BANGLADESH JOURNAL OF
OTORHINOLARYNGOLOGY
DOI: https://doi.org/10.3329/bjo.v29i2.72273
www.banglajol.info

Article info
Received : 03-06-2023
Accepted : 07-10-2023
No. of Tables : 45
No. of Figure : 01
No. of References : 18

Original Article

Distributive pattern of aero-allergen sensitivity among patients with naso-bronchial allergy in a tertiary care center of North India

Singh AP[1], Rawat J[2], Pandey AK[3], Hernot S[4], Jangpangi DS[5]

Abstract:

Objective: *The aims of our study are to determine the pattern of allergen sensitivity among patients with Naso-bronchial allergy and to determine the difference between the pattern of allergen sensitivity among 3 groups- Bronchial asthmas, allergic rhinitis, and bronchial asthma with allergic rhinitis.*

Methodology: *A total of 50 patients with nasobronchial allergy who had either presented to the OPD of the Department of Respiratory Medicine or were referred from the Otorhinolaryngology Department fulfilling the inclusion criteria were included in this prospective observational study conducted from June 2019 to June 2021. A total of 48 antigens were used on 50 patients for Skin prick testing and results were recorded.*

Result: *We observed that all allergens showed positive results however significant positive reaction was seen most commonly in House dust mites (37.3%) and insects (26%) followed by Dust (22.6%), and Dander (20%).*

Conclusion: *Our study concludes that the variation in the prevalence of allergen reactivities in different regions is due to different geo-climatic conditions and adaptation of specific microbiological flora and fauna to a specific climate, pollution, and lifestyle change.*

Keywords: *Nasobronchial allergy; Allergic Rhinitis; Asthma; Aeroallergens; Skin Prick Test*

Cite the Article: Singh AP, Rawat J, Pandey AK, Hernot S, Jangpangi DS. A Study on the distributive pattern of aero-allergen sensitivity among patients with naso-bronchial allergy in a tertiary care center of North India. Bangladesh J Otorhinolaryngol 2023; 29(2): 55-66

1. Dr. Abhay Pratap Singh, Junior Resident (Pulmonary medicine),Department of Pulmonary Medicine.Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun
2. Dr. Jagdish Rawat ,Professor & Head, Department of Pulmonary Medicine, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun
3. Dr. Apoorva Kumar Pandey , Professor, Department of ENT and Head-Neck surgery, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun
4. Dr. Sharad Hernot ,Assistant Professor, Department of ENT and Head-Neck surgery, Sri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun
5. Dr. Dev Singh Jangpangi, Professor ,Department of Pulmonary Medicine, Sri Guru Ram Rai Institute of Medical and Health Sciences, Patel Nagar, Dehradun,

Correspondence: Dr. Apoorva Kumar Pandey, Professor, Department of ENT, Sri Guru Ram Rai Institute of Medical and Health Sciences, Patel Nagar, Dehradun, 248001, Uttarakhand, India, Cell Phone: +91- 9411324477, Email id - pande.apoorva@gmail.com ORCID id-0000-0001-6974-8031

Introduction:

Respiratory allergy is a major form of allergy and airway allergy is now thought of as a disorder affecting the respiratory tract in its entirety.[1,2] The word naso-bronchial allergy is used very commonly for the reason that nasal and bronchial allergy co-exist or precede each other. For this reason, the concept of one airway, one disease was given by Grossman (1997) and hence is also referred to as United Airway Disease, the Rhino-sino-bronchitis.[3,4].

Types of aeroallergens differ variedly depending upon the geographic region and climate. India, due to its huge size and varied climatic conditions, has a wide range of allergens in different regions.[1] There is a dearth of information due to very few studies that have been conducted in our region of interest. This led to the conception of this study with the aim to determine the pattern of allergen sensitivity among patients with Naso-bronchial allergy, and to determine the difference between the pattern of allergen sensitivity among 3 groups - Bronchial asthmas, allergic rhinitis, and bronchial asthma with allergic rhinitis.

Materials and methods:

This was a prospective observational study conducted from June 2019 to June 2021, on OPD patients with nasobronchial allergy in the department of Respiratory Medicine of a tertiary care hospital and also on all the referred cases from the otorhinolaryngology department of the hospital. The inclusion criteria were:

1. Clinical Symptoms and signs of rhinitis (as per allergic rhinitis and its impact on asthma (ARIA) guidelines).[5]
2. Clinical symptoms and signs of bronchial asthma [as per Global Initiative for Asthma (GINA) guideline][6]
3. All cases of asthma with or without rhinitis were included in the study.

