Published Online: 16 December 2025 *eISSN 2984-8644*

https://doi.org/10.70552/pjaai.25.2.15985

ORIGINAL ARTICLE

Philippine Journal of Allergy, Asthma and Immunology

Prevalence of Pollen Allergen Sensitization Among Atopic Filipino Patients seen in Specialty Clinics in Three Areas of Luzon from 2021 to 2023

Michaela Ann A. Gonzales-Montalbo, MD and Shirley L. Kwong-Buizon, MD

Fe del Mundo Medical Center,
Quezon City, Philippines

Correspondence to:
Michaela Ann A. Gonzales-Montalbo, MD, FPCP
Fe del Mundo Medical Center
11 Banawe St., Quezon City 1113, Metro Manila
Tel. No.: +632-8712 0845
E-mail: mitchiegonz22@gmail.com
ORCiD: https://orcid.org/0009-0005-7258-8012

ABSTRACT

Objectives: This study aims to determine the prevalence of pollen sensitization through a skin prick test among patients with allergic rhinitis, bronchial asthma, and atopic dermatitis in three areas of Luzon: The National Capital Region (NCR) and North and South Luzon.

Methodology: This is a cross-sectional chart review of skin test results in NCR, North and South Luzon, from 2021 to 2023. Demographic and clinical data were collected and analyzed.

Descriptive statistics were used to tabulate demographic and clinical data. The association of pollen sensitization was determined using Fisher's exact test. The level of significance was set at 5%.

Results and Conclusion: Of the 355 patients included (97 from NCR, 102 from North Luzon, and 156 from South Luzon), 63.1% showed pollen sensitization. Grass pollen, most commonly carabao grass, Bermuda, and pigweed, are our subjects' most prevalent pollen allergens. A significant association was found between pollen sensitization and age and season. Climatological changes, urbanization, and differences in vegetative growth could have affected the pollen sensitization profile in each area.

Keywords: pollens, allergens, skin prick test, National Capital Region, North Luzon, South Luzon

INTRODUCTION

Knowledge of local pollens is essential for an allergologist to diagnose and treat atopy.[1] Due to the differences in climate and temperature among countries, it is, therefore, noteworthy to know the spectrum of local aeroallergens. Urbanization and changes in biodiversity can alter allergen sensitization patterns, potentially increasing the burden of atopic symptoms; hence, continuous monitoring is needed.[2-5] Air pollution can also increase airway hyperresponsiveness to aeroallergens.[4] Besides house dust mites (HDM), pollens significantly cause atopic diseases like allergic rhinitis, asthma, and atopic dermatitis.[1,6-8] Pollinosis can be used to study the interrelationship between respiratory allergy, air pollution, and other climatic factors.[4]

In the Philippines, allergic rhinitis, a burdensome disease that affects patients of all ages, has an overall prevalence of 20%.[9] Bronchial asthma, on the other hand, has a prevalence of 9.2% and 8.7% in pediatric and adult populations, respectively, based on the second National Nutrition and Health Survey (NNHeS).[10,11] For atopic dermatitis, its prevalence is 12.7% and 2% among pediatric and adult populations, respectively.[12] These high prevalence rates underscore the need for comprehensive research and effective management strategies.

However, compared to Western countries, current information on pollen allergen sensitization profile of Filipinos is notably limited.[1,5,7] The 1978 study of Cua-Lim and Payawal showed sensitization to grass and weed allergens through skin tests.[1] In a community-based study by Sabit et al. in 2020, Filipinos in highly urbanized were noted to be sensitized to local pollen.[8] These studies,[1,6,8,13] along with the climatological changes and global allergic disease burden trends,[2-5] suggest the need for additional sensitization studies in different regions of the country, thus giving birth to the context of this study.

SIGNIFICANCE OF THE STUDY

The Philippines has yet to establish an updated pollen calendar and pollen forecasts. In House Bill 9575, "Pollen Detection and Management Act," introduced by House Representative Anna Bondoc, in collaboration with the Philippine Society of Allergy, Asthma and Immunology (PSAAI), there is a need to emphasize the importance of evaluating pollen grains and their relationships with allergic diseases by monitoring atmospheric pollens, as pollen calendars and forecasts play a significant role in preventing and managing atopic diseases.[14]

This study aims to determine the pattern of pollen allergen sensitization in patients with allergic rhinitis, allergic asthma, and atopic dermatitis in Greater Manila and Northern and Southern Luzon and to provide data that could aid in their diagnosis, allergen avoidance strategies, and overall management. The potential benefits for the patients are substantial, making this study a vital step in improving their quality of life.

METHODOLOGY

Study design

This is a cross-sectional analytical study.

Study population and setting

This research included patients diagnosed with allergic rhinitis, bronchial asthma, and atopic dermatitis who underwent allergen skin prick tests from 2021 to 2023 at free-standing specialty clinics in three areas: National Capital Region (NCR), North Luzon, and South Luzon.

Sample size

At a 95% confidence level and 0.05 margin of error, the minimum number of patients needed to estimate the prevalence of pollen allergen sensitization is at least 185. The computation is based on the study of Andaya, where the prevalence of pollen allergens is 14%.

Inclusion criteria

1. Patients diagnosed with allergic rhinitis, bronchial asthma and atopic dermatitis.
2. Patients who underwent skin prick test for pollen allergens

Exclusion criteria

1. Patients with incomplete charts

Data collection tool and data collection process

The ethics committee reviewed and approved the study protocol before implementation.

A letter was sent to the different allergy clinics in the three areas to seek permission to gather the clinical data from their records. The principal investigator collected and recorded the demographic and clinical data from patients of Fe del Mundo Medical Center (NCR), North Luzon (Tuguegarao and Ilocos), and South Luzon (Batangas and Laguna). The following data were obtained:

1. Age, gender, family history of atopy, and month when the procedure was done, as indicated in the data collection form (Appendix A)
2. Allergic diagnosis made by the attending allergologists
3. List of pollens tested with positive results

All clinical data gathered was anonymized, pooled per area, and stored using a password-requiring folder. Data was only available to the primary investigator.

Allergen skin prick test

The skin tests were performed using the prick method by trained physicians using prepared allergens. Histamine (1.0 mg/mL) was used as positive control, and saline was used as negative control. The allergen skin prick test procedure was done as follows:

1. The skin of the volar arm (5 cm proximal to the wrist or 3 cm from distal to the antecubital fossa) or on the upper back was cleansed with alcohol and was allowed to air dry.
2. Lines on the skin (2 to 2.5 cm apart) marked where the allergen extracts, histamine, and normal saline solution were tested. A drop of each was placed on its designated line marking.
3. A sterile blood lancet was passed through the drop of extract and control solutions (histamine, saline) at a 45° to 60° angle to the skin. The skin was gently lifted, creating a small break in the epidermis through which the solutions penetrated.
4. After 15-20 minutes, the wheal diameter was measured horizontally and vertically and was recorded in millimeters.

A prick/puncture test with a net wheal diameter of at least 3 mm more than the negative control, done simultaneously, was considered positive and indicative of sensitization.

Data analysis

Data analysis was performed in Stata SE version 13. Age, sex, diagnosis, common sensitizing allergens, and atopy in family history were tabulated as frequencies and percentages per area. Fisher's exact test was used to determine the association of the different variables. The level of significance was set at 5% (p-value = 0.05).

RESULTS

Demographic profile

A total of 355 patient subjects aged 2 years old and above who were diagnosed with allergic rhinitis, bronchial asthma, or atopic dermatitis were included in the study (Table 1) . Of these, 27.3% (n = 97) of the subject population were from the National Capital Region (NCR), 28.7% (n = 102) were from North Luzon, and the remaining 43.9% (n = 156) were from South Luzon. The results showed that 29.9% (n -106) of the subject population were aged 20 to 40, while 26.5% (n = 94) were aged 10 to 19. In terms of age, 56.1% (n = 199) were female and 43.9% (n = 156) were male. More than half (58.6%; n = 208) had allergic rhinitis alone, 1.7% (n = 6) had bronchial asthma alone, 12.7% (n = 45) had atopic dermatitis and 27% (n = 96) had combinations of these atopic diseases. The majority (92.1%; n = 327) had a positive family history of atopy.

