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Research Article

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Allergen Sensitization Profiles in Patients Aged over Fifty from Southern China: A Multi-Center Study

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Abstract

Background: *Against the backdrop of China's rapidly aging population, the prevalence of allergic diseases among the middle-aged and elderly patients has shown a significant upward trend. This study aims to explore the sensitization of the patients aged over fifty in southern China and provide support for the prevention of allergic diseases in this group.*

Methods: *Retrospective analysis the real-world data of 3,387 suspected allergy patients aged over fifty who underwent 8 kinds of common allergen sIgE testing including Mold-Mix-1, Blattella germanica, Dermatophagoides pteronyssinus, Gallus domesticus, Bos domesticus, Cancer pagurus, Penaeus monodon and Canis familiaris from 14 central hospitals.*

Results: *Overall, B.germanica (25.8%) had the highest positive rate, followed by C.pagurus (23.4%), D.pteronyssinus (21.9%), and P.monodon (21.4%). For 50-59 years old, C.pagurus (58.4%) had the highest positive rate, but for 80-89 years old, B.domesticus (19.4%) had the highest positive rate. For D.pteronyssinus allergen, it`s showed the highest positive rates in the summer, and gradually decreasing until winter. In addition, 75.5% of patients were positive for at least one allergen, and the optimal scale analysis further indicated three main sensitization patterns for the study population: I. House dust and seafood-dominated; II. Mold and animal hair-dominated; III. Proteins-dominated (Cronbach's α = 0.929).*

Conclusion: *Totally, B.germanica, C.pagurus, D.pteronyssinus, and P.monodon were the main allergens in the study population. The sensitization of middle-aged and elderly with different characteristics was different, mainly in three patterns. In the context*

of health management, particular emphasis should be placed on the sensitization profile of middle-aged and elderly, which can be effectively prevention and control through allergen avoidance.

Keywords: Allergen Sensitization, Aging Population, House Dust Mite, Cockroach Allergy, Food Allergy, Mold Sensitization, Allergen Avoidance, Co-Sensitization, ImmunoCAP, Allergen; SIgE, Middle-Aged and Elderly, Clinical Laboratory, Real-World Study

1.Introduction

China's middle-aged and elderly population represents a substantial demographic cohort. In 2023, the proportion of the population aged 65 and over in China exceeded 15% for the first time, indicating China's formal transition into a moderately aging society according to the United Nations' population aging criteria [1,2]. According to data from the National Bureau of Statistics of China, in 2024, the population aged 50 and older accounted for 33% of the national demographic composition [3]. This middle-aged and elderly demographic has played a foundational role in China`s social development. As such, greater attention must be given to their health needs, particularly in the prevention and management of chronic diseases [4].

Allergic diseases are conditions caused by the human immune system's excessive reaction to certain typically harmless substances, such as pollen, dust mites, pet dander, food, or medication, and it`s one of the common chronic diseases in the 21st century. The main clinical symptoms include sneezing, runny nose, nasal congestion, itchy eyes, wheezing, and breathing difficulties. These symptoms not only reduce the quality of life for patients, but also impose a heavy economic burden on their families [5,6]. A multi-center epidemiological study in Europe indicated that the prevalence of allergic rhinitis among seniors aged 60 and older is about 20% [7]. In China, the lifestyle of middle-aged and elderly has changed, such as a reduction in outdoor activities, changes in dietary habits, and an increase in underlying diseases, which will lead to different allergy characteristics. Meanwhile, allergies can worsen the condition of their underlying diseases. For patients with heart disease, an allergic asthma attack may increase the burden on the heart, leading to symptoms such as difficulty breathing and chest tightness. For patients with sleep disorders, allergic diseases may exacerbate their condition [8,9]. However, there is still a lack of epidemiological surveys on allergies among middle-aged and elderly patients in China.

Therefore, this study retrospectively analyzed 8 common allergen detection data from 14 primary hospitals in southern China, collected from KMD Allergen Detection Center (the largest allergen testing center in South China), and aimed to investigate the distribution of allergen sensitization pattern of middle-aged and elderly in southern China, to provide guidance for allergen avoidance measure and evidence-based allergy prevention.