The exclusion criteria were as follows:

1. Cases with Age < 15yrs or > 50yrs
2. Pregnant and lactating women
3. Patients with generalized skin disease/ dermographism
4. Patient with cardiac disease
5. Active pulmonary tuberculosis
6. Immunocompromised state

After a review of clinical history, and physical examination along with all investigations, patients were selected based on inclusion and exclusion criteria. A proforma was prepared which was used to collect the patient's demographic data, clinical history, past history, duration of illness, seasonal exacerbations of symptoms, family history, general ENT examination, chest examination, other systemic examinations.Routine investigations like Complete Blood Count with absolute eosinophil count, Chest X-ray PA view, Total serum IgE, and Spirometry (for the degree of reversibility in FEV1) were done.After the diagnosis of patients , skin prick tests (SPT) were performed on the patients. Before performing SPT, oral drugs including antihistamines, steroids, and any other drugs considered to affect SPT were stopped 48 hours before the test.

Skin prick test **(Fig.1**):

Fig. 1: *Figure showing Skin Prick test*

Site of application: The sites used for the skin prick test were the volar surface of the forearm, upper arm, and back. The test was performed with purified extracts of various allergens like pollens, weeds, trees, fungi, insects, animal danders, various dust and mites, and feathers obtained from Evexia Life Sciences Private Limited. In case of an anaphylactic reaction, bedside resuscitative measures were always kept ready.

Antigen extract: 1:10 concentration in glycerinated buffer saline

Negative Control: Glycerinated buffered saline

Positive Control: Histamine acid phosphate in glycerinated buffer saline (1mg/ml)

Skin Testing:

The positions for skin pricks were marked by numbers on the skin to identify the allergen, and pricks were made by a Lancet at 45 degrees and the skin was raised with the needle for proper exposure to allergen. Allergens were placed at least 2 cm apart to avoid overlapping reactions and false-positive results. Allergens were applied in the form of drops before pricking the skin. Reading of the test was done after 15 to 20 minutes of prick test.

Measurement of result:

Wheal reaction for every allergen was measured with a transparent ruler. If the reaction was a circular wheal, one measurement of the diameter (in mm) was sufficient; if ovoid or irregular, it was measured by calculating the mean diameter as (D + d)/ 2.

D = largest diameter, and

d = orthogonal or perpendicular diameter at the largest width of D .

Grading of the skin prick test reaction was done by comparison to the negative control and it is described below.Only 2+, 3+, 4+, reactions were labeled as significant positive reactions because of the high incidence of 1+ reactions in non-allergic people.

Grading System for Skin Prick Test[7]

Grade of Skin response	Wheal of positive reactions
Negative= (Negative Control)	0 mm
1+	<3 mm above the negative control
2+	≥3 mm and <5 mm above the negative control
3+	≥5 mm and <7 mm above negative control
4+	≥7 mm and <9 mm above negative control

Statistical analysis: Data were analyzed using the statistical package SPSS (SPSS version 22 for Windows; IBM SPSS Inc., Chicago, IL). Data were expressed as numbers (percentage) and continuous variables were expressed as Mean ± SD. Categorical data is to be compared using the chi-square test. A p-value of < 0.05 will be considered statistically significant.

Results:

This study was conducted for a period from June 2019 to June 2021. During this period, 58 patients attended the Respiratory Medicine Department, however, a total of 50 patients met the eligibility criteria and were included in the study for the initial diagnosis of naso-bronchial allergy.

Out of 50 cases, 30 cases (60%) had perennial distribution, while only 20 cases (40%) had seasonal distribution. Out of 50 patients in the study, 19 (38%) were males and 31 (62%) were females. Most of the male and female patients were in the age group of 15-30 years. (Table I).

Table I : *Age and gender-wise distribution of the patients*

Age Group (yrs.)	Male		Female	
	Number	% age	Number	% age
15–30	16	84.21%	14	45.16%
31-40	0	0	08	25.81%
41-50	03	15.78%	09	29.03%
Total	19	100	31	100

Among 50 patients, 30 were in the younger age group (15-30 years). Out of 30 patients, 9 (30.0%) patients had Allergic Rhinitis, 5 (16.7%) had Bronchial Asthma and 16(53.3%) had both Allergic Rhinitis and Bronchial Asthma. In the other age groups, the pattern of distribution of Allergic Rhinitis and Bronchial Asthma was as follows: (Table II, A).

