

The risk factors and quality of life in children with allergic rhinitis in relation to seasonal attack patterns

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Summary

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A questionnaire survey was conducted to examine whether risk factors and allergic rhinitis (AR)-related quality of life (QOL) were different among children with different seasonal patterns of AR. Participants were students enrolled in elementary and middle schools in Taipei County, Taiwan. Using moving average and principal component analysis, children with current AR were grouped by attack seasons. The effects of personal and environmental factors on AR seasonality were assessed by logistic regression models. AR severity and AR-related QOL were compared within AR seasonal subtypes.

Among 4221 children who completed the questionnaire, 1144 and 1605 children were current AR cases and healthy controls, respectively. Four AR subtypes were categorised as follows: perennial, spring, summer/fall, and winter. Age, gender, parental education, maternal passive smoking during pregnancy, breast feeding, and mouldy walls were found to contribute differentially to different AR subtypes. Children suffering from perennial and winter AR were found to have more severe symptoms and significantly lower QOL score compared with other subtypes. Specific personal and environmental risk factors could contribute to different AR seasonal subtypes. Active allergen avoidance and symptomatic treatment should be the focus of management aiming to improve the QOL among children with perennial and winter subtype.

Keywords: allergic rhinitis, seasonality, disease severity, quality of life, maternal prenatal passive smoking, breast feeding, mould.

Abbreviations: 95% CI: 95% confidence interval; AR: allergic rhinitis; BMI: body mass index; ETS: environmental tobacco smoke; OR: odds ratio; PCA: principal component analyses; QOL: quality of life; WMA: weighted moving average

Introduction

Allergic rhinitis (AR) is a disease of high prevalence that affects 1.4% to 39.7% of children worldwide.¹ In

Taiwan, the AR prevalence in children is about 38.1%.² Several population-based epidemiological studies demonstrate that the prevalence of childhood AR, especially in 6- and 7-year-old children, has been increasing over time.³

Allergic rhinitis is clinically defined as a symptomatic disorder of the nose (including nasal obstruction, rhinorrhea, sneezing, itching of the nose and postnasal drainage) induced by an immunoglobulin E-mediated inflammation after allergen exposure of the membranes lining the nose. Climate factors, air pollutants, fungal spores, indoor environment, and inherent

characteristics of children may contribute to the occurrence of AR.⁴ AR is not limited to physical symptoms of the target organ. It also provokes disturbances in the general well-being of the affected subjects. It has been suggested that AR can alter perceived health status, pose limitations in daily activities, and affect school performance in affected children.⁵

Although the aetiology of childhood AR is not well established, a seasonal variation in AR has been described locally. More cases of AR symptoms have been observed in colder climates, as opposed to warmer ones.⁶ A better understanding of AR risk factors, AR attack frequency, AR severity, and AR-related quality of life (QOL) in relation to seasonality will be helpful for AR prevention and improvement of QOL among children with AR.

This population-based questionnaire survey aims to examine whether personal and environmental risk factors contribute differently among children with different AR seasonal subtypes and whether the severity of symptoms and QOL vary with AR seasonality.

Materials and methods

Subjects

In September 2007, a cross-sectional population-based study was conducted in three elementary and two middle schools located within a 2.5-km radius of the Environmental Protection Administration monitoring station in Sinjhuang City, Taipei metropolis, northern Taiwan. The population and territory of this city in 2007 comprised 396 000 residents and 19.7 km². Stratified sampling by grade was performed in each school. A total of 5664 candidates between 6 and 14 years of age were selected from a total of 6685 students. A structured questionnaire was taken home by students and answered by their parents. A total of 4221 students completed the questionnaire out of 5664 candidates (response rate = 74.5%). Participation in the survey was voluntary. The study was approved by the Institutional Review Board of National Taiwan University Medical Center. Written informed consents were obtained from all the participants.