Table 1. Baseline characteristics of patient subjects

	NCR (N = 97)		North Luzon (N = 102)		South Luzon (N = 156)		All (N = 355)	
	n	%	n	%	n	%	n	%
Age (years)								
2-4	9	9.3	3	3.2	3	1.9	15	4.2
5-9	23	23.7	10	10.5	30	19.2	63	17.7
10–19	15	15.5	33	34.7	46	29.5	94	26.5
20–40	33	34.0	25	26.3	48	30.8	106	29.9
41–60	14	14.4	12	12.6	21	13.5	47	13.2
≥61	3	3.1	19	20.0	8	5.1	30	8.5
Sex								
Male	54	55.7	40	42.1	62	39.7	156	43.9
Female	43	44.3	62	65.2	94	60.3	199	56.1
Diagnosis								
Allergic Rhinitis	66	68.0	48	50.5	94	60.3	208	58.6
Bronchial Asthma	1	1.0	4	4.2	1	0.6	6	1.7
Atopic Dermatitis	10	10.3	12	12.6	23	14.7	45	12.7
AR + BA	9	9.3	19	20.0	11	7.1	39	11.0
AR + AD	8	8.2	17	17.9	27	17.3	52	14.6
BA + AD	3	3.1	2	2.1	0	0.0	5	1.4
Family history of atopy								
Presence	93	95.9	93	97.8	141	90.4	327	92.1
Absence	4	4.1	9	9.5	15	9.6	28	7.9
Pollen sensitization								
Presence	53	54.6	64	62.8	107	68.6	224	63.1
Absence	44	45.4	38	37.2	49	31.4	131	36.9

Sensitization profile

Overall, the most prevalent pollen allergens were carabao grass (26.8%, n = 95), followed by Bermuda (26.2%, n = 93) and pigweed (23.4%, n = 83) (Table 2). In NCR, the most prevalent pollen allergens were koros-korosan (26.8%, n = 26), Bermuda (22.7%, n = 22), and wild daisies (20.6%, n = 20). In North Luzon, the most common pollen allergens were carabao grass (51.5%, n = 17), mango tree (48.5%, n = 16), and amorseco (39.4%, n = 13), while in South Luzon, the most common were mutha (58.9%, n = 63), carabao grass (56.1%, n = 60) and cogon (46.7%, n = 50). The complete list of pollens and their sensitization profiles for each area can be found in Appendix B (Table B1).

Sensitization according to allergic disease present

Allergic rhinitis (AR)

Frequency distribution of pollen sensitization

In NCR, AR patients were most frequently sensitized to koros-korosan (27.7%; n = 23), Bermuda (25%; n = 21), and both Johnson and wild daisy (21.7%; n = 18) (Table 3). However, none of the pollen allergens was found to be significantly associated with allergic rhinitis.

In North Luzon, acacia (23.8%; n = 20), Bermuda (21.4%; n = 18), and corn (19%; n = 16) were found to be the most frequent pollen sensitizations among subjects with allergic rhinitis (Table 3). Only Bermuda grass (p = 0.01) showed a significant association with allergic rhinitis.

In South Luzon, the most frequent pollen sensitizations were mutha (43.6%; n = 58), carabao grass (42.1%; n = 56), and pigweed (39.8%; n = 53) (Table 3). Only mutha (p = 0.05), carabao grass (p = 0.02), and cogon (p = 0.03) were found to be significantly associated with allergic rhinitis.

Pollen sensitization according to severity

The profile of pollen sensitization according to the severity of allergic rhinitis in each area is detailed in Appendix B, Table 3. Bermuda was the most common pollen among mild intermittent AR patients in NCR and North Luzon, while mutha was the most common in South Luzon. The predominant pollens varied among mild persistent and moderate-severe intermittent AR patients. Among moderate-severe persistent patients, koros-korosan was the most common pollen in NCR and North Luzon, whereas carabao grass was the most frequent pollen in North and South Luzon.

In NCR, Bermuda grass and koros-korosan (26.8%; n = 11) were found to be the most prevalent among 41 mild intermittent AR patients. Among the 14 mild persistent AR patients, the most common pollens found were koros-korosan and wild daisy (50%; n = 7). Among the four moderate-severe intermittent AR patients, carabao grass,

Table 2. Top five pollen sensitizations in each area

NCR			North Luzon			South Luzon			All		
	n	%		n	%		n	%		n	%
Koros-korosan	26	26.8	***Carabao grass***	17	51.5	***Mutha***	63	58.9	***Carabao grass***	95	26.8
Bermuda	22	22.7	***Mango tree***	16	48.5	***Carabao grass***	60	56.1	***Bermuda***	93	26.2
Wild Daisy	20	20.6	***Amorseco***	13	39.4	***Cogon***	50	46.7	***Pigweed***	83	23.4
Carabao grass	18	18.6	***Makahiya***	12	36.4	***Bermuda***	44	41.1	***Acacia***	77	21.7
Cogon	17	17.5	***Bermuda***	27	36.0	***Corn***	44	41.1	***Mango tree***	77	21.7
Johnson	17	17.5				***Mango tree***	44	41.1	***Cogon***	67	18.9
Mango tree	17	17.5				***Pigweed***	59	37.8			

Table 3. Top five pollen sensitizations in patients with allergic rhinitis in each area

NCR				North Luzon				South Luzon			
Pollen	**n**	**%**	***p* value**	**Pollen**	**n**	**%**	***p* value**	**Pollen**	**n**	**%**	***p* value**
Koros-korosan	23	27.7	0.62	***Acacia***	20	23.8	0.40	***Mutha***	58	43.6	0.05*
Bermuda	21	25.3	0.13	***Bermuda***	18	21.4	0.01*	***Carabao grass***	56	42.1	0.02*
Johnson	18	21.7	0.20	***Corn***	16	19.0	0.18	***Pigweed***	53	39.8	0.21
Wild Daisy	18	21.7	0.53	***Carabao***	15	17.9	0.49	***Cogon***	47	35.3	0.03*
Carabao grass	17	20.5	0.23	***Mango tree***	14	16.7	0.56	***Bermuda***	41	30.8	0.08
Cogon	15	18.1	0.73					***Corn***	41	30.8	0.08
Mango tree	15	18.1	0.76								

**statistically significant*

Johnson, and makahiya (50%; n = 2) were the most common pollens. Among the 24 moderate-severe persistent AR patients, the most common pollens found were koros-korosan and pigweed (16.7%; n = 4).

In Northern Luzon, Bermuda grass was the most prevalent pollen among the 48 mild intermittent AR patients, affecting 31.3% (n = 15). Among the 28 mild persistent AR patients, acacia was the most common pollen (25%; n = 7). Among the eight moderate-severe persistent AR patients, carabao grass, koros-korosan, and mango tree (25%; n = 2) were the most common pollens. No patients in this region had moderate-severe intermittent AR.

In South Luzon, mutha (41.58%; n = 42) was found to be the most prevalent among 101 mild intermittent AR patients. There was only 1 mild persistent AR patient gathered, and he was sensitized to these pollens: amorseco, Bermuda grass, camachile, carabao, corn, Johnson, mango, mutha, tridox, and yardgrass (100%; n = 1). Cogon (88.89%; n = 8) was the most common pollen among the 9 moderate-severe intermittent AR patients. Among the 21 moderate-severe persistent AR patients, carabao grass was the most common pollen (52.38%; n = 11).

Bronchial asthma

Frequency distribution of pollen sensitization

In NCR, the most prevalent pollen sensitizations were pigweed and foxtail (30.8%; n = 4), followed by mango tree, cogon, and Egyptian (23.1%; n = 3), then Bermuda and yard grass (15.4%; n = 2) (Table 4).

In North Luzon, the most common sensitizing pollens among asthmatic patients were corn (28%; n = 7), Bermuda grass and pine tree (16%; n = 4), rice pollen and Johnson (12%; n = 3) (Table 4). As seen in Appendix B Table B4, the pollens significantly associated with the diagnosis of bronchial asthma in North Luzon were pine tree ($p = 0.04$), acacia (8%; n = 2; $p = 0.02$), and makahiya (0%; n = 0; $p = 0.04$), carabao (0%; n = 0; $p = 0.01$), pigweed (0%; n = 0; $p = 0.05$), amorseco (0%; n = 0; $p = 0.03$), mango tree (0%; n = 0; $p = 0.01$), koros-korosan (0%; n = 0; $p = 0.05$) and yardgrass (0%; n = 0; $p = 0.05$).

In South Luzon, the allergens most prevalent among bronchial asthma patients were pigweed and acacia (50%; n = 6), Bermuda grass (41.7%; n = 5), and Johnson grass, camachile, cogon, corn, and carabao grass (33.3%; n = 4) (Table 4). The pollens significantly associated with bronchial asthma in South Luzon were Johnson (33.3%; n = 4; $p = 0.01$) and foxtail (25%; n = 3; $p = 0.04$).

Table 4. Top pollen sensitizations in patients with bronchial asthma in each area

NCR			
Pollen	**n**	**%**	***p* value**
Pigweed	4	30.8	0.05*
Foxtail	4	30.8	0.05*
Mango tree	3	23.1	0.65
Cogon	3	23.1	0.57
Egyptian	3	23.1	0.15
Bermuda	2	15.4	0.50
Yard grass	2	15.4	0.10
Johnson	2	15.4	0.68
Rice Pollen	2	15.4	0.62
Carabao grass	1	7.7	0.28
Amorseco	1	7.7	0.46
Wild Daisy	1	7.7	0.22
Acacia	1	7.7	0.81
Koros-korosan	1	7.7	0.09
Coconut pollen	1	7.7	0.01*
Makahiya	0	0.0	0.19
Ipil ipil	0	0.0	0.42
Talahib	0	0.0	0.28

North Luzon			
Pollen	**n**	**%**	***p* value**
Corn	7	28.0	0.37
Bermuda	4	16.0	0.17
Pine tree	4	16.0	0.04*
Rice pollen	3	12.0	0.97
Johnson	3	12.0	0.97
Acacia	2	8.0	0.02*
Bahia	1	4.0	0.81
Kapok	1	4.0	0.51

South Luzon			
Pollen	**n**	**%**	***p* value**
Pigweed	6	50.0	0.37
Acacia	6	50.0	0.09
Bermuda	5	41.7	0.28
Carabao grass	4	33.3	0.70
Cogon	4	33.3	0.92
Corn	4	33.3	0.68
Camachile	4	33.3	0.25
Johnson	4	33.3	0.01*
Mutha	3	25.0	0.26
Mango tree	3	25.0	0.80
Makahiya	3	25.0	0.82
Amorseco	3	25.0	0.82
Kapok	3	25.0	0.64
Tridox	3	25.0	0.55
Coconut	3	25.0	0.46
Egyptian	3	25.0	0.27
Foxtail	3	25.0	0.04*
Talahib	2	16.7	0.68
Yardgrass	2	16.7	0.27

**statistically significant*

Pollen sensitization according to severity

Appendix B, Table B5 presents the pollen sensitization profile according to asthma control level. Pigweed was found to be the most common pollen among patients with controlled asthma in both NCR and Southern Luzon, while corn predominated in Northern Luzon. Pigweed remains the most common pollen among patients with partly controlled asthma in NCR and Southern Luzon. Patients with uncontrolled asthma were only encountered in NCR, and they were sensitized to foxtail and Johnson grass.