The disease is more common in females than males. Out of 31 patients, 16 (51.6%) females had both Allergic Rhinitis and Bronchial Asthma. However in males, the most common was also Allergic Rhinitis along with Bronchial Asthma followed by Allergic Rhinitis (Table II, B).

Table II : *Distribution of patients age and gender wise according to their respiratory allergy*

(A) Age distribution of patients

Age Group (Yrs.)						
Diagnosis	15 -30 yrs		31 – 40 yrs		41 – 50 yrs	
	Number	%age	Number	%age	Number	%age
Allergic Rhinitis	9	30 %	2	25%	3	25 %
Bronchial asthma	5	16.7 %	2	25%	4	33.3 %
Allergic Rhinitis + Bronchial Asthma	16	53.3 %	4	50%	5	41.7 %
Total	30	100	8	100	12	100

(B) Sex distribution of patients

Diagnosis	Male		Female	
	Number	%age	Number	%age
Allergic Rhinitis	8	42.1 %	6	19.4 %
Bronchial asthma	2	10.5 %	9	29%
Allergic Rhinitis + Bronchial Asthma	9	47.4 %	16	51.6%
Total	19	100	31	100

Table III shows the number of allergens in each group and the total test performed in each group.

Table III: *Tests of different allergens*

Group of allergens	No. of patient	No. of allergen in group	Total test performed
Insects	50	05	250
House dust mite	50	03	150
Dust	50	03	150
Pollen	50	16	800
Wool	50	01	50
Food	50	05	250
Feathers	50	02	100
Dander's	50	01	50
Fungus	50	09	450
Pets	50	02	100
Pigeon dropping	50	01	50
Total	50	48	2400

As shown in Table 4 (A), among Grass pollen, Cynodon (28%) was the most common allergen with a maximum percentage of significant reaction, followed by others.

Table IV: *Positive reactions of different allergens on SPT*

	Total number of tests performed	Positive test	
		Number	%age
(A) Grass pollen allergen group			
Cenchrus barbatus	50	7	14%
Cyprus Rondus	50	5	10%
Ischaemum Indicum	50	11	22%
Cynodon	50	14	28%
Total	200	37	18.5%
(B) Weed pollen allergen group			
Parthenium	50	7	14%
ArgemoneMexicana	50	14	28%
Amaranthus	50	15	30%
BrassicaNigra	50	15	30%
ChenopodiumAlbum	50	14	28%
ChenopodiumMurale	50	13	26%
Total	300	78	26%

Table IV: *Positive reactions of different allergens on SPT (Cont'd)*

	Total number of tests performed	Positive test	
		Number	%age
(C) Tree pollen allergen group			
Prosopis Juliflora	50	8	16%
Putranjiva Roxburghii	50	4	8%
Eucalyptus	50	7	14%
Cassia Siamea	50	4	8%
Holoptelean Integrifolia	50	7	14%
Ricinus Communis	50	8	16%
Total	300	38	12.6%
(D) Fungal allergen group			
Alternaria Alternata	50	1	2%
Aspergillus Fumigatus	50	8	16%
Aspergillus Niger	50	3	6%
Candida Albicans	50	6	12%
Cladosporium	50	2	4%
Curvularia	50	6	12%
Rhizopus Nigricans	50	8	16%
Aspergillus Flavus	50	5	10%
Aspergillus Tamarii	50	3	6%
Total	450	42	9.3%
(E) Dust allergen group			
Cotton Dust	50	12	24%
House Dust	50	12	24%
Paper Dust	50	10	20%
Total	150	34	22.6%
(F) Insect allergen group			
Cockroach	50	25	50%
Mosquito	50	14	28%
House Fly	50	11	22%
Moth	50	6	12%
Rice Weevil	50	9	18%
Total	250	65	26%