Questionnaire

The questionnaire included the following sections: demographic characteristics, family history of respiratory disease, indoor environmental factors at home, AR

history, AR severity, and AR-related QOL. The definition and common manifestations of AR were explained to improve the parents' recognition of the condition. The validity of the questionnaire has been confirmed previously.⁷ The children and their parents were unaware of our hypothesis. To our knowledge, no study on risk factors and QOL in relation to AR seasonality had been carried out in this region. Children were defined as currently having AR if their parents answered 'yes' to all of the following questions: (Q1) 'Has this child ever been diagnosed by a physician as having AR?', (Q2) 'Has this child ever experienced problems with sneezing, a runny nose, or a blocked nose while not having a cold or the flu?', and (Q3) 'Has this child ever experienced the above symptoms in the past 12 months?'. Children whose parents answered 'no' to Q1 and Q2 were grouped as the healthy controls.

Children with current AR were asked to identify the months of AR attack in the past 12 months when they did not have a cold or the flu. The month with AR attack was given an original attack score of '1', and the month without attack was given a score of '0'. Classification of AR seasonal subtypes was adopted from the method of Han *et al.*⁸ as follows: (i) Children were classified as having perennial AR if they experienced AR symptoms at least once in each season; (ii) For those without perennial AR, a weighted moving average (WMA) approach was used to represent monthly occurrences. The WMA score of each target month was calculated as (original attack score $\times$ 1) + (original attack scores of months before and after the target month $\times$ 0.5) + (original attack scores of 2 months before and 2 months after the target month $\times$ 0.25). The moving average can effectively smooth out random fluctuations and the results could point out real changes better. For each child, a WMA attack score was assigned to each month, ranging from 0 to 2.5; (iii) Principal component analyses (PCA) were used to categorise AR subtypes based on the WMA scores. The PCA yielded three rotated factors with eigenvalues > 1.0 . Children with AR attacks in March, April and May were counted towards the spring subtype; those in June, July, August and September, the summer/fall subtype; those in October, November, December, January and February, the winter subtype (see details in supplement); (iv) If children with current AR could not be classified into any of these four subtypes, they were excluded when conducting multivariate analysis by AR subtypes.

Exposure and outcome measurements

Gender- and age-specific body mass index (BMI) was calculated and used to determine whether a subject was overweight. For boys/girls aged from 6 to 14 years, BMI higher than 17.8/17.6, 18.6/18.0, 19.3/18.8, 19.7/19.3, 20.3/20.1, 21.0/20.9, 21.5/21.6, 22.2/22.2 and 22.7/22.7 kg/m², respectively, were defined as overweight.⁹ Parental allergic disease was defined by a history of asthma, AR, or atopic eczema in either the father or mother. Information on maternal smoking during pregnancy, maternal passive smoking during pregnancy, and breast feeding was obtained from the questionnaire. Indoor environmental factors at home included the presence of cockroaches in the past month, water damage in the past year, wall with visible mould, and environmental tobacco smoke (ETS).

To evaluate AR severity, the following data were collected: frequency of AR attacks (>3 or ≤3 times), nose problems accompanied by itchy-watery eyes (ever/never), clinic or emergency room visit (3+ or <3 times), and oral or intranasal medicine usage (yes/no) in the past 12 months. AR-related QOL questions were extracted and modified from the Pediatric Allergic Disease Quality of Life Questionnaire.¹⁰ Parents of children were asked: 'How much was this child bothered by AR doing each of the following activities during the past month?'. These include 10 items divided into three domains: activity limitation domain (being unable to play sports outdoors and being unable to play with friend), symptoms domain (being unable to sleep or have quality sleep, being out of breath or tightness in the chest, and being tired or worn out), and emotional function domain (feeling irritable or frustrated, feeling angry, feeling different from your friends, feeling uncomfortable, and being unable to concentrate). Response options for each item were based on a 7-point scale, where '1' indicated maximum impairment and '7' indicated no impairment. Individual items within the questionnaire were equally weighted. Results were expressed as the mean score per item for each of the domains, as well as for overall QOL. Each domain and overall score ranged from 1 to 7.