2. Method

2.1 Study Design

This was a retrospective study based on real-world medical data. The analysis was included 3,387 suspected allergy middle-aged and elderly (≥ 50 years) who underwent sIgE detection with ImmuoCAP (ThermoFisher, USA) from January 1, 2023 to December 31, 2024. Patients with cancer, immunodeficiency, immunotherapy, parasitic infection, autoimmune diseases and those with no data regarding age were excluded, and the remaining patients were enrolled in this study. Patients sought medical attention when suffering allergic symptoms. Based on the clinical presentation, physicians suspected an allergic etiology and subsequently ordered allergen testing. The following symptoms were considered as indications of a suspected allergy by doctors: dyspnea, wheezing and/or cough not attributable to common cold, runny nose, sneezing, nasal itching/obstruction, rashes, wheal, urticaria, abdominal pain, diarrhea, indigestion and itchy eyes. 8 common allergens were tested in KMD Allergen Detection Center: Mold (Mold mix 1: *Penicillium chrysogenum, Cladosporium herbarum, Aspergillus fumigates* and *Alternaria alternata*), cockroach (*Blattella germanica*), house dust mite (*Dermatophagoides pteronyssinus*), egg white (*Gallus domesticus*), milk (*Bos domesticus*), crab (*Cancer pagurus*), shrimp (*Penaeus monodon*) and dog dander (*Canis familiaris*) and this was according to the locally established allergen testing panel.

2.2 Detection Method

All serum samples were taken from the hospital`s clinic with separation gel vacuum coagulation tube in different regions in southern China (1237 from Guangdong, 232 from Jiangsu, 145 from Anhui, 356 from Yunnan, 134 from Chongqing, 167 from Sichuan, 297 from Guangxi, 169 from Guizhou, 256 from Shanghai, 115 from Zhejiang, 85 from Jiangxi, 87 from Hunan, 65 from Hainan, 42 from Hubei). A venous blood sample of 5 ml was drawn and centrifuged for 10 minutes at 3,000 r/min. They were then cold-chain delivered to KMD Allergen Detection Center from their respective area. Sera were analyzed using ImmunoCAP 1000 (ThermoFisher, USA) by trained technicians and the results were reported in kU/L, with ≥ 0.35 kU/L as a positive cutoff. Based on the RAST Class, the reactivity was categorized into six classes: Class 1 (≥ 0.35 kU/L to < 0.70 kU/L), Class 2 (≥ 0.70 kU/L to < 3.50 kU/L), Class 3 (≥ 3.50 kU/L to < 17.50 kU/L), Class 4 (≥ 17.50 kU/L to < 50.00 kU/L), Class 5 (≥ 50.00 kU/L to < 100.00 kU/L), and Class 6 (≥ 100.00 kU/L).

2.3 Statistical Method

Data was analyzed using SPSS 22.0 (IBM Corp, Armmonk, NY, USA). Normally distribution data, such as age were presented as mean ± standard deviation. Non-parametric quantitative data such as sIgE levels were presented as median (25th and 75th percentiles). Qualitative information such as positive rate was presented as percentage or frequency. Inter-group difference was assessed using the chi-square test ($\chi 2$). Correlations between non-parametric data were analyzed using Spearman's tests, with correlation coefficients presented as "rs". Interrelationship between allergens was analyzed using optimal scale analysis, and statistical significance was defined as $P < 0.05$.

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2.4 Ethics Approval and Informed Consent

Approval was obtained from the ethics committee of Shangrao People's Hospital (2023-092). All methods were performed in accordance with the relevant guidelines and regulations. The informed consent of patients was obtained by Biobank for KMD Allergen Detection Center which informed each patient that their clinical examination data would be used for possible future studies.