Table IV: *Positive reactions of different allergens on SPT (Cont'd)*

	Total number of tests performed	Positive test	
		Number	%age
(G) Feather allergen group			
Chicken Feather	50	6	12%
Pigeon Feather	50	7	14%
Total	100	13	13%
(H) Dander allergen group			
Buffalo Dander	50	10	20%
Total	50	10	20%
(I) Pigeon droppings allergen group			
Pigeon Dropping	50	6	12%
Total	50	6	12%
(J) Wool allergen group			
Sheep	50	5	10%
Total	50	5	10%
(K) Pets allergen group			
Cats	50	5	10
Dogs	50	13	26
Total	100	18	18
(L) House dust mites allergen group			
House Dust Mite (D. Farinae)	50	20	40%
House Dust Mite (D. Pteronyssinus)	50	18	36%
House Dust Mite (Blomia)	50	18	36%
Total	150	56	37.3%
(M) Foods allergen group			
Curd	50	9	18%
Wheat	50	18	36%
Bajra	50	11	22%
Tea	50	6	12%
Peanut/Groundnut	50	6	12%
Total	250	41	16.4%

Among Weed pollen [Table 4 (B)], Amaranthus and Brassica both had the same percentage (30%) (also the most common) followed by others. As mentioned in Table 4 (C), among Tree pollen, Prosopis Juliflora (16%) and Ricinus Communis (16%) were the most common followed by others.Among Fungal allergens, Aspergillus Fumigatus (16%) and Rhizopus Nigricans (16%) were the most common followed by others [Table 4 (D)].

Among the Dust group of allergens most common significant reaction was shown by House Dust (24%) and Cotton Dust (24%) followed by Paper Dust (20%) [Table 4 (E)]. Among Insects, most common allergen was Cockroach (50%) and the least common was Moth (12%) [table 4 (F)].

Among Feather allergens most common was Pigeon (14%) followed by Chicken (12%) [table no 4 (G)]. The percentage of Buffalo Dander allergen was (20%),pigeon-dropping allergen was 12% and sheep wool allergen was 10% [Table 4 (H,I,J)].

Among the Pet allergens, the more common allergen sensitivity was towards Dog (26%) and cats(10%) [Table 4 (K)].In House dust mite most common was D.Farinae (40%) followed by others[Table 4 (L)]. Among the Food allergens, Wheat (36%) was the most common followed by others [Table 4 (M)].

As shown in Table 5 significant reaction is most common in-House dust mite (37.33%), followed by others and the least common was Fungus (9.3%).

Table V: *Distribution of offending allergens*

Allergen Group	Total test Performed	Positive test	Percentage
Insects	250	65	26%
House Dust Mite	150	56	37.33%
Dust	150	34	22.67%
Pollen	800	153	19.13%
Wool	50	5	10%
Food	250	41	16.40%
Feathers	100	13	13%
Dander's	50	10	20%
Fungus	450	42	9.33%
Pets	100	18	18%
Pigeon Dropping	50	6	12%
Total	2400	419	17.46%

Discussion:

The common allergens include pollen grains, fungal spores, house dust mites, house dust, animal dander, insect emanations, drugs, food, etc. This study shows a relative predominance of specific allergens in the region of study responsible for naso-bronchial allergy. In the present study, a total of 2400 skin tests (419 positive and 1981 negative) were performed with 48 allergens.

In this study out of 50 patients with naso-bronchial allergy, the majority of patients (76.0%) belong to the 15-40 years age group (mean 30.88 +/- 9.18 years). Similarly, Prasad et al (8) found in their study that all the patients with nasobronchial allergy in their study were between 12 to 45 years of age and the majority were less than 30 years of age. Giridhar et al (9) also found in their study that 85% of patients belong to the age group between 12-40 years.[9]

In our study, the females were more affected than the males, and the female-to-male ratio was 1.6:1. Agrawal et al[10] had similar results and found that 33 (66%) patients were females and 17(34%) were males in their prospective study. Gowda et al[11] studied 139 patients with bronchial asthma and found that 56 (40.29%) were males and 83 (59.71%) were females. A retrospective analysis of the ECRHS I (European Community Respiratory Health Survey) data estimated the incidence of asthma according to gender and at different periods of life—

- During childhood, girls have a significantly lower risk of developing asthma than boys.
- At puberty, the risk is more or less equal in both sexes from puberty to adulthood.
- However, the risk is higher in adult women as compared to adult men.[12]

In our study, we found that insects were the second most common allergens after house dust mites showing significant reactions in 26% of patients. Raj Kumar et al[13] conducted a study in the Delhi region and found that insects were the most common allergens and Moth (33%) was the most common allergen showing significant positive reaction followed by the mosquito (31.92%) and housefly (26.36%). Prasad et al[8] conducted a study in Lucknow and found female locust (33.3%) was the most common allergen followed by male locust (25%), grasshopper (20.8%), cricket (16.7%), female cockroach (16.7%), and male cockroach (14.6%). We concluded, like the other studies conducted in other parts of India, that the insect group formed the most common allergen group but the species of insect group varied among different studies.