Daily temperature record was obtained from the Environmental Protection Administration Sinjhuang monitoring station, and monthly average temperatures between October 2006 and September 2007 were calculated.

Statistical analysis

Bivariate analyses were conducted to evaluate the distribution of demographic characteristics between healthy controls and all current AR cases. Identical analytical methods were used for comparison between healthy controls and each of the AR subtypes. To estimate risk factors associated with AR seasonality, backward stepwise logistic regression and adjusted odds ratios (aOR) with 95% confidence intervals [95% CI] were used to determine the effect of personal and indoor environmental factors on each of the four AR subtypes. Each model was adjusted for age, gender, parental allergic disease and parental education.

Pearson chi-squared and step-down Holm-Bonferroni methods were used for multiple comparisons of AR severity among the four AR subtypes. One-way ANOVA and Tukey's Honestly Significant Differences test were used for multiple comparisons of AR-related QOL among the four AR subtypes. Considering spontaneous remission in children with AR and the effect modification of parental allergic disease, children were stratified by three age groups (6–9, 10–12 and 13–15 years) and by the condition of parental allergic disease (yes/no), respectively, to evaluate stratified seasonal distributions of AR severity and AR-related QOL.

Results

A total of 1144 and 1605 school children were identified as being current AR cases and healthy controls, respectively. Among children with current AR, 251 were classified as perennial AR, 263 spring AR, 294 summer/fall AR and 315 winter AR. A total of 21 children could not be categorised into any of the seasonal subtypes. Characteristics of the study population are shown in Table 1. Compared with healthy controls, children with current AR (including four AR subtypes and non-categorised AR) had a higher percentage of boys, higher parental education and a higher percentage with parental allergic disease. Age, height, weight, BMI, and overweight were not significantly different between healthy and current AR children (with the exception that the spring AR group were younger and lower in height and weight compared with controls).

Figure 1 illustrates the number of children who experienced AR attacks in each month including all current AR combined and each of the four AR subtypes. The monthly temperature was highest in July

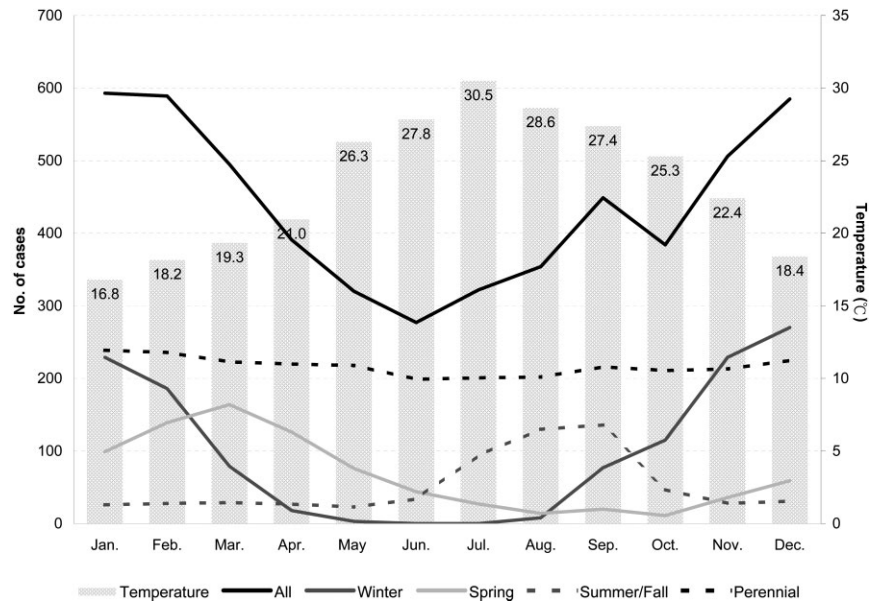
Table 1. Characteristics of participating school children