3. Result

3.1 Overall Status of Middle-Aged and Elderly Patients

A total of 3,387 patients were included in this study, with 47.3% male (n = 1601) and 52.7% female (n = 1786), and the average age was 61 years. Among them, 1582 were ≥ 60 years, 634 were ≥ 70 years, 196 were ≥ 80 years and 14 were ≥ 90 years. 75.5% of patients were positive for at least one allergen, 53.6% positive for inhaled allergens and 40.4% positive for food allergens. Among the inhaled allergens, the highest sensitization rate was *B.germanica* (25.8%), followed by *D.pteronyssinus* (21.9%), Mx1 (4.0%), and C.familiaris (4.3%). For food allergens, the highest sensitization rate was P.monodon (21.4%), followed by C.pagurus (23.4%), G.domesticus (4.5%), and *B.domesticus* (2.1%). The average concentration of allergens positive in positive patients was shown in Table 1. In addition, for all allergens, patients were mainly concentrated in the middle or low class (Class 1-3). (Table.2)

Characteristic	**Patient**
Total (N)	3,387
Age (years)	61.00 ± 9.68
Gender (Male/Female, n)	1,601/1,786
Disease (n, %)	
Respiratory symptom	1212, 35.8%
Skin symptoms	1361, 40.2%
Other	814, 24.0%
Season (n, %)	
Spring	800, 23.6%
Summer	1023, 30.2%
Autumn	812, 24.0%
Winter	752, 22.2%
Positive rate for allergen (n, %)	
D.pteronyssinus	710, 21.9%
C.familiaris	120, 4.2%
B.germanica	851, 25.8%
G.domesticus	109, 4.5%
B.domesticus	62, 2.1%
C.pagurus	533, 23.4%
P.monodon	665, 21.4%
Mx1	133, 4.0%
Positive level for allergen (kU/L)	
D.pteronyssinus	0.59 (0.35, 1.11)
C.familiaris	0.47 (0.35, 0.66)
B.germanica	0.56 (0.35, 0.95)
G.domesticus	0.43 (0.35, 0.57)
B.domesticus	0.46 (0.35, 0.69)
C.pagurus	0.54 (0.35, 0.88)
P.monodon	0.50 (0.35, 0.85)
*Mx1	0.65 (0.45, 1.85)

*Mx1: Mold mix 1, Respiratory symptom: Patients with respiratory related symptoms who seek medical attention in the respiratory department; Skin symptoms: Patients with skin related symptoms seeking medical assistance in dermatology

Table 1: Baseline Data of Middle-Aged and Elderly Patients

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Positive number for inhalation allergen (n, %)	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
D.pteronyssinus	223, 31.4%	326, 45.9%	107, 15.1%	37, 5.2%	13, 1.8%	4, 0.6%
B.germanica	306, 36.0%	433, 50.9%	103, 12.1%	8, 0.9%	1, 0.1%	0, 0.0%
C.familiaris	62, 51.7%	41, 34.2%	13, 10.8%	4, 3.3%	0, 0.0%	0, 0.0%
*Mx1	73, 54.9%	56, 42.1%	4, 3.0%	0, 0.0%	0, 0.0%	0, 0.0%
Positive number for ingestive allergen (n, %)						
G.domesticus	60, 55.1%	45, 41.3%	4, 3.7%	0, 0.0%	0, 0.0%	0, 0.0%
B.domesticus	33, 53.2%	21, 33.9%	7, 11.3%	1, 1.6%	0, 0.0%	0, 0.0%
C.pagurus	204, 38.3%	267, 50.1%	53, 9.9%	8, 1.5%	1, 0.2%	0, 0.0%
P.monodon	278, 41.8%	320, 48.1%	59, 8.9%	7, 1.1%	0, 0.0%	1, 0.2%