In NCR, cogon and pigweed (28.57%; n = 25) were the most prevalent among 7 patients with controlled asthma. Among the 4 patients with partly controlled asthma, the most common pollens identified were Egyptian, foxtail, mango tree, pigweed, and rice pollen (25%; n = 1). Among the 2 patients with uncontrolled asthma, foxtail and Johnson (100%; n = 2) were the most frequent sensitizations.

In North Luzon, corn (28%; n = 7) was the most prevalent allergen among the 25 patients with controlled asthma. No patients with partly controlled or uncontrolled asthma were gathered in this region.

Acacia, Bermuda, and pigweed (45.45%; n = 5) were the most prevalent among 11 patients with controlled asthma in South Luzon. Only 1 patient in this region had partly controlled asthma and was sensitized to acacia and pigweed (100%; n = 1). No patients with uncontrolled asthma were documented in this area.

Atopic dermatitis

Frequency distribution of pollen sensitization

Among patients with atopic dermatitis in NCR, the most common sensitizing pollens were koros-korosan, yard grass, and Johnson grass (19%; n = 4); carabao grass, amorseco, wild daisy, mango tree, and cogon (14.3%; n = 3); and Bermuda, pigweed, acacia, talahib, foxtail and rice pollen (9.5%; n = 2) (Table 5).

In North Luzon, Bermuda grass (32.3%; n = 10), corn (25.8%; n = 8), and acacia (22.6%; n = 7) were found to be the most frequent sensitizing pollens in AD patients. In South Luzon, talahib (40%), mutha (36%), and pigweed (34%) were found to be the most common allergens among patients with AD (Table 5). None of the pollens tested were significantly associated with atopic dermatitis in NCR and North Luzon.

In South Luzon, however, only talahib (40%; n =20; p = 0.00), corn (16%, n = 8, p=0.02), and Johnson grass (4%, n = 2, p = 0.04) were found to be significantly with atopic dermatitis, as shown in Appendix B, Table B6.

Pollen sensitization according to severity

Appendix B, Table B7 shows pollen sensitization according to the severity of atopic dermatitis. Patterns vary across regions.

In NCR, Johnson grass (25%; n = 4) was found to be the most prevalent among the 16 patients with mild AD. Among

Table 5. Top pollen sensitizations in patients with atopic dermatitis in each area

NCR			
Pollen	**n**	**%**	***p* value**
Koros-korosan	4	19.0	0.36
Yard grass	4	19.0	0.61
Johnson	4	19.0	0.94
Carabao grass	3	14.3	0.57
Amorseco	3	14.3	0.98
Wild Daisy	3	14.3	0.42
Mango tree	3	14.3	0.57
Cogon	3	14.3	0.66
Bermuda	2	9.5	0.10
Pigweed	2	9.5	0.56
Acacia	2	9.5	0.47
Talahib	2	9.5	0.64
Foxtail	2	9.5	0.56
Rice Pollen	2	9.5	0.77
Makahiya	1	4.8	0.34
Ipil ipil	1	4.8	0.87
Egyptian	1	4.8	0.28
Coconut pollen	0	0.0	0.60

North Luzon			
Pollen	**n**	**%**	***p* value**
Bermuda	10	32.3	0.38
Corn	8	25.8	0.49
Acacia	7	22.6	0.66
Rice pollen	4	12.9	0.81
Johnson	4	12.9	0.81
Pigweed	4	12.9	0.65
Mango tree	3	9.7	0.27
Koros-korosan	3	9.7	0.81

South Luzon			
Pollen	**n**	**%**	***p* value**
Talahib	20	40.0	0.00*
Mutha	18	36.0	0.44
Pigweed	17	34.0	0.50
Carabao grass	14	28.0	0.07
Cogon	12	24.0	0.12
Mango tree	12	24.0	0.42

**statistically significant*

the 4 patients with moderate AD, koros-korosan, pigweed, and yard grass were the most frequent sensitizations (25%; n=1). Only 1 patient with severe AD showed no sensitization to any pollen.

In North Luzon, Bermuda grass (32.14%; n = 9) was found to be the most prevalent among the 28 patients with mild AD. Among the 3 patients with moderate AD, ipil-ipil (66.67%; n = 2). None of the patients gathered in this area had severe AD.

In South Luzon, mutha and pigweed (31.43%; n = 11) were the most prevalent among the 35 patients with mild AD. While, among the 12 patients with moderate AD, the most common pollen was still mutha (50%; n = 6). For the 3 patients with severe AD, the most common pollens were kapok, makahiya, mutha, and pigweed (33.33%; n = 1)

Sensitization according to age

Patients aged 20-40 years had the most pollen sensitizations across all areas. Pediatric patients aged 2-4 years had the least sensitizations in both NCR and North Luzon, while in South Luzon, the >60-year-old group had the least sensitizations (Appendix B Figures B1-B3).

In NCR, Bermuda grass, carabao grass, and makahiya (11.11%; n = 1) were prevalent in the age group 2-4 years old. Bermuda was also the most common among the age group of 5 to 9 years old. Koroskosan was found to be the most predominant pollen in the age groups 10 to 19 years (40%; n = 6), 20 to 40 years (30.3%; n = 10) and 41 to 60 years (35.71%; n = 5). For the elderly population (>60 years old), foxtail and Johnson grass (100%; n = 3) were the most common. However, only pigweed (p = 0.01), Bermuda grass (p = 0.02), and Egyptian grass (p = 0.05) were found to be significantly associated with age, as seen in Appendix B Table B8.

In North Luzon, talahib (66.67%; n = 2), corn (30%; n = 3), and acacia and Bermuda grass (24.24%; n = 8) were found to be the most prevalent allergens among the age groups 2 to 4, 5 to 9, and 10 to 19 years old, respectively. For the adult population, Bermuda grass (32%; n = 8), acacia and pigweed (33.33%; n = 4), and corn (31.58%; n = 6) were found to be the most prevalent for age groups 20-40, 41 to 60, and older than 60 years old, respectively. However, only talahib (p = 0.00) and pigweed (p = 0.02) were significantly associated with age

In South Luzon, corn, Bermuda grass, carabao grass, mango tree, mutha, and pigweed (100%; n = 3) were prevalent in the age group 2-4 years old. Carabao grass (46.67%; n = 14) and mutha (50%; n = 23) were the most prevalent allergens among the age groups 5 to 9 and 10 to 19 years old, respectively. For the adult population, cogon (41.67%; n = 20), acacia and pigweed (38.10%; n = 8) were the most common pollens among age groups 20 to 40 and 41 to 60 years. Acacia (25%; n = 2) was found to be the most prevalent for patients older than 60 years old. Among all the pollens tested, mutha (p = 0.02), carabao grass (p = 0.04), Bermuda grass (p = 0.01), and mango tree pollen (p = 0.04) were the only allergens found to be significantly associated with age.

Sensitization according to sex

Males were found to have more pollen sensitizations in NCR, but females had more pollen sensitizations in both North and South Luzon (Appendix B Figures B4-B6). There was no significant association between pollen sensitization and sex in all areas. (Appendix B Table B9)

Sensitization according to family history of atopy

Patients with a family history of atopy in all areas had a higher pollen sensitization percentage than those without a family history of atopy (Appendix B Figures B7-B9).

Similar to sex, no significant association was found between pollen sensitization and a positive family history of atopy in all areas (Appendix B Table B10).

Sensitization according to season

Pollen sensitization was found to be more frequent in all areas during the wet/rainy season (June to November) (Appendix B Figures B10-B12).

In NCR, koros-korosan was the most predominant pollen in dry (54.17%; n = 13) and wet (23.64%; n = 13) seasons. Among the tested pollens, only wild daisy (p = 0.05) was significantly associated with the season (Appendix B Table B10).

In North Luzon, Bermuda grass was the most predominant pollen in the dry (29.27%; n = 12) and wet (24.59%; n = 15) seasons. Other predominant pollens during the wet season were acacia and corn (24.59%; n = 15). No significant association was observed between pollen sensitization and season for North Luzon.

In South Luzon, mutha was the most predominant pollen in the dry (37.97%; n = 30) and wet (42.86%; n = 33) seasons. Another predominant pollen during the dry season was carabao grass (37.97%; n = 30). There was no significant association between pollen sensitization and season for Southern Luzon.

