, symptoms persist for several months or years (25). There are studies suggesting that monosensitization and polysensitization constitute two distinct phenotypes of AR, and polysensitization has been significantly associated with moderate to severe persistent AR (26). According to our data, the proportion of polysensitized patients was higher than that of monosensitized patients among those sensitized to both indoor and outdoor aeroallergens. However, because our clinic is located in a tertiary hospital, we believe that the higher proportion of polysensitized patients is likely due to the higher referral rate of patients with moderate and severe persistent rhinitis.

Although previous studies have shown no association between induration diameter and clinical symptoms (27, 28), we observed grass pollen diameter was significantly higher than other pollen aeroallergens.

Our study is valuable because it covers a total of 4 years, including a high patient participation rate, and especially data from the COVID-19 period, when people spent more time indoors. Aeroallergen sensitization was evaluated not only in patients residing in Kayseri province but also in other cities in Central Anatolia. Due to the retrospective nature of the study, detailed clinical findings and comorbidities of the patients could not be evaluated. Furthermore, due to seasonal variations in the brands and types of aeroallergen solutions provided by the institution, not all aeroallergens could be applied to all patients.

The diversity of our findings suggests that aeroallergen protection measures can be developed based on regional sensitization differences. In the coming years, there is a need for studies with wider participation, which will map detailed aeroallergen sensitization, especially pollen, according to the geographical characteristics of Türkiye.

References

1. Türkiye Ulusal Allerji ve Klinik İmmünoloji Derneği Alerjik-Rinit-Tani-ve-Tedavi-Rehberi https://www.aid.org.tr/wp-content/uploads/2022/11/Alerjik-Rinit-Tani-ve-Tedavi-Rehberi-2022-web-vers4.pdf

2. Bousquet J, Anto JM, Bachert C, et al. Allergic rhinitis. Nat Rev Dis Primers 2020; 6(1): 95.

3. Jo EJ, Eom JS, Mok J, et al. Patterns of sensitization to aeroallergens and their effect on airway hyper-responsiveness in Busan, Korea. Asian Pac J Allergy Immunol 2021; 39(3): 182-189.

4. Tantilipikorn P, Pinkaew B, Talek K, et al. Pattern of allergic sensitization in chronic rhinitis: A 19-year retrospective study. Asian Pac J Allergy Immunol 2021; 39(3): 156-162.

5. Valero A, Justicia JL, Antón E, et al. Epidemiology of allergic rhinitis caused by grass pollen or house-dust mites in Spain. Am J Rhinol Allergy 2011; 25(4): e123-128.

6. Erel F, Karaayvaz M, Calişkaner Z, Ozangüç N. The aeroallergen spectrum in Turkey and the relationships between aeroallergens and age, sex, birth month, birthplace, blood groups and family history of atopy. J Investig Allergol Clin Immunol 1998; 8(4): 226-233.

7. İğde M, İğde FA, Sancak R, Öztürk F. Orta Karadeniz Bölgesindeki çocuklarda allerji deri testi sonuçları. Turkiye Klinikleri Journal of Pediatrics. 2009;18(2):82-90.

8. Bilgir F, Uzum Y, Balikci O, Korkmaz UB, Dede B. Aeroallergen sensitivity in patients with allergic respiratory tract symptoms in Izmir and its Environs, Aegean Region of Turkey. Asthma Allergy Immunol 2023; 21: 120-127

9. Kökoğlu K, Kutlu Ö. Kayseri ilinde alerjik rinit hastalarının ve deri prick testi sonuçlarının değerlendirilmesi. KBB Uygulamaları 2020; 8(3): 137-144.

10. Kayseri İl Çevre Durum Raporu 2013, page 48 https://webdosya.csb.gov.tr/db/ced/editordosya/Kayseri_icdr2013.pdf

11. D'Amato G, Cecchi L, Bonini S, et al. Aeroallergenic pollen and pollen allergy in Europe. Allergy 2007; 62: 976-990.

12. Bousquet J, Guérin B, Hewitt B, Lim S, Michel FB. Allergy in the Mediterranean area. III: Cross reactivity among Oleaceae pollens. Clin Allergy 1985; 15(5): 439-448.

13. Evcen R, Çölkesen F, Yıldız E et al. Increasing Prevalence of Sensitization to Cat/Dog Aeroallergens in the COVID 19-19 Pandemic. Int Arch Allergy Immunol 2024; 185(2): 133-141.

14. Arslan B, Çetin GP, Yilmaz İ. Genetic predisposition and increased environmental aeroallergen exposure in cat allergy: The pandemic is a very good example. Allergol Immunopathol (Madr) 2025; 53(3): 1-7.

15. Yang X, Zhang J, Sima Y, et al. A multicenter time series study on pollen exposure and COVID 19-19 infection in five cities in China. Allergy 2023; 78(6): 1711-1713.

16. Sözener ZÇ, Öztürk BÖ, Aydın Ö, et al. Coincidence of pollen season and coronavirus disease 2019 pandemic: less time dış-ortams - lesser allergy symptoms in 2020. Asia Pac Allergy 2021; 11(2): e16

17. Sin BA, Inceoglu O, Mungan D, et al. Is it important to perform pollen skin prick tests in the season? Ann Allergy Asthma Immunol 2001; 86: 382-386.

18. Lam HCY, Jarvis D. ECRHS I Investigators. Seasonal variation in total and pollen-specific immunoglobulin E levels in the European Community Respiratory Health Survey. Clin Exp Allergy 2021; 51(8): 1085-1088.

19. Wild, C.P. The exposome: From concept to utility. Int J Epidemiol 2012; 41: 24-32.

20. Ziska LH. An Overview of rising CO_2 and climatic change on aeroallergens and allergic diseases. Allergy Asthma Immunol Res 2020; 12: 771-782.

21. Manangan A, Brown C, Saha S, et al. Long-term pollen trends and associations between pollen phenology and seasonal climate in Atlanta, Georgia (1992-2018). Ann Allergy Asthma Immunol 2021; 127(4): 471-480.

22. Lo F, Bitz CM, Battisti DS, Hess JJ. Pollen calendars and maps of aeroallergenic pollen in North America. Aerobiologia 2019; 35(4): 613-633.

23. Ziska LH, Makra L, Harry SK, et al. Temperature-related changesin airborne aeroallergenic pollen abundance and seasonality across thenorthern hemisphere: A retrospective data analysis. Lancet Planet Heal. 2019; 3: e124-e131.

24. Barnes CS. Impact of climate change on pollen and respiratory disease. Curr Allergy Asthma Rep 2018; 18: 59.

25. Gerth van Wijk R, Smits HH. Heterogeneity in allergic rhinitis: Explained by inducible mechanistic traits? J Allergy Clin Immunol 2021; 148(2): 358-360

26. Asha'ari ZA, Yusof S, Ismail R, Che Hussin CM. Clinical features of allergic rhinitis and skin prick test analysis based on the ARIA classification: A preliminary study in Malaysia. Ann Acad Med Singap 2010; 39: 619-624.

27. Madani S, Zandieh F, Ahmadi M, Parvizi M, Rezaei N. Does the reaction size of skin prick test associated with the allergic rhinitis symptom severity? Allergologia et Immunopathologia 2021; 49: 60.

28. Ryll LS, Rohlfing ML, Rubin SJ, et al. A prospective analysis of allergy skin-prick test wheal size association with symptom severity. In International Forum of Allergy & Rhinology,2021,Oct;11(10):1501-1503