*Mx1: Mold mix 1

Table 2: Severity of Sensitization in Middle-Aged and Elderly Patients

3.2 Sensitization Rates Among Different Age Groups and Disease Group

All the allergens had the highest positive rate in 50-59 years groups, and the positive rate gradually decreases with age.For 50-59 years, *C.pagurus* (58.4%) had the highest positive rate, follow by *B.germanica* (57.8%) and *D.pteronyssinus* (57.5%). For 60-69 years, *G.domesticus* (29.4%) had the highest positive rate, follow by *B.germanica* (28.0%) and Mx1 (27.8%). For 70-79 years, B.domesticus (24.2%) had the highest positive rate, follow by Mx1 (18.8%) and *C.familiaris* (15.0%). For 80-89 years, *B.domesticus* (19.4%) had the highest positive rate, follow by *G.domesticus* (10.1%) and *C.familiaris* (7.5%). For 90-99 years, *D.pteronyssinus* (0.3%) had the highest positive rate, follow by *B.germanica* (0.2%) and *P.monodon* (0.2%). (Figure 1a) Among patients with respiratory symptoms, the positive rates of *B.germanica* (33.5% vs. 19.1%, χ^2= 53.5, P < 0.001), and *D.pteronyssinus* (29.1% vs. 16.7%, χ^2= 10.9, P < 0.001) were higher than those with skin symptoms. (Figure 1b).

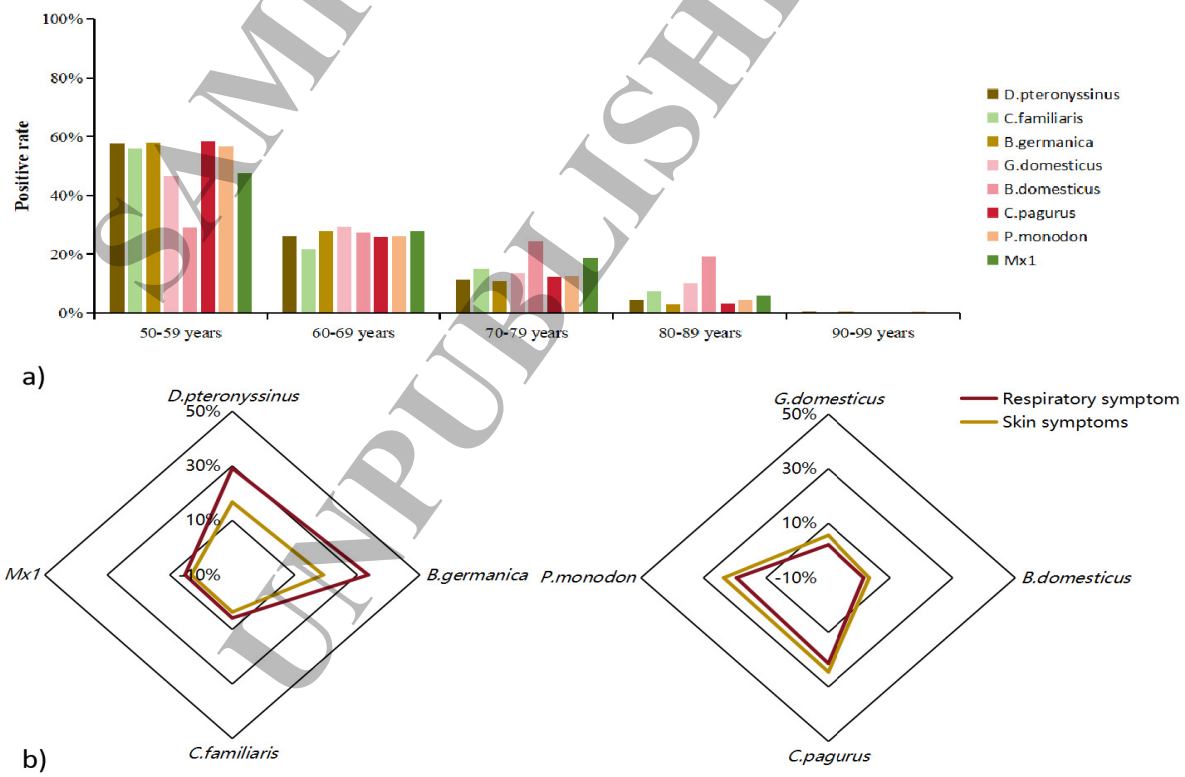

Figure 1: Sensitization Rate of Middle-Aged and Elderly Patients with Different Characteristics
a) Bar chart of sensitization rate in middle-aged and elderly patients with different age groups. b) Radar chart of sensitization rate of middle-aged and elderly patients with different diseases. Mx1: Mold mix