DISCUSSION

Pollens are among the most important causes of allergic sensitization, contributing to the development of allergic rhinitis, bronchial asthma, and atopic dermatitis.[6–8] Produced in large quantities by local flora, they are

wind-pollinated, highly antigenic, and may be clinically significant because it can trigger symptoms in sensitized individuals.[6] A single pollen can contain several allergens. The size, solubility, stability, and high accessibility can determine the pollen's allergenicity since these characteristics allow the crossing of mucosal barriers.[15] Several environmental studies noted that the urban heat island effect, unsuitable green space construction, and traffic pollution found in urban areas aggravate pollinosis.[16] Skin prick tests can detect sensitizations to these pollens among infant to adult patients with atopic diseases. These tests have high sensitivity to aeroallergens, particularly house dust mites and pollens.[6]

Pollen sensitization profiles

Pollen sensitization profile in Luzon

Among the 355 patients in this study, 63.1% showed sensitization to pollen based on skin prick testing (Table 1). The most common pollen allergens with positive results were carabao grass (*Paspalum conjugatum*), Bermuda grass (*Cynodon dactylon*), and pigweed (*Amaranthus spp*) (Table 2).

This current finding is consistent with the previous studies of Cua-Lim and Payawal and Punay et al. In the study of Cua-Lim and Payawal, skin prick tests of pollens were done on atopic patients in five areas of Luzon: Baguio, Laguna, Quezon City, Naga and Davao, showing grass pollens to be the most predominant allergens in all locations.[1] In the study of Punay et al., in 523 atopic and non-atopic subjects, grass pollen grains were likewise the most predominant allergens sampled from Bulacan, Leyte, and Ilocos Norte.[1,5] In a study by Santos-Estrella (2012), 72% of the outdoor allergens with positive skin tests were grass pollens among patients in a tertiary government hospital in Manila.[17] Another study by Cua-Lim (1985) also showed that 26% of atopic and non-atopic patients showed positive skin test results to grasses.[18]

Grasses are classified under the Poaceae or Gramineae family, a group of ubiquitous monocot flowering plants to which most sequenced plant allergens belong.[19] In the study of pollen allergenicity by Diehart, the allergenicity of the Poaceae family was found to be very high, which they attributed to the following characteristics: a reduced pollenkitt, undetectable endexine, microchannels in ektexine and the presence of starchy reserve material in the pollens.[15]

Pollenkitt is composed of lipids to help contain allergenic water-soluble proteins of the pollen inside the exine. An exine is the pollen's coating, and the endexine and ektexine are its inner and outer layers. Having an endexine can lessen allergenic protein release from the pollen. Thus, the lack or absence of pollenkitt and endexine can allow water-soluble proteins to pass through and induce allergic symptoms, increasing the pollen's allergenicity.[15]

In Europe, America, and Australia, grass pollen allergens were also found to belong among the most potent causes of type I allergies.[20] In the GA²LEN skin test study, grass pollens were found to have the highest rate of clinical relevance as 88.4% of patients were positive by skin prick tests.[21] Compared to Asian countries such as Thailand and Vietnam, pollen sensitization is less common than indoor allergens.[22,23] In Singapore, oil palm pollen was found to be their most frequent sensitization among outdoor allergens, which they hypothesized to be due to monsoon blow from Malaysia, which has large plantations of the said flora.[24]

In subtropical and tropical areas such as the Philippines, grasses can flower at any time of the year. Climatological changes can also contribrute to perennial pollination.[1,18] Among the grass pollens Cua-Lim and Payawal tested in 1978, carabao grass, which is naturalized widely in tropical areas and ranked first in this current study, ranked fourteenth in their study.[1] Bermuda grass, which ranked second in this current study, ranked first as evidenced by the most positive reactions on skin tests of atopic patients and was found to be the most allergenic among grass pollens.[1] Pigweed, the third most common in this current study, was found to be the most allergenic among non-graminaceous weeds in the 1978 study by Cua-Lim and Payawal and ranked first among allergens in the 1988 study by Agbyan.[1,25]

Pollen sensitization profile in the NCR

In our current study, among the 97 atopic patients in Fe del Mundo Medical Center (FDMMC) who underwent a skin prick tests, 54.6 % showed sensitization to pollen (Table 1). The most prevalent pollens were koros-korosan (*Chloris barbata*), Bermuda grass, and wild daisy (*Tridax procumbens*) (Table 2).

In a study by Sabit et al.(2020) in Metro Manila, 14% had a positive skin prick tests for pollens.[8] These findings are consistent to the previous studies of Cua-Lim and Payawal in Quezon City (representing NCR), Remo and Laserna in Makati, and Agbayani, wherein grass pollens were predominant sensitizers.[1,25-26] contrast to the present study, the studies by Remo and Laserna, and Agbayani, reported yard grass and foxtail as the predominant pollens.[25,26]

Grass pollens are the dominant allergens since grasses can endure urban conditions and reproduce rapidly.[19] Their higher sensitization rates may be due to wind-pollination and their ability to flower throughout the year.[27] The allergen profiles of koros-korosan and Bermuda grass, the most prevalent pollens in NCR in this study, were found

by Cabauatan to have major group 1 and 13 allergens.[28] Bermuda grass originated from Turkey and Pakistan and was introduced to tropical, subtropical, and temperate regions.[19]

This research study also highlights the role of the members of the Asteraceae family, such as wild daisy, as a prevalent pollen in NCR. These plants, being entomophilous or insect-pollinated, can be airborne and cause sensitization if they produce adequate pollen, as noted by Hate et al.[29]

On the other hand, Manila also has widespread distribution of Fabaceae plants, such as makahiya, acacia, ipil-ipil, and camachile. Although Fabaceae plants can flower all year round, they were noted to have lower sensitization rates than grass pollens. According to Sabit et al., the lower sensitization rate may be due to the presence of more active competing pollinators such as birds and bees.[27]

Amaranths, such as pigweed, thrive in warm areas because, as xerophytic plants, they produce less pollen. The decreased pollen production can explain the lower sensitization rate of pigweed in NCR.[27]

Overall, Metro Manila has been progressively industrializing and becoming urbanized; there is a decline in green space cover, which may cause a decrease in airborne pollen concentrations.[27]

Pollen sensitization profile in North Luzon (Tuguegarao and Ilocos)

Among 102 patients from North Luzon, 62.7% demonstrated sensitization to pollen through skin prick tests (Table 1). Carabao grass, mango (*Mangifera indica*), and amorseco (*Andropogon aciculatus*) had the highest number of positive reactions (Table 2).

Similar to the pollen sensitization profile of NCR in this study, grass pollens, owing to their ubiquitous nature, were also predominant in North Luzon, with carabao grass and amorseco having the highest sensitization percentages among atopic patients seen and tested.[19]

Carabao grass is widely established throughout the Philippines and other Pacific islands. According to the partial characterization study of Castor et al., carabao grass has allergen groups 2/3, group 6 and/or profilin, group 1 or 5, and group 4.[19]

Amorseco, another predominant pollen in this study, is also found throughout the country, namely in Benguet, Cagayan, and Isabela in North Luzon. It is commonly seen in open spaces and is a common lawn or roadside grass. It has spikelets that readily attach to clothing or animal fur.[30]

Consistent with the present findings, in two previous studies by Punay et al., mango was also found to have the highest sensitization rates on skin prick testing, which they hypothesized to be due to its prevalence near residential homes in urban settings.[5] Mango pollen, which is also insect-pollinated, can cause sensitization when adequate pollen is produced and becomes airborne.[29]

Cua-Lim and Payawal identified pine tree, makahiya, and cogon grass as the predominant pollen pollutants in Baguio City (representing Northern Luzon in their study).[1] Bulalacao's pollen survey in Baguio City showed Benguet pine, Japanese alder, and Graminaneae or grass pollens to be predominant.[31] In contrast to previous studies, our results showed pine tree pollen ranking only tenth. This finding may be because most of the patients in this study were from Tuguegarao and Ilocos rather than Baguio.

Pollen sensitization profile in South Luzon (Batangas and Laguna)

In our study, among 156 atopic patients tested in South Luzon, 68.6% showed sensitization to pollen through skin prick tests (Table 1). The most common allergens were mutha (*Cyperus rotundus*), carabao grass, and cogon (*Imperata cylindrical*) (Table 2). Mutha was also prevalent pollen identified in Cua-Lim and Payawal's findings, resurging especially in June owing to its wide distribution in the area.[1]

Similar to the pollen sensitization profiles of NCR and North Luzon in this study, grass pollens were also predominant in South Luzon. In the study by Sabit et al., there is a high distribution of grass pollens in Laguna, especially during the beginning of the year, then eventually declining thereafter.[27]

Carabao grass, a predominant pollen in North Luzon, also showed high sensitization rates in South Luzon owing to its ubiquitous nature. Cogon, another dominant grass pollen in South Luzon, is native to Asia and common in humid tropics. In the study of Castor et al., the protein allergen groups of cogon were almost similar to those of the carabao grass.[19]

The previous study of Agbayani in South Luzon showed that the top three predominant pollens were makahiya (*Mimosa spp*), pigweed (*Amaranth spp*), and grass pollens.[25] Makahiya, although abundant in lowland tropics, only ranked sixth in this current study.[25] Pigweed, which is also predominant in South Luzon according to a study by Cua-Lim and Payawal, only ranked fifth in this current findings.[1]

Pollen sensitization and allergic rhinitis

Regardless of severity, grass pollens predominated among patients with allergic rhinitis across three areas of Luzon:

koros-korosan, Bermuda, and Johnson for NCR; Bermuda grass and corn for North Luzon; and carabao grass for South Luzon (Table 3). This study found that Bermuda grass in North Luzon, and mutha, carabao grass, and cogon in South Luzon were the only pollens significantly associated with allergic rhinitis. (Appendix B Table B2).