In our study, we found that among three dust allergens, house dust and cotton dust were equally common followed by paper dust. Similarly, Aggarwal et al[10] in their study reported that house dust exhibited marked positive skin response in maximum cases (60%) followed by paper dust (58%), cotton dust (50%), and hay dust (42%).

In our study, we observed that Pigeon and chicken allergens showed almost equal significant positive reactions. Prasad et al[8] in their study also revealed that a significant positive reaction was shown by Pigeon (5.7%) and Chicken antigens (5.7%).

In our study, the overall pollen group (grass pollen, weed pollen, tree pollen) showed a significant reaction in 19.13% of the patients. Similar to our study, a study by Raj Kumar et al[13] also reported that among grass pollens, Cynodon (3.05%) was the most common allergen showing significant positive SPT followed by Cenchrus (1.96%). Rasool et al[14] in their study also found that 24% of cases showed significant reaction to Cynodon grass.

Among weed pollens, we found that 30% of patients showed positive results for Amaranthus and as well as Brassica (30 % each). Our findings matched with the study conducted by Prasad et al[8] in Lucknow, where they also observed that the most common pollen was Amaranthus spinosus (35.4%) followed by Argemone mexicana (22.9%). Singhal et al[15] conducted a study in Delhi and showed that Brassica (5.27%), Amaranthus spinosus (4.98%), Argemone (4.98%), and Amaranthus H. (3.51%) were the common weed allergens.

The present study shows that among tree pollen Prosopis (16%) and Ricinus (16%) were most common followed by Eucalyptus (14%) and Holoptelia (14%), Casia Siamea (8%), Putranjiva (8%). A study conducted by Raj Kumar et al[13] revealed that among tree pollen Holoptelia (5.01%) followed by Salvadora (4.36%) were the most common, and the least common was Ehretia (0.54%).

In this study, we observed that D.Farinae (40%) was the most common allergen among house dust mites. Yuen et al[16] conducted a study in Hong Kong and found that the commonest allergen was house dust mite (63%) of the patients. Rasool et al[14] studied at Srinagar, Kashmir, and found that the commonest allergen was pollen (52%).

Aggarwal et al[10] and Raj Kumar et al[13] both revealed that Aspergillus fumigatus was the top sensitizer (16%) fungal allergen responsible for Nasobronchial allergy. Whereas, Singhal et al[15] showed that the most common fungal spores with significant skin reaction were Mucor (2.05%), Aspergillus Fumigatus (2.05%), Rhizopus (1.75%), and Fusarium (1.75%). Our findings were similar to these studies and we found that among fungal spores most common allergen were Rhizopus (16%) and Aspergillus Fumigatus (16%).

Prasad et al[8] studied in Lucknow and found that Cow dander (18.1%) was the most common among danders and the least common was Dog dander (10.5%). However, in our study, we took only one allergen, which was Buffalo Dander accounting for (20%) of positive SPT reactions. The differences in significant reaction in dander may be due to different population compositions or occupations of patients or may be due to different panels of dander antigens for testing.

In the current study dog allergen positivity (26%) was more common in patients when compared to cat allergen, which was positive in 10%. Yuen et al[16] in a prospective study in Hong Kong found that the commonest allergen was cockroach (23%), cat (14%) dog (5%), pollen (4%), and mold (3%). Sastre et al[17] conducted a study in an urban Madrid and found that pollen sensitivity (66.5%) was most prevalent, distantly followed by sensitivity to cockroaches (25.7%), mites (20%), cats (15.5%), dog (14%), and food (2%). This shows allergens responsible for nasobronchial allergy vary not only in different parts of the World but also in different parts of the country.

We observed Wheat (36%) as the most common food allergen in our study followed by Bajra (22%), Curd (18%), peanut/ groundnut oil (12%), and Tea (12%). Kumar et al[18] evaluated 1860 patients with asthma and/or allergic rhinitis, 1528 of whom had allergic rhinitis, for the presence of food allergy. Of these patients, 1097 (58.9%) gave a history of food allergy, with allergies being reported to curd (48.1%), rice (43.9%), citrus fruits (35.2%), banana (27%), milk (11.9%) and black gram (9.7%).