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3.3 Sensitization Rates in Different Seasons

The sensitization of allergens varies in different seasons, in spring, the positive rates of B.domesticus was the highest; in summer, the positive rates of mx1 was the highest (38.3%); in autumn, the positive rates of G.domestieus was highest (28.4%); and in winter, the positive rates of C.familiaris was the highest (20.8%). For P.monodon allergen, it`s showed the highest positive rates in the summer (34.8%), and gradually decreasing, showed lowest positive rates in the winter (19.9%). (Figures 2a) For D.pteronyssinus allergen, it`s showed the highest positive rates in the summer (34.6%), and gradually decreasing, showed lowest positive rates in the winter (20.0%). (Figures 2b) For B.germanica allergen, it`s showed the highest positive rates in the summer (33.6%), and gradually decreasing, showed lowest positive rates in the winter (19.6%). (Figures 2c) For C.familiaris allergen, it`s showed the highest positive rates in the summer (32.5%), and gradually decreasing, showed lowest positive rates in the winter (20.8%). (Figures 2d) For mould allergen, it`s showed the highest positive rates in the summer (38.4%), and gradually decreasing, showed lowest positive rates in the winter (16.5%). (Figures 2e) For C.pagurus allergen, it`s showed the highest positive rates in the summer (37.9%), and gradually decreasing, showed lowest positive rates in the winter (17.6%). (Figures 2f) For G.domesticus allergen, it`s showed the highest positive rates in the summer (37.6%), and gradually decreasing, showed lowest positive rates in the winter (9.2%). (Figures 2g) For B.domesticus allergen, it`s showed the highest positive rates in the summer (30.7%), and gradually decreasing, showed lowest positive rates in the winter (16.1%). (Figures 2h).