	Healthy children (<i>n</i> = 1605)	Current AR											
		All (<i>n</i> = 1144)		Perennial AR (<i>n</i> = 251)		Spring AR (<i>n</i> = 263)		Summer/fall AR (<i>n</i> = 294)		Winter AR (<i>n</i> = 315)		Non-categorised AR (<i>n</i> = 21)	
		<i>n</i>	<i>P</i> -value	<i>n</i>	<i>P</i> -value	<i>n</i>	<i>P</i> -value	<i>n</i>	<i>P</i> -value	<i>n</i>	<i>P</i> -value	<i>n</i>	<i>P</i> -value
Gender ^a													
Boy	702	665	<0.01	153	<0.01	149	<0.01	164	<0.01	189	<0.01	10	0.66
Girl	872	452		92		110		122		118		10	
Age (years) ^b													
Mean ± SD	10.8 ± 2.5	10.6 ± 2.5	0.10	10.8 ± 2.5	0.65	10.2 ± 2.5	<0.01	10.6 ± 2.5	0.05	10.9 ± 2.4	0.41	10.6 ± 2.9	0.74
Height (cm) ^b													
Mean ± SD	145.1 ± 16.0	143.9 ± 16.2	0.07	144.5 ± 16.4	0.64	141.6 ± 16.4	<0.01	143.2 ± 16.1	0.08	146.0 ± 15.7	0.37	142.5 ± 17.1	0.51
Weight (kg) ^b													
Mean ± SD	40.6 ± 14.1	40.2 ± 14.4	0.43	39.9 ± 15.2	0.51	38.2 ± 0.9	0.01	39.6 ± 13.5	0.25	42.4 ± 14.9	0.06	42.1 ± 14.1	0.67
BMI (kg/m ²) ^b													
Mean ± SD	18.8 ± 3.7	18.8 ± 3.7	0.86	18.6 ± 3.9	0.45	18.3 ± 3.6	0.07	18.8 ± 3.4	0.94	19.3 ± 3.9	0.08	20.2 ± 3.9	0.14
Overweight ^a													
Yes	331	258	0.44	49	0.51	50	0.41	68	0.44	83	0.06	8	0.19
No	902	652		150		157		164		170		11	
Parental allergic disease ^a													
Yes	444	729	<0.01	163	<0.01	159	<0.01	171	<0.01	224	<0.01	12	<0.01
No	1161	356		88		104		123		91		9	
Parental education ^a													
≥13 years	486	445	<0.01	118	<0.01	99	0.03	110	0.02	110	0.14	8	0.47
<13 years	1072	686		131		163		179		201		12	

^aPearson chi-squared test.^bStudent's *t*-test.

AR, allergic rhinitis; BMI, body mass index.

Figure 1. Temporal trends for allergic rhinitis case number (person/time) by month. Black line represents all current allergic rhinitis cases combined. Light grey bar represents average monthly temperature in Taipei County, Taiwan, 2007.



and lowest in January during the study period. Overall, the number of children's attacks peaked in January and decreased as the temperature increased, reaching a nadir in June. The temporal pattern of perennial AR appeared to be flat over time. A peak of spring AR was observed in March. Higher attack numbers of summer/fall AR were observed in August and September.

After adjustment for potential confounders, we found that breast feeding and maternal passive smoking during pregnancy were related to a higher risk of perennial AR (aOR = 1.60, 95% CI 1.18, 2.18; aOR = 2.19, 95% CI 1.36, 3.45, respectively; Table 2). Exposure of walls with visible mould significantly increased the risk of winter AR (aOR = 1.46, 95% CI 1.08, 1.99).