We observed that the limitations of our study were its small sample size, this being an institutional study so the results may be different from a population-based study, and lastly a limited number of allergens being used

in this study. However, the strength of the study was that no study to our knowledge has been conducted in our region of interest till now, and hence identifying allergens in this specified geographic area can help prepare the best formulation for Allergen immunotherapy for this area.

Conclusion

We conclude that the variation in the prevalence of allergen reactivities in different regions is due to different geo-climatic conditions and adaptation of specific microbiological flora and fauna in a specific climate, industrialization, environmental pollution, and change in lifestyle.

References:

1. Patel A, Choudhary S. Prevalence of allergen sensitivity in nasobronchial allergy in Gujarat, India. Natl J Med Res. 2012;2(4):431–34.
2. Kant S. Socio-economic dynamics of asthma. Ind J Med Res 2013;138: 446-8.
3. Grossman J. One airway, one disease. Chest. 1997;111: 11S-6S
4. Rowe Jones JM. The link between the nose and lung, perennial rhinitis and asthma—is it the same disease? Allergy 1997;52: 20-8.
5. Brozek JL, Bousquet J, Agache I, Agarwal A, Bachert C, Bosnic-Anticevich S, et al. Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines—2016 revision. J Allergy Clin Immunol 2017;140: 950-8.
6. National Institutes of Health. Global Initiative for Asthma. Global Strategy for Asthma Management and Prevention. NHLBI/WHO workshop report 2021:44.
7. Shivpuri DN. Comparative evaluation of the sensitivity of common methods of diagnostic antigen tests in patients of respiratory allergy. Indian J Chest Dis 1962;4: 102.
8. Prasad R, Verma SK, Dua R, Kant S, Kushwaha RA, Agarwal SP. A study of skin sensitivity to various allergens by skin prick test in patients of nasobronchial allergy. Lung India 2009;26: 70
9. Giridhar BH, Kumar S, Verma AK, Singh A, Kumar D, Prasad R, et al. A study on profile of allergens sensitivity and associated factors in naso-bronchial allergic patients. Natl J Med Res 2012;2: 70-6.
10. Agrawal RL, Chandra A, Jain S, Agrawal S, Borkar S. Identification of common allergens by skin prick test associated with united airway disease in Allahabad, Uttar Pradesh, India. Indian J Allergy Asthma Immunol. 2008;22: 7-13.
11. Gowda G, Nagaraj C, Parasuramalu BG, Huliraj N. Aeroallergen sensitivity among patients suffering from bronchial asthma in Bangalore. Int J Health Allied Sci 2013;2: 237.
12. Fuseini H, Newcomb DC. Mechanisms driving gender differences in asthma. Curr Allergy Asthma Rep. 2017; 17(3): 19.
13. Kumar R, Sharan N, Kumar M, Bisht I, Gaur SN. Pattern of skin sensitivity to various aeroallergens in patients of bronchial asthma and/or allergic rhinitis in India. Indian J Allergy Asthma Immunol 2012;26: 66.
14. Rasool R, Shera IA, Nissar S, Shah ZA, Nayak N, Siddiqi MA, et al. Role of skin prick test in allergic disorders: a prospective study in Kashmiri population

in light of review. Indian J Dermatol 2013 ;58: 12.

15. Singhal P, Kumar R. A study of skin sensitivity to various allergens by intradermal test in patients with respiratory allergy (bronchial asthma and allergic rhinitis) in India. J Int Med 2003;19: 202-7.

16. Yuen APW, Cheung S, Tang KC, Ho WK, Wong BYH, Cheung ACS, et al. The skin prick test results of 977 patients suffering from chronic rhinitis in Hong Kong. Hong Kong Med J 2007; 13: 131-6.

17. Sastre J, Ibanez MD, Lombardero M, Laso MT, Lehrer S. Allergy to cockroaches in patients with asthma and rhinitis in an urban area. Allergy. 1996;51: 582-6.

18. Kumar V, Abbas K, Abul A, Aster J, Nelson F. Diseases of the immune system. Robbins and Cotran Pathologic Basis of Disease; 2010:197-199.