Pollen sensitization among AR patients in NCR

Among AR patients in NCR, the pollens with the highest frequency distribution, as shown by positive skin test results, were grass pollens: koros-korosan and Bermuda grass, both Johnson grass, sensitization profile on NCR (Table 2), where the koros-korosan, Bermuda, and wild daisy were also the predominant pollens.

Similarly, in the study of Navarro-Locsin and Lim-Jurado, Bermuda grass and Johnson grass were found to be the most common outdoor allergens among AR patients tested in Manila.[32] Two studies from Thailand reported that 17% of AR patients had positive skin prick test results for Bermuda grass. While Sirirat et al. found 39% of AR patients had positive SPT results for Bermuda grass and 20% for Johnson grass identifying Bermuda as one of the major sensitizers.[33,34]

In this study, none of the pollens showed a statistically significant association with allergic rhinitis in NCR.

Regarding disease severity, koros-korosan had the highest sensitization rates among mild intermittent (along with Bermuda grass), mild persistent (along with wild daisy), and moderate-severe persistent allergic rhinitis. For moderate-severe intermittent rhinitis, carabao grass, Johnson grass, and makahiya had the highest sensitization rates (Appendix B Table B3).

In the Rapadas-Aguirre study, koros-korosan was likewise significantly associated with moderate-severe intermittent allergic rhinitis, and yard grass was significantly associated with moderate-severe persistent allergic rhinitis.[13]

In the study of Cabauatan regarding grass pollen extracts, the IgE-binding potential of the proteins found in grass pollens such as koros-korosan and Bermuda grass leads to the IgE sensitization of atopic patients, causing the symptoms of allergic rhinitis.[7]

Wild daisy, with sufficient pollen production, can be airborne and cause sensitization, as Hate et al. noted, leading to the clinical manifestations of allergic rhinitis.[29]

Pollen sensitization among AR patients in North Luzon

Among AR patients in North Luzon, the pollens with the highest frequency of sensitization, as shown by positive skin tests, were acacia (*Acacia spp*), Bermuda grass, and corn (*Zea mays*). Only Bermuda grass, however, showed a significant association with disease presence (Table 3).

Acacia, predominant pollen allergen, is found in many areas of North Luzon, particularly Ilocos Norte and Zambales, and throughout the Philippines.[35] This finding is similar to previous studies in Indonesia and Singapore, where acacia produced positive skin test reactions among allergic rhinitis and asthma patients.[23,36] In the study of Phamnuvich in Thailand, 19% out of 100 AR patients tested by skin prick test were positive for acacia.[33]

Bermuda grass, the only pollen found in this study to have a statistically significant association with disease presence and was characterized by Cabauatan to have IgE-binding proteins, which may lead to sensitization and clinical symptoms among AR patients.[7]

Ilocos region is a major producer of corn, another predominant pollen identified in this study. Corn pollen may induce an upper airway allergy symptoms and may be due to the corn's heavy weight of 150-500 ng (60 to 125 μm in diameter), making it likely to deposit in the upper airways.[37]

Regarding disease severity, Bermuda grass and acacia were still the most common pollens among mild intermittent and mild persistent AR patients, respectively. Other grass pollens, such as carabao grass, koros-korosan, and mango pollen, were found to have high sensitization rates among moderate-severe persistent AR patients (Appendix B Table B3).

Carabao grass, which was dominant pollen in the overall North Luzon sensitization profile (Table 2), along with koros-korosan may have contributed to AR symptoms, not only because of their ubiquitous nature but also due to their major allergen components as reported by Castor et al. and Cabauatan.[19,28] Mango pollen is likewise a dominant pollen, as seen in the overall sensitization profile of North Luzon in this study (Table 2). It was also shown to be a sensitizing agent in 16% of AR patients in a study in Thailand by Phamnuvich.[33]

Pollen sensitization among AR patients in South Luzon

Among AR patients in South Luzon, the pollens that showed the highest frequency distribution, based on positive skin test results, were mutha, carabao grass, and pigweed. However, only mutha, carabao grass, and cogon showed significant association with AR (Table 3).

Mutha, carabao grass, and cogon were the top 3 allergens found in South Luzon, as seen in this study's overall pollen sensitization profile, while pigweed ranked fifth (Table 2).

In the atmospheric study of Cua-Lim and Payawal, mutha or nutsedge, a widely distributed weed in the region, was found to cause pollen resurgence around June in South Luzon. It can bloom throughout the year and is usually found in open meadows and parks.[1] A study in Thailand by Sirirat et al., among 121 AR patients, 62.8% had a positive skin prick tests to mutha or nutsedge. Mutha was considered as a primary sensitizing pollen in AR patients.[34] In this study, with regard to the severity of the disease, mutha was the most common pollen among mild intermittent AR patients, who comprised 71% of AR patients tested in South Luzon.

Carabao grass, ubiquitous native in the Philippines, was also a predominant pollen in North Luzon in the overall pollen sensitization profile and was the most common pollen among moderate-severe AR patients, probably due to its major allergen proteins.[19,28] Regarding disease severity, carabao grass was the most common pollen in this study among moderate-severe persistent AR patients (Appendix B Table B3).

Pigweed, from the Amaranthaceae family, was found to be allergenic in the studies of Cua-Lim and Paywal and Agbayani.[1,25] Similarly, Thailand, 30% of AR patients were sensitized to pigweed.[33]

Cogon, which ranked sixth among AR patients in South Luzon, along with mutha and carabao grass, showed a significant association with disease presence in this study. As mentioned in the study of Castor et al., cogon pollens share major allergen groups with carabao grass.[19] In this study, cogon was the most common pollen among moderate-severe intermittent AR patients (Appendix B Table B3).

Pollen sensitization and bronchial asthma

Among patients with bronchial asthma, regardless of severity, grass pollens were still the most common sensitizing allergen in all areas, as determined by positive skin prick test results: Bermuda grass was predominant in all regions. Cogon was common for both NCR and South Luzon, while corn was frequently identified for both North Luzon and South Luzon. Additional prevalent pollens included foxtail, Egyptian and yard grass in NCR; rice pollen and Johnson in North Luzon; carabao grass in South Luzon (Table 4). This is consistent to the previous study by Agbayani and Castillo-Ochoa, which showed that seasonal incidence of asthma consultations followed the pattern of monthly pollen count, reflecting the country's peak pollination of grasses and weeds.[38]

Pollen sensitization among asthmatic patients in NCR

Among asthmatic patients in NCR, the pollens that showed the highest frequency distribution, based on positive skin test results were pigweed and foxtail, followed by the mango tree, cogon, and Egyptian grass, and then Bermuda and yard grass (Table 4). Only pigweed, foxtail, and coconut pollen were significantly associated with disease presence. (Appendix B Table B4)

Pigweed and foxtail ranked eighth in this study's overall pollen sensitization profile of NCR (Table 2).

A study on the environmental behavior of airborne Amaranthaceae, the family of pigweed, found that urbanization and changes in rainfall distribution patterns can cause the annual pigweed pollen index to decline. However, even in low concentrations, pigweed can trigger allergic symptoms in sensitized patients.[39] In this study, pigweed was also predominant among controlled and party-controlled bronchial asthma patients.

On the other hand, Foxtail was third in abundance from the previous study by Remo and Laserna in Makati. Its profuse vegetative growth was attributed to frequent rainfall in October and November.[40] In the present study, foxtail was found to be predominant among uncontrolled bronchial asthma patients.

In the study on pollen allergenicity by Diethart, foxtail was one of the pollens they examined under the Gramineae or Poaceae family.Its hardly detectable endexine and less abundant pollenkitt lead to its very high allergenicity.[15] Cogon, Egyptian grass, Bermuda grass, and yard grass, were the other predominant pollens among asthmatics in NCR in this study. These pollens also belong to the Poaceae group and therefore, share the abovementioned characteristics.[15] Yardgrass, in the study by Remo and Laserna, was noted to be the most abundant, owing to their longer duration of pollination.[40]

In this study, cogon and Egyptian grass were likewise predominant among controlled and partly controlled bronchial asthma patients, respectively.

In another study by Punay et al., it was found that those with positive skin prick test results for mango had higher odds of reporting asthma symptoms than those who tested negative.[5] Mango, having been naturalized in the Philippines, is widely distributed, including in urban areas.[41] Anacardiaceae pollens are sticky and insect-pollinated but can still induce sensitization when present in large airborne quantities. Air pollution can also contribute to its allergenicity, especially in urban areas. Exines can become fragile upon exposure to air pollutants, causing the pollens to burst and release their protein contents, inducing allergic symptoms such as asthma.[29] In this study, mango pollen was predominant among partly controlled bronchial asthma patients.

Another statistically significant pollen found in this study was coconut pollen, which is widely cultivated in the Philippines. It has high pollen production and can easily become airborne. Thus, continuous exposure to these coconut pollens may induce allergic symptoms. Jaggi et al. studied the immunochemical characterization of coconut pollen and identified Cocos 11, VI, and VII as its allergenic proteins, causing sensitization.[42]

Pollen sensitization among asthmatic patients in North Luzon

Among asthmatic patients in North Luzon, the pollens with the highest frequency distribution, as seen by positive skin test results, were corn, followed by Bermuda grass and pine tree, rice pollen, and Johnson (Table 4). The pollens significantly associated with disease presence were pine tree, acacia, makahiya, carabao, pigweed, amorseco, mango tree, koros-korosan, and yardgrass (Appendix B Table B4).