The distribution of symptomatic severity among the four AR subtypes is shown in Table 3. In the past 12 months, 100% of perennial AR children experienced AR attacks more than three times, 72.9% had nose problems accompanied by itchy-watery eyes, and 60.1% visited a clinic/emergency room at least three times. Compared with spring and summer/fall AR, a higher percentage of winter AR children experienced AR attacks more than three times. Winter AR children also experienced a higher frequency of nose problems and clinic/emergency room visits. Frequency of using oral or intranasal medicine was not found to be different among the four AR subtypes.

The AR-related QOL among four AR subtypes are shown in Table 4. Among all current AR children, the

average QOL scores are 6.5, 5.9, 6.3 and 6.2 for domains of activity limitations, symptoms, emotional functions, and all domains combined, respectively (data not shown). Among four AR subtypes, the perennial AR children had a significantly lower QOL score in each QOL domain compared with the other AR subtypes. QOL scores were not found to be different among winter, spring and summer/fall subtypes. The seasonal distributions of AR severity and AR-related QOL were found to be similar between each age group. Similar seasonal distributions were also found among children with and without parental allergic disease (see detail in supplement).

Discussion

This study used a rather simple statistical approach to classify current AR into different seasonal subtypes according to the month of symptomatic attack. Categorising AR into perennial, spring, summer/fall and winter AR allows further in-depth investigation into the seasonal variations of aetiological factors, AR severity and AR-related QOL.

Similar to a previous study in Taiwan,⁶ we reported that, among all current AR children, more children experienced AR symptoms in colder months and fewer in warmer months (Figure 1). In general, AR attacks were thought to occur more often in the colder season(s). When categorising AR based on the month of symptomatic attack in our study, the perennial subtype comprised children whose symptoms were

Table 2. Association between suspected risk factors and seasonal childhood allergic rhinitis (AR)^a

	Healthy children (<i>n</i> = 1605)		Perennial AR (<i>n</i> = 251)		Spring AR ^b (<i>n</i> = 263)		Summer / fall AR ^b (<i>n</i> = 294)		Winter AR (<i>n</i> = 315)	
	<i>n</i>		<i>n</i>	aOR	[95% CI]	<i>n</i>		<i>n</i>	aOR	[95% CI]
Overweight										
No	902		150			157		164		
Yes	331		49			50		68		
Maternal smoking during pregnancy										
No	1542		245			256		282		
Yes	14		2			1		3		
Maternal passive smoking during pregnancy										
No	1430		211	1.00	Reference	231		257		
Yes	117		34	2.19	[1.36, 3.45]	26		27		
Breast feeding										
No	868		115	1.00	Reference	141		149		
Yes	671		129	1.60	[1.18, 2.18]	114		133		
Cockroach										
No	267		50			43		45		
Yes	1241		192			208		237		
Water damage										
No	1402		221			225		255		
Yes	138		26			31		23		
Wall with visible mould										
No	1203		169			183		194	1.00	Reference
Yes	345		80			71		87	1.46	[1.08, 1.99]
Environmental tobacco smoke										
No	957		154			172		175	1.00	
Yes	588		91			84		105	–	

^aStatistical analysis by backward stepwise multiple logistic regression analysis. Adjusted for age, gender, parental allergic disease and parental education.^bNo factors were statistically significant

Table 3. The symptomatic severities among children with current allergic rhinitis (AR)

	Perennial AR (<i>n</i> = 251)	Spring AR (<i>n</i> = 263)	Summer/fall AR (<i>n</i> = 294)	Winter AR (<i>n</i> = 315)
Children with more than 3 AR attacks in the past 12 months (%)	100.0	51.3 ^a	58.5 ^a	67.3 ^{a,b,c}
Children that had nose problem accompanied by itchy-watery eye in the past 12 months (%)	72.9	60.2 ^a	61.5 ^a	67.1
Children with at least 3 clinic or emergency room visits due to AR in the past 12 months (%)	60.1	39.4 ^a	28.2 ^a	45.9 ^{a,c}
Children that used oral or intranasal medicine in the past 12 months (%)	75.3	73.0	65.0	74.0

The comparisons were made by using Pearson chi-squared test. Step-down Holm-Bonferroni was used for multiple comparisons.