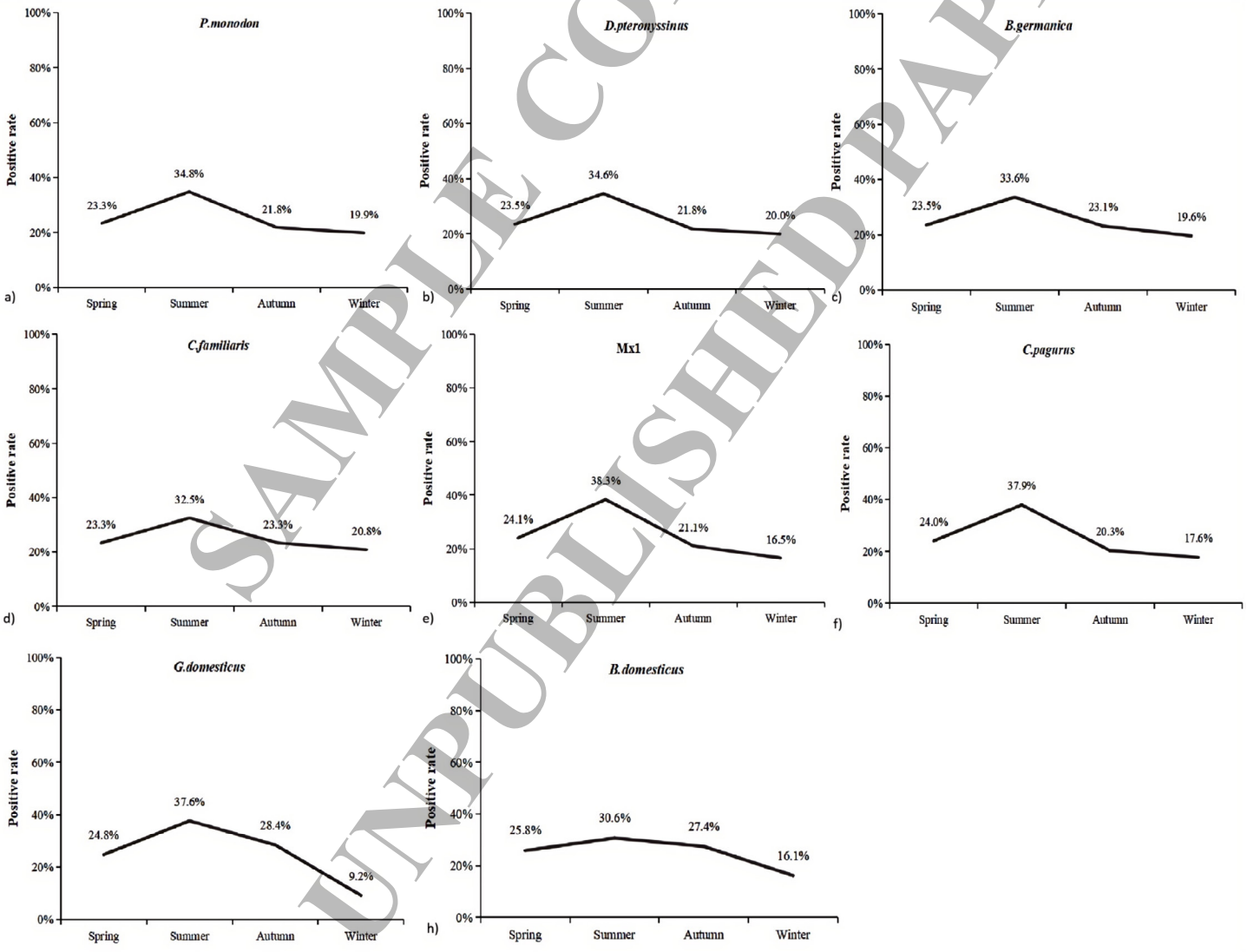

Figure 2: Sensitization Rate of Middle-Aged and Elderly Patients in Different Seasons

Line chart analysis the sensitization rates of a) *P.monodon*; b) *D.pteronyssinus*; c) *B.germanica*; d) *C.familiaris*; e) mould allergen, Mx1: Mold mix 1; f) *C.pagurus*; g) *G.domesticus*; h) B.domesticus in different seasons.

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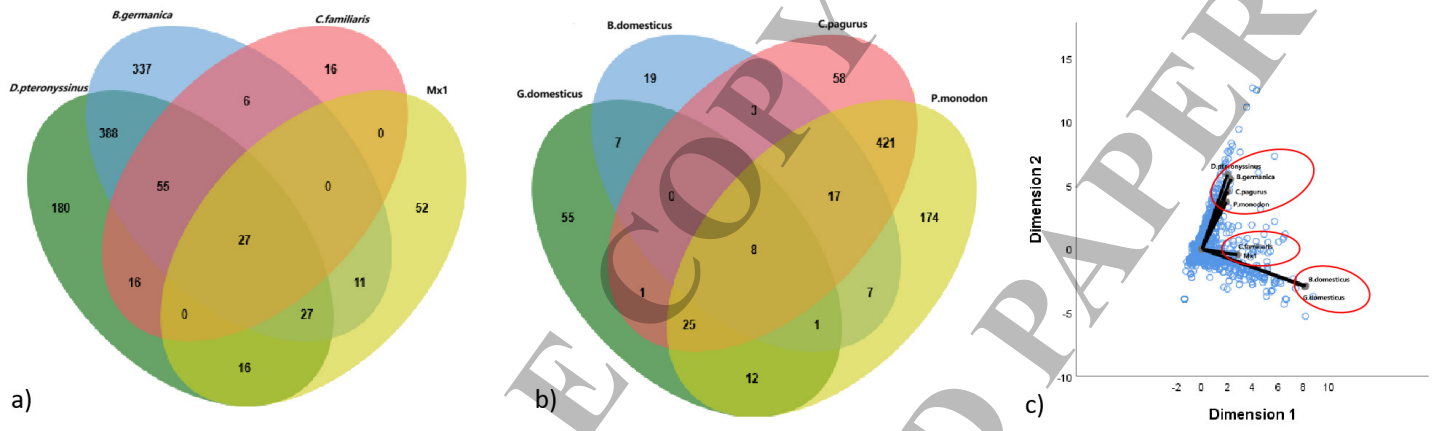
3.4 The Correlation Between Allergens and Patients` Sensitization Patterns