Gramineae, to which corn, Bermuda grass, rice pollen, Johnson, carabao grass, koros-korosan, and yard grass belong, were found in the pollen of survey of Bulalacao in Baguio City to be the fourth most abundant group of pollens, peaking in October and November. This was also noted to be predominant in the study of Cua-Lim and Payawal on the atmospheric pollens in Baguio, representing North Luzon.[1,31] As mentioned in the study of Diethart, Gramineae or Poaceae family share pollen characteristics that can increase their allergenicity.[15]

In this study, corn was the most prevalent pollen among asthmatic patients in North Luzon. It was also the most common pollen among patients with controlled bronchial asthma (Appendix B Table B5).

Pine tree, a predominant pollen found outside the grass family and abundant in the elevated regions of Northern and Central Luzon, was significantly associated with bronchial asthma.[6] This current finding is parallel to the pollen studies of Bulalacao and Cua-Lim and Payawal, wherein pine tree was the most commonly occurring pollen throughout the year.[1,31]

Pollen sensitization among asthmatic patients in South Luzon

Among asthmatic patients in South Luzon, the pollens that showed the highest frequency distribution, as seen by positive skin test results, were pigweed and acacia, followed by Bermuda grass, Johnson, camachile, cogon, corn, and carabao grass (Table 4). Only Johnson and foxtail were significantly associated with disease presence (Appendix B Table B4).

In this study, pigweed ranked fifth in South Luzon's pollen sensitization profile (Table 2). A study of the Amaranthaceae family, to which pigweed belongs, has shown that even low concentrations of this pollen can induce allergic symptoms.[27] Pigweed was the most common among controlled and partly controlled bronchial asthma patients in South Luzon (Appendix B Table B5).

Acacia was ranked ninth in South Luzon's overall pollen sensitization profile (Table 2). Similarly, a study conducted in Indonesia showed that 12.15% of 107 patients with asthma showed sensitivity to acacia.[23] A study regarding pollen proteases by Widmer et al. demonstrated that acacia can release proteases that can cause airway epithelial cell detachment, leading to sensitization and asthmatic symptoms.[43] Acacia was noted as the most common among controlled and partly controlled bronchial asthma patients in South Luzon (Appendix B Table B5).

Grass pollens were then the next predominant pollens in this study among asthmatic patients in South Luzon (Table 2). Johnson and foxtail were the only pollens with a statistically significant association. Grass pollens are ubiquitous and wind-pollinated. Their structural characteristics, such as the lack of exine, confer very high allergenicity, causing it to induce allergic symptoms such as asthma.[15] In this study, Bermuda grass was one of the most common pollens identified in patients with controlled bronchial asthma patients in South Luzon.

Pollen sensitization and atopic dermatitis

Atopic dermatitis caused by pollens may be considered, especially if patients have a history of hay fever or bronchial asthma secondary to pollens. Due to pollen sensitivity, atopic dermatitis can present in seasonal variations or occur perennially with or without seasonal exacerbations.[44] Therefore, the association of pollen sensitization to the presence of atopic dermatitis is an important area of interest.

Among patients with atopic dermatitis, grass pollens were still the most common sensitizers across all areas: Bermuda for both NCR and North Luzon; talahib for both NCR and South Luzon; koros-korosan, yard grass, Johnson, carabao grass, amorseco, cogon, foxtail and rice pollen in NCR; and corn in North Luzon. Other dominant pollens outside the grass family were acacia for NCR and North Luzon, pigweed for North and South Luzon, wild daisy and mango tree for NCR, and mutha for South Luzon. However, no significant association between these pollens and atopic dermatitis was found in NCR and North Luzon. While in South Luzon, only talahib, corn, and Johnson were found to be significantly associated (Table 5).

Pollen sensitization among AD patients in NCR

Among atopic dermatitis patients in NCR, the pollens that showed the highest frequency distribution, as seen by

positive skin test results, were koros-korosan, yard grass, and Johnson, followed by carabao grass, amorseco, wild daisy, mango tree, and cogon and then, Bermuda grass, pigweed, acacia, talahib, foxtail, and rice pollen. No pollen was significantly associated with disease presence (Table 5). Consistent with pollen sensitization among allergic rhinitis and asthmatic patients, grass pollens were found to be predominant among atopic dermatitis patients in NCR in this study, owing to their structural characteristics as wind-pollinated pollens, which readily cause sensitization and allergic symptoms.[15,19]

Pollen sensitization among AD patients in North Luzon

Among atopic dermatitis patients in North Luzon, the pollens that showed the highest frequency distribution, as seen by positive skin test results, were Bermuda, corn, and acacia. No pollen was significantly associated with disease presence (Table 5). Besides grass pollens, namely Bermuda grass and corn, whose increased allergenicity was discussed above[15], acacia was also found to be the predominant cause of sensitization among atopic dermatitis in North Luzon in this study. Acacia, a member of the Fabaceae family, is insect-pollinated and can cause less sensitization than the Gramineae or Poaceae family. However, acacia pollens can become airborne and cause sensitization when produced in sufficient amounts.[29]

Pollen sensitization among AD patients in South Luzon

Among atopic dermatitis patients in North Luzon, the pollens that showed the highest frequency distribution, as seen by positive skin test results, were talahib, mutha, and pigweed. Only talahib, corn, and Johnson were significantly associated with disease presence (Table 5). Similar to NCR and North Luzon, grass pollens, namely talahib and corn, are predominant and statistically significant among atopic dermatitis in South Luzon in this study, owing to their high allergenicity.[15,19] Pigweed, on the other hand, can induce sensitization even at low concentrations.[27,39]

In summary, plant and grass sensitization was high in NCR, North, and South Luzon, due to expected vegetative growth.[45] Allergic diathesis may also require to 2 to 3 years of environmental exposure before clinical sensitization can occur.[6]

Pollen sensitization and patient characteristics (age, sex, family history of atopy)

In this study, pollen sensitization according to age showed that patients 20-40 years of age had the most pollen sensitization in all areas (Appendix B Figures B1-B3). This finding is consistent with Sabit et al. in Manila, where pollen sensitization was also found to be highest in the same age group.[8]

This current study also showed that the age groups with the least amount of pollen sensitization are pediatric patients 2-4 years old in NCR and North Luzon and elderly patients (>60 years old) in South Luzon (Appendix B Figures B1-B3). In a similar study by Sabit et al. in Manila, the elderly group had the least pollen sensitization, followed by the pediatric age group of 2-9 years.[8]

In the study from China by Li et al., pollen sensitization was found to be the least among pediatric patients 5-14 years old, peaked among 25-35 years old, and then declined among 55-65 years old.[46]

In terms of frequency distribution among pollens, only Bermuda grass, Egyptian, and pigweed had a significant association with age in NCR; pigweed, and talahib in North Luzon; and mutha, carabao grass, Bermuda, corn, mango, and ipil-ipil in South Luzon.

In terms of sex distribution, males had more pollen sensitization in NCR, but more common among females in North and South Luzon. There was no significant association between sex and pollen sensitization. (Appendix B Figures B4-B6). Conversely, Punay et al., found males to be more prone to sensitization.[5] Whereas Sabit et al., reported females have a higher pollen sensitization in all age groups.[8] Significance of association, however, was not done in these previous studies.

It can be hypothesized that pollen sensitization profiles may be due to lifestyle differences between age groups and sexes.[5]

Patients who have a positive family history of atopy are more likely to have atopic diseases.[5] In this study, pollen sensitization was noted to be more frequent among those with a family history of atopy, but the association was not statistically significant. (Appendix B Figures B7-B9). According to Kallio et al., intradermal skin tests for ragweed pollen and grass pollen were compared in between parents and siblings of children with ragweed hay fever and positive skin tests, and those parents and siblings of children without ragweed hay fever and negative skin tests. The showed that the ability to form sensitization to ragweed and grass pollens is familial and may be genetically determined.[47] Another study by Somoza et al., examined the pattern of sensitization among Spanish and Moroccan children and adolescents born in the same rural area. This study reported that although ancestry can contribute to sensitization, the environment may have a greater influence on its development.[48]

Pollen sensitization and season

Since our local flora pollinates throughout the year, it is believed that there is no seasonal occurrence of atopy in

the Philippines. However, previous studies have mentioned seasonal incidence of atopic disease consultations for bronchial asthma following the pattern of peak pollination of certain grass pollens and weeds., Accordingly, this highlights the need to review pollen sensitization and their seasonal associations.[38] Contrary to temperate countries, the Philippines has only two seasons: rainy season (June to November) and dry season (December to May).[49] The seasonal occurrence of atopic disease consultations cannot be expected to happen regularly since pollination peaks may be affected by seasonal variations.[38]

In this study, pollen sensitization was higher during the rainy season than in the dry season across all areas (Appendix B Figures B10-B12). This contrasts with Agbayani's findings, which showed peak pollinations in several areas in the Philippines, particularly Manila, occurring from March to April compared to November to December. Around May to October, heavy rain downpours can wash away the pollens, causing decreased pollen count from June to October.[38] This was confirmed in the study by Sabit et al., where pollen concentrations peak during the dry season (March-May), and with only 13% of pollen concentrations during the rainy season, suggesting a positive correlation with temperature, and negative correlation with humidity and rainfall.[27]

In this study, grass pollens were the most remained predominant across all areas. Koros-korosan was the predominant pollen in NCR's rainy and dry seasons. In North Luzon, Bermuda grass was predominant in both seasons, while corn pollen was also common during the rainy season. Carabao grass was predominant during the dry season in South Luzon.