^aThe symptomatic severity was significantly different from perennial AR.

^bThe symptomatic severity was significantly different from spring AR.

^cThe symptomatic severity was significantly different from summer/fall AR.

essentially unchanged throughout the past 12 months, regardless of change in temperature. Although overall a higher percentage (51%) of children experienced AR symptoms in colder months (winter and spring subtypes), severe AR attacks were also found to occur in warmer months (summer/fall subtype). Children with summer/fall AR may represent a pathophysiologically distinctive group.

After adjustment for potential confounders, we found that maternal passive smoking during pregnancy, breast feeding, and mouldy walls were related to different AR seasonal subtypes. Maternal passive smoking during pregnancy was found to be associated with perennial AR. The effect of prenatal exposure to ETS on childhood AR has not yet been extensively studied. However, it has been reported that pregnant women exposed to ETS during the third trimester had a higher risk of giving birth to children who suffered from allergy-related symptoms at pre-school age.¹¹ A murine study has shown that, *in utero* exposure to ETS altered critical developmental pathways, leading to

poorer lung function, increased bronchial responsiveness, and subsequent tendency to wheezing and asthma.¹² Among our study subjects, maternal passive smoking during pregnancy might have made their respiratory mucosa more susceptible to non-specific causal agents of AR and caused perennial AR symptoms.

Breast feeding was found to be associated with perennial AR, but not other seasonal subtypes. It has been suggested that breast feeding increases transmissions of oestrogenic hormones to infants,¹³ which might result in enhanced allergic responses in children. The effects of bacteria and endotoxins on the immune system are reduced by breast feeding through directly reducing the exposure or through passively transferring immune responses from the mother to the child so that the infant does not fully develop mature immunological mechanisms.^{14–16} Based on a 6-year cohort study in children, a U-shaped relationship was shown between duration of breast feeding and the risk of asthma and chronic respiratory symptoms, with an

Table 4. The quality of life (QOL) scores among children with current allergic rhinitis (AR)

	Perennial AR (<i>n</i> = 251)	Spring AR (<i>n</i> = 263)	Summer/fall AR (<i>n</i> = 294)	Winter AR (<i>n</i> = 315)
Overall QOL (score)	5.7 ± 1.0	6.4 ± 0.7 ^a	6.4 ± 0.6 ^a	6.3 ± 0.7 ^a
Activity limitation domain (score)	6.2 ± 1.1	6.7 ± 0.6 ^a	6.7 ± 0.6 ^a	6.6 ± 0.7 ^a
Symptoms domain (score)	5.4 ± 1.3	6.2 ± 0.9 ^a	6.1 ± 0.9 ^a	6.0 ± 1.0 ^a
Emotional function domain (score)	5.8 ± 1.1	6.5 ± 0.8 ^a	6.4 ± 0.7 ^a	6.3 ± 0.8 ^a

Items are mean ± standard deviation. Higher scores indicate better quality. The comparisons were made by using one-way ANOVA. Tukey's honestly significant differences test was used for multiple comparisons.

^aThe QOL score was significantly different from perennial AR.

optimal duration of 4 to 6 months.¹⁷ Future study is needed to elucidate our findings on differential effects of breast feeding on different seasonal types of AR.

Mouldy walls were found to relate to winter AR. A critical meta-analysis concluded that dampness and moulds in a building were associated with approximately 30–50% increases in allergic respiratory responses.¹⁸ Asthma or AR symptoms can be triggered by breathing in mould spores or hyphal fragments.¹⁹ In Taiwan, mouldy walls were found to increase the risk of asthma⁷ and atopic eczema.²⁰ In addition, the indoor concentration of airborne fungal spores was reported to be two times higher in winter than in summer.²¹ Higher concentrations of mould and higher exposure to fungal spores in colder months could have triggered some of the AR symptoms.