Overall, 23.0% patients was poly-sensitization, and 16.3% was positive for more than three allergens. For inhaled allergens, the rate of co-sensitization to both *D.pteronyssinus* and *B.germanica* was the highest, reaching 34.3%, followed by the positive for *B.germanica* alone, reaching 29.8%. (Figure 3a) For food allergens, the rate of co-sensitization to both *C.pagurus* and *P.monodon* was the highest, reaching 52.1%, followed by the positive for P.monodon alone, reaching 21.5%. (Figure 3b) The optimal scale analysis further indicated three main sensitization patterns for middle-aged and elderly: I. House dust and seafood-dominated [*D.pteronyssinus, B.germanica, C.pagurus, P.monodon*]; II. Mold and animal hair-dominated [*C.familiaris*, Mx1]; III. Proteins-dominated [*B.domesticus, G.domesticus*] (Cronbach's α = 0.929). (Figure 3c) The Spearman's analysis revealed strong correlations among specific allergens: *P.monodon* showed strong correlations with B.germanica ($r_s = 0.836$, $P < 0.001$). And *C.familiaris* showed strong correlations with *D.pteronyssinus* ($r_s = 0.638$, $P < 0.001$). (Figure 3d).



Mx1	*D.pteronyssinus*	*C.familiaris*	*B.germanica*	*G.domesticus*	*B.domesticus*	*C.pagurus*	*P.monodon*	*r s*
-	0.267	0.311*	0.014	0.153	0.132	-0.004	0.021	**Mx1**
	-	0.638*	0.176	0.200	0.233	0.168	0.195	***D.pteronyssinus***
		-	0.151	0.248	0.377*	0.174	0.168	***C.familiaris***
			-	0.063	0.086	0.207	0.836*	***B.germanica***
				-	0.448*	0.116	0.102	***G.domesticus***
					-	0.064	0.112	***B.domesticus***
						-	0.233	***C.pagurus***
							-	***P.monodon***

d)

Figure 3: Multi Sensitization in Middle-Aged and Elderly Patients
Venn diagram analysis the combined positive cases: a) inhaled allergens and b) ingested allergens, respectively. c) Optimal scale analysis the sensitization patterns in middle-aged and elderly patients, divided into three categories (Cronbach's α = 0.929), the shorter the distance between points, the closer the connection, and classification is based on this. d) Spearman correlation analysis the correlation coefficients between allergens. Mx1: Mold mix 1

4. Discussion

Allergen detection was the primary step in avoiding allergens. Analyzing the positive rate of allergens in middle-aged and elderly in the region can effectively provide a basis for the prevention and control of allergic diseases in the area [10]. This study found that for patients aged over fifty, *B.germanica* had the highest positive rate, followed by *C.pagurus, D.pteronyssinus*, and *P.monodon* in South China. A survey on allergies from 14 research centers in southern Italy show that Parietaria represent the most common sensitizing agent, followed by dust mites, grass pollen and Olea europaea [11]. The sensitization of patients varies in different regions, when they show symptoms of allergy such as wheezing, unexplained runny nose, rash, wheals and chronic cough, timely allergen detection should be carried out [12]. Avoiding allergens based on the detection results was the most effective way to prevent and control the attack of allergic diseases in them.

In addition, the main allergens of patients in different age groups were different, although the positive rate of allergens decreases with age, the proportion of food allergies and mold allergies in all allergies was increasing. A study from Tokyo, Japan shows that as the age of inclusion of patients with allergic diseases increases, the positive rate of house dust mite allergens decreases from 60% at the age of 20-29 to 30% at the age of 59-60 [13]. Another study from Germany showed that the positive rate of fungal sensitization did not change significantly with age, and remained at around