In the study of Cua-Lim and Payawal, the Graminaceae family peaked around January to April.[1] On the other hand, grass pollens were found to peak around October to November in two studies of Remo and Laserna in Makati and Bulalacao's study in Baguio City. Tall grasses were abundant during the rainy season, causing profuse vegetative growth.[26,31,40] These previous studies of Remo and Laserna, and Bulalacao support our present findings, which showed that grass pollens have more positive sensitization rates during the rainy season than in the dry season in all areas.

In Remo and Laserna's study, Cyperaceae was found to be abundant in July.[26] In this study, mutha, a member of Cyperaceae, was the most common pollen during the rainy and dry season in South Luzon.

According to the study of Agbayani et al., the pine tree was observed to peak from February to March, while in the study of Bulalacao, the peak was from January to February.[6,31] In this study, however, the pine tree was found to have more positive reactions via skin test during the wet season than the dry season.

Fabaceae or Leguminsoae family has a year-round flowering season but was reported to be abundant in March in the study by Remo and Laserna.[26,40] Makahiya, a member of the Fabaceae or Leguminosae family, was observed in the study of Agbayani to have its peak pollinations from January to May.[6] In this study, however, makahiya had more positive skin test reactions during the wet season. Other members of the Fabaceae family are ipil-ipil and camachile.[26] In the study of Agbayani (1989), ipil-ipil was found to be present in the atmosphere in March, September, and December.[40] In this current study, both ipil-ipil and camachile were found to have more positive skin test reactions during the wet season.

Remo and Laserna also noted that Amaranthaceae were more prevalent in September.[26] Similar to this current study's findings, pigweed had a higher positive sensitization rate during the wet season in North and South Luzon.

Most fruit-bearing trees, such as mango trees, flower from January to March.[26] The present findings showed that mango pollen sensitization is the same during dry and wet seasons.

Only wild daisy, a member of the Asteraceae family, whose anthesis stage is from September to May,[29] had increased positive skin test reactions during the dry season compared to the rainy season and showed significant association in NCR. For North and South Luzon, no other pollens showed a significant association (Appendix B Table 11).

These findings may be affected by climatological factors such as humidity, temperature, rainfall, wind velocity, and direction. High wind velocity, heat, and warm temperature increase atmospheric pollen count, while high humidity and heavy rain can decrease it.[26]

CONCLUSION

This study showed that among the 355 patients included, there was an increased sensitization (63.1%) to pollen compared to previous studies, possibly due to climate and urban changes.

Similar to previous local studies, grass pollens are still the most predominant cause of pollen sensitization across all areas. Carabao grass, Bermuda grass, and pigweed were the most common pollen allergens in Luzon.

Grass pollens were also one of the top causes of pollen sensitization among allergic rhinitis, bronchial asthma,

and atopic dermatitis patients in each area. The most predominant pollens per area were as follows: koros-korosan, Bermuda grass, and wild daisy (NCR); carabao grass, mango, and amorseco (North Luzon); and mutha, carabao grass, and cogon (South Luzon).

Bermuda grass (North Luzon) and mutha, carabao grass, and cogon (South Luzon) were pollens with statistically significant associations with disease presence among allergic rhinitis patients.

Among asthmatic patients, pollens that had a statistically significant associations with disease presence were pigweed, foxtail, and coconut pollen (NCR); pine tree, acacia, makahiya, carabao grass, pigweed, amorseco, mango, koros-korosan, and yard grass (North Luzon); and Johnson and foxtail (South Luzon).

Among atopic dermatitis patients, the pollens talahib, corn, and Johnson grass (South Luzon) had statistically significant associations with disease presence.

Sensitization frequency was highest among the age group of 20-40 years.

Most pollens elicited more positive skin reactions during the wet season than in the dry season. Only wild daisy was found to have a significant association with the season.

In summary, plant and grass sensitization was high in areas due to expected vegetative growth. The timing of this study, which followed after the Covid-19 pandemic may have contributed to reduced exposure and decreased sensitization to outdoor pollens. Allergic diathesis may take up 2 to 3 years of environmental exposure before clinical sensitization.

These changes in the pollen sensitization profiles may be due to progressive urbanization, climatological changes, and differences in vegetative growth across all regions.

The researcher hopes these findings can help achieve the objectives of House Bill 9575, the "Pollen Detection and Management Act," and support in the diagnosis, management, and allergen avoidance strategies of patients with allergic rhinitis, asthma, and atopic dermatitis.

LIMITATIONS AND RECOMMENDATIONS

This study mainly focused on pollen allergens, their sensitization profile in association with atopic diseases and their severity, and possible risk factors such as age, sex, season, and family history of atopy. However, it did not consider indoor allergens such as house dust mites.

Since this is a retrospective study, selection bias may have occurred. Healthy controls without atopic diseases were not included, and the sensitization profiles of patients and health controls could not compared.

It is recommended that a prospective study be conducted on our standardized local pollens among subject controls and allergic patients, as this may provide a better sensitization profile. This study was limited Luzon, and it would benefit allergists to have local studies done in Visayas and Mindanao. Increasing the number of sample populations to be tested and doing the procedure in other rural areas can further the interest of making a more accurate pollen sensitization profile in the country.

Multiple sensitizations among patients with atopic diseases in this study suggest homologous protein structures, which cause cross-reaction. Since grass pollens are the most predominant outdoor pollens in the country and show a high degree of cross-reactivity, further study on pollen cross-reactivity may also be another research endeavor in the future.

Acknowledgments
The authors would like to acknowledge Dr. Frances Rose Palabrica, Dr. Marie Liz Bugho-Fortuna, Dr. Gretchen Guerrero, Dr. Celeste Tolentino, and Dr. Paulita Teruel for their contributions to the data on the pollen sensitization profiles in different areas of Luzon.

Statement of Authorship
All authors fulfilled ICMJE authorship criteria.

Data Availability Statement
The supplementary files (Appendices A and B) are available from the corresponding author upon reasonable request.

Author Disclosure
Dr. Shirley L. Kwong-Buizon is an Associate Editor of PJAAI.

Funding Source
The study was funded by the Fe del Mundo Medical Foundation.

REFERENCES

1. Cua-Lim F, Payawal P, Gloria L. Studies on atmospheric pollens in the Philippines. Ann Allergy. 1978;40(2):117-23. PMID: 629427
2. Yin W, Xiaoli Z, Wenjin D, et al. Sensitization profiles of aeroallergens among allergic rhinitis patients in China: a 13-year multicenter retrospective study. Allergy. 2024;79(5):1329-32. PMID: 37305996 DOI: 10.1111/all.15784
3. Liu Y, Yang S, Zeng Y, et al. Influence of the COVID-19 pandemic on the prevalence pattern of allergens. Int Arch Allergy Immunol. 2022;184(1):43-53. PMID: 36279853 PMCID: PMC9747740 DOI: 10.1159/000526892