Indoor and outdoor aeroallergens not included in our study should also be considered. In Taiwan, house dust mite (*Dermatophagoides pteronyssinus*, *Dermatophagoides farinae* and *Blomia tropicalis*), dog dander, cockroach, cat dander, fungus (*Candida albicans*, *Aspergillus fumigatus* and *Penicillium chrysogenum*) and pollen are common aeroallergens confirmed by human serum allergen-specific immunoglobulin E identification.^{22–24} Remarkable seasonal variation of house dust mite, ambient fungus, and ambient pollen levels in northern Taiwan have been demonstrated. Peaks of house dust mites occur in November and December (winter).²⁵ The highest levels of ambient fungus spores occur in June and September (summer and fall).²⁶ The pollen levels peak in March and April (spring).²⁷ As a result, dust mite, fungus and pollen need to be considered as likely sources of the exacerbation of seasonal AR. Further evaluation of sensitisation to specific allergens associated with different AR seasonal subtypes would elucidate the causal pathway between indoor/outdoor factors and AR seasonality.

This is the first study we know of to investigate the seasonal variation of AR severity and AR-related QOL among AR children. The distribution of AR severity is significantly different among four AR subtypes. In addition to perennial AR children who had the most severe symptoms, children suffering from winter AR had a higher frequency of AR attacks, nose and eye symptoms and clinic/emergency room visits compared with spring or summer/fall AR. Further research is needed to ascertain which aspects of seasonal variation may explain the differences in AR severity as well as whether different treatment is needed according to AR subtypes.

Quality of life is 'the functional effects of an illness and its therapy upon a patient, as perceived by the patient himself/herself'.²⁸ It has been recognised as a crucial parameter for evaluating diseases and treatments. We used the instrument to assess the effect of AR on QOL. Theoretically, healthy children without AR should have a QOL score of 7, indicating that QOL is not affected by AR. Among children with AR, each domain of the QOL score was significantly lower than 7. This suggests that AR symptoms may alter physical activity and mental health among school-aged children. Children with perennial AR had significantly lower QOL scores compared with other AR subtypes. Reasons for lower QOL among children with perennial AR have been discussed. A clinical study has indicated that children with seasonal AR were more knowledgeable regarding their health conditions and have developed personal strategies to achieve and maintain symptomatic control compared with those with perennial AR. Moreover, children with perennial AR had a lower success rate of treatment, felt disappointed more often and had a lower level of satisfaction.²⁹ The authors suggested that education concerning allergen avoidance and use of highly effective therapies on children with AR, especially perennial AR, could improve satisfaction with therapy, symptom control and AR-related QOL.

In Taiwan, children are compulsorily enrolled in the national health insurance system, which provides high-quality, accessible and affordable health care. In general, children with AR are frequently diagnosed by physicians. To confirm the allergic condition of participants, 37 current AR and 30 healthy children were sampled randomly and diagnosed by an otolaryngologist, who was blinded to the questionnaire responses, to examine whether their nasal membranes appear boggy and blue-gray, a typical feature of AR. We found that among 37 current AR children, 27 of them had allergic appearances (sensitivity = 0.7). A total of 27 children were diagnosed to be without any typical allergic symptoms among the 30 healthy children (specificity = 0.9). Although underestimation of AR cases may occur because of lower sensitivity, reported physician-diagnosed AR cases enrolling in the study generally reflect the prevalence of AR in Taiwan children.

Respiratory infection was a critical factor that may affect AR severity and AR-related QOL among different AR subtypes. To avoid misclassification, subjects who suffered from AR symptoms when they had a

cold or flu were excluded. Potential exacerbation of upper respiratory symptoms due to infection was also excluded.

Some study limitations should be discussed. First, given that the participants in our study were recruited from one city, generalisation to other geographical regions might be limited. However, a similar geographical background has the advantage of covering similar environmental agents that may cause AR. Second, misclassification is