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10%, especially among the middle-aged and elderly, the proportion of fungal sensitization may increase [14]. Due to the weaker immunity of the middle-aged and elderly, fungal spores can enter the respiratory tract through the air, while hyphae degrade mucosal cells and extracellular matrix by secreting enzymes (such as proteases and phospholipases), invade tissues, and trigger allergic reactions [15]. Therefore, keep the room dry and regularly clean to prevent mold growth were important ways to prevent fungal sensitization. Further, it is being discovered that, food allergies was regarded as a pediatric problem, since some of them start in early childhood and may spontaneously disappear in adulthood. However, on the contrary, these problems were increasingly affecting even the middle-aged and elderly according to our results. Massimo De Martinis, et al report that several factors render the older susceptible to food allergies, including the physiological changes of aging, a decline in gut barrier function, the skewing of adaptive immunity to a Th2 response, dysregulation of innate immune cells, and age-related changes of gut microbiota. We also fround that among patients with respiratory symptoms, the positive rates of D.pteronyssinus, and B.germanica were higher than those with skin symptoms [16]. A study from New York was suggested that sensitivity to particular allergens such as the indoor allergens, dust mite and cockroach, were more prominently associated with the presence of asthma in an middle-aged and elderly population, which was consistent with our research [17].

Besides, the sensitization of allergens was also different in different seasons, however, the positive rates for allergens to D.pteronyssinus was highest throughout the year. This is similar to our previous research, which survey of 39,813 adults and children showed that most allergens were also high in summer and low in winter, with the highest dust mite positivity rate throughout the year [18]. The warm and humid climate in the south leads to the breeding of a large number of dust mites, and dust mite debris, feces, etc. are easily inhaled, causing sensitization [19].

Interestingly, for inhaled allergens, the rate of co-sensitization to both D.pteronyssinus and B.germanica was the highest, while for food allergens, the rate of co-sensitization to both C.pagurus and P.monodon was the highest. Our previous research has also shown that 75.0% of shrimp sensitized patients were positive for moth, D.pteronyssinus, cockroach and crab at the same time [20]. This was caused by cross-reactivity between allergens. If there were identical or similar cross epitopes between two allergens, when a patient was sensitization to one allergen, they will also sensitization to the other. Meanwhile, the optimal scale analysis further indicated three main sensitization patterns for middle-aged and elderly: I. House dust and seafood-dominated; II. Mold and animal hair-dominated; III. Proteins-dominated. Therefore, for middle-aged and elderly in the same sensitization mode, in addition to avoiding allergens that test positive, attention should also be paid to allergens that cause cross reactions or co sensitization [21].

This was the first report on the allergy situation of middle-aged and elderly in southern China based on real-world data analysis. A limitation of this study was the lack of detailed clinical information, such as lung function, induced sputum, etc, this needs to be supplemented by prospective studies in the future. Meanwhile, the sample size of the study may be insufficient, which may result in some bias in the data, especially for the age group of 90 and above, but this also reflects real-world data, where the older one gets, the fewer people seek medical attention for allergies. Finally, in order to facilitate clinical operations and avoid the risk of adverse reactions, our study enrolled patients through clinical symptoms and quantitative detection of sIgE in vitro. And the study currently includes only 8 allergens to detection, some potential allergens may be missing, which requires further improvement in the future.

5. Conclusion

In summary, *B.germanica, C.pagurus, D.pteronyssinus*, and *P.monodon* were the main allergens in our study. Food allergies need to be taken seriously among middle-aged and elderly. The sensitization rate of patients with different characteristics was different, mainly in three patterns (I. House dust and seafood-dominated; II. Mold and animal hair-dominated; III. Proteins-dominated). In the context of health management, particular emphasis should be placed on the sensitization profile of middle-aged and elderly, which can be effectively prevention and control through allergen avoidance.

Declarations

Ethics approval and consent to participate

Approval was obtained from the ethics committee of Shangrao People's Hospital (2023-092). All methods were performed in accordance with the relevant guidelines and regulations. The informed consent of patients was obtained by Biobank for KMD Allergen Detection Center which informed each patient that their clinical examination data would be used for possible future studies.

Data Availability

The datasets generated and/or analysed during the current study are not publicly available due the need for further research, but are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Author's Contributions

Conceived and designed the experiments: CX. Performed the experiments: YCX, DDC. Analyzed the data: LSX. Wrote the paper:

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YQZ, PZ. All authors read and approved the final manuscript.

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