4. D'Amato G, Liccardi G, D'Amato M, Cazzola M. Outdoor air pollution, climatic changes and allergic bronchial asthma. Eur Respir J. 2002;20(3):763-76. PMID: 12358357 DOI: 10.1183/09031936.02.00401402
5. Punay J, Lucas MF, Arpon IM, Jalbuena Q, Albano PM, Sabit M. Sensitisation profile to pollen allergens of selected grass and tree species in Filipino communities. Grana. 2024;63(1):52-66. DOI: 10.1080/00173134.2024.2316045
6. Bulalacao L, Lim H, Agbayani B. A study of Philippine common allergenic pollen grains IV. Allergenicity studies of isolated pollens by skin tests. Philipp J Intern Med. 1989;27(4):215-9.
7. Cabauatan CR, Ramos JDA. Immunoglobulin E-binding reactivities of natural pollen grain extracts from selected grass species in the Philippines. Asia Pac Allergy. 2012;2(2):136-43. PMID: 22701864 PMCID: PMC3345327 DOI: 10.5415/apallergy.2012.2.2.136
8. Sabit M, Wong C, Andaya A, Ramos JD. Pollen allergen skin test and specific IgE reactivity among Filipinos: a community-based study. Allergy Asthma Clin Immunol. 2020;16:74. PMID: 32922458 PMCID: PMC7477877 DOI: 10.1186/s13223-020-00471-9
9. Abong JM, Kwong SL, Alava HDA, Castor MAR, De Leon JC. Prevalence of allergic rhinitis in Filipino adults based on the National Nutrition and Health Survey 2008. Asia Pac Allergy. 2012;2(2):129-35. PMID: 22701863 PMCID: PMC3345326 DOI: 10.5415/apallergy.2012.2.2.129
10. Alava H, Dans L, Sumpaico M, Castor MA, De Leon J. Prevalence of asthma among Filipino children 0-19 years old based on National Nutrition and Health Survey (NNHeS). Philipp J Pediatr. 2006;55(4): 189–96.
11. Varona L, Alava H, Abong J, Castor MA, De Leon J, Kwong S. Prevalence of asthma among Filipino adults based on the National Nutrition and Health Survey (NNHeS). Philipp J Intern Med. 2014;52(4):1-7.
12. Gabriel MT, Lim HG, Gulmatico-Flores Z, et al. Guidelines for the management of atopic dermatitis: A literature review and consensus statement of the Philippine Dermatological Society. J Phil Dermatol Soc. 2020:35–58. https://pesquisa.bvsalud.org/portal/resource/pt/wpr-876398
13. Rapadas-Aguirre MA. Pattern of allergen sensitization in Filipino pediatric patients with allergic diseases seen in an allergy clinic. [Unpublished manuscript]. Fe del Mundo Medical Center; 2018.
14. House Bill No. 9575, 18th Congress of the Republic of the Philippines. Senate of the Philippines Legislative Reference Bureau. Published 2022. Accessed June 22, 2024. https://issuances-library.senate.gov.ph/bills/house-bill-no-9575-18th-congress-republic
15. Diethart B, Sam S, Weber M. Walls of allergenic pollen: special reference to the endexine. Grana. 2007;46(3):164–75. DOI: 10.1080/00173130701472181
16. Jianan X, Zhiyun O, Hua Z, Xiaoke W, Hong M. Allergenic pollen plants and their influential factors in urban areas. Acta Ecologica Sinica. 2007;27(9):3820–7.
17. Santos-Estrella PFR, Recto MT, Castor MR, et al. Skin prick test reactivity to aeroallergens and food allergens among pediatric patients. [Unpublished manuscript].
18. Cua-Lim F. Aeroallergens in the Philippines. Phil J Aller Immunol Ann Allergy. 1985;54(2):99-104.
19. Castor MAR, Sumpaico MW, Matias RR, Geniston LA. Partial characterization of Bermuda, Carabao, Cogon and Talahib grass pollen extracts. Acta Med Philipp. 2016;50(2):62-9. DOI: 10.47895/amp.v50i2.844
20. Fischer S, Grote M, Fahlbusch B, Müller W, Kraft D, Valenta R. Characterization of Phl p 4, a major timothy grass (Phleum pratense). J Allergy Clin Immunol. 1996;98(1):189–98. PMID: 8765834 DOI: 10.1016/s0091-6749(96)70242-7
21. Burbach G, Heinzerling L, Edenharter G, et al. GA(2) LEN skin test study II: clinical relevance of inhalant allergen sensitizations in Europe. Allergy. 2009;64(10):1507–15. PMID: 19772516 DOI: 10.1111/j.1398-9995.2009.02089.x
22. Lâm HT, Ekerljung L, Bjerg A, Văn Tường N, Lundbäck B, Rönmark E. Sensitization to airborne allergens among adults and its impact on allergic symptoms: a population survey in northern Vietnam. ClinTransl Allergy. 2014;4(1):6. PMID: 24512828 PMCID: PMC3923743 DOI: 10.1186/2045-7022-4-6
23. Baratawidjaja IR, Baratawidjaja PP, Darwis A, et al. Prevalence of allergic sensitization to regional inhalants among allergic patients in Jakarta, Indonesia. Asian Pac J Allergy Immunol. 1999;17(1):9–12. PMID: 10403003
24. Chew FT, Lim SH, Shang HS, et al. Evaluation of the allergenicity of tropical pollen and airborne spores in Singapore. Allergy. 2000; 55(4):340–7. PMID: 10782518 DOI: 10.1034/j.1398-9995.2000.00308.x
25. Agbayani BF. Pollenosis in the Philippines. Acta Med Philipp.1998;24(3), 99-105.
26. Remo I, Laserna G. Aeropalynological studies in the Makati Area. Philipp J Sci. 1970;99(1-2):1–11.
27. Sabit M, Ramos JD, Alejandro GJ, Galán C. Seasonal distribution of airborne pollen in Manila, Philippines, and the effect of meteorological factors to its daily concentrations. Aerobiologia. 2015;32(3):375–83. DOI: 10.1007/s10453-015-9414-2
28. Cabauatan CR, Luinek C, Scheiblhofer S, et. al. Allergen microarray detcts high prevalence of asymptomatic IgE sensitizations to tropical pollen-derived carbohydrates. J Allergy Clin Immunol. 2014;33(3): 910-4.e5. PMID: 24315449 PMCID: PMC6597356 DOI: 10.1016/j.jaci.2013.10.004
29. Hate K, Castor MA, Cruz MK, et al. Characterization of pollen grain and pollen extract from common allergenic plants in the Philippines. Philipp J Sci. 2023;152(6B):2445-53.
30. PhilAtlas. National Capital Region (NCR) profile. PhilAtlas. Accessed Dec 12, 2024. https://www.philatlas.com/luzon/ncr.html
31. Bulalacao L. Pollen survey in Baguio City in 1984. Acta Med Philipp. 1985:21(2):51-3.
32. Navarro-Locsin CG, Lim-Jurado M. Aeroallergen sensitization and associated comorbid diseases of an adult Filipino population with allergic rhinitis. Asia Pac Allergy. 2018;8(3):e25. PMID: 30079303 PMCID: PMC6073179 DOI: 10.5415/apallergy.2018.8.e25
33. Pumhirun P, Towiwat P, Mahakit P. Aeroallergen sensitivity of Thai patients with allergic rhinitis. PubMed. 1997;15(4):183–5. PMID: 9579610
34. Aud-in S, Juprasong Y, Pinkaew B, Talek K, Tantilipikorn P, Songnuan W. Incidence of grass and weed sensitization in Bangkok, Thailand: a clinical study. Frontiers Public Health. 2024;12:1301095. PMID: 38605873 PMCID: PMC11007029 DOI: 10.3389/fpubh.2024.1301095
35. Luzon. Brittanica Accessed December 12, 2024. https://www.britannica.com/place/Luzon
36. Sam CK, Soon SV, Liam CK, Kesavan Padmaja, Hwee Ming Cheng. An investigation of aeroallergens affecting urban Malaysian asthmatics. Asian Pac J Allergy Immunol. 1998;16(1):17–20. PMID: 9681124
37. Oldenburg M, Petersen A, Baur X. Maize pollen is an important allergen in occupationally exposed workers. J Occup Med Toxicol. 2011;6: 32. PMID: 22165847 PMCID: PMC3269392 DOI: 10.1186/1745-6673-6-32
38. Agbayani BF, Castillo-Ochoa A. The seasonal incidence of bronchial asthma: A preliminary report. I. The relationship of asthma consults with pollen counts. Philipp J Intern Med. 1968;6(4):165.
39. Paloma C, Alcázar P, Galán C, Dominguez-Vilches E. Environmental behaviour of airborne Amaranthaceae pollen in the southern part of the Iberian Peninsula, and its role in future climate scenarios. Science of The Total Environment. 2014;470-471C(4):480–7. PMID: 24176695 DOI: 10.1016/j.scitotenv.2013.10.024:
40. Remo I. Laserna G Field survey of probable allergenic plants in The Makati Area,1968-69. Philipp J Sci. 1970;99(1-2):13–20.
41. EMB – National Capital Region | DENR-Environmental Management Bureau. Regional profile. Accessed Dec. 12, 2024. https://ncr.emb.gov.ph/regionalprofile/
42. Karmakar PR, Chatterjee BP. Cocos nucifera pollen inducing allergy: sensitivity test and immunological study. Indian J Exp Biol. 1995;33(7):489-96. PMID: 7590957
43. Widmer H, Whittaker K. Substrate preference profiles of proteases released by allergenic pollens. Clin Exp Allergy. 2000;30(4):571-6. DOI: 10.1046/j.1365-2222.2000.00784.x
44. Wang X, Zhuang Y, Chen Y, Wang H, Wang X. Prevalence of adult eczema, hay fever, and asthma, and associated risk factors: a population-based study in the northern Grassland of China. Allergy Asthma Clin Immunol. 2021;17(1):27. PMID: 33750462 PMCID: PMC7941905 DOI: 10.1186/s13223-021-00532-7
45. Bousquet PJ, Chinn S, Janson C, Kogevinas M, Burney P, Jarvis D; European Community Respiratory Health Survey 1. Geographical variation in the prevalence of positive skin tests to environmental aeroallergens in the European Community Respiratory Health Survey I. Allergy. 2007;62(3):301-9. PMID: 17298348 DOI: 10.1111/j.1398-9995.2006.01293.x

46. Li J, Sun B, Huang Y, et al. A multicentre study assessing the prevalence of sensitizations in patients with asthma and/or rhinitis in China. Allergy. 2009;64(7):1083–92. PMID: 19210346 DOI: 10.1111/j.1398-9995.2009.01967.x
47. Kallio EIS, Bacal HL, Eisen A, Fraser FC. A familial tendency toward skin sensitivity to ragweed pollen. J Allergy. 1966;38(4):241-9. PMID: 5224047 DOI: 10.1016/0021-8707(66)90058-x
48. Somoza ML, Pérez-Sánchez N, Torres-Rojas I, et al. Sensitisation to pollen allergens in children and adolescents of different ancestry born and living in the same area. J Asthma Allergy. 2022;15:1359-67. PMID: 36189188 PMCID: PMC9525024 DOI: 10.2147/JAA.S370279
49. PAGASA. Climate-Philippines 2025. https://www.pagasa.dost.gov.ph/information/climate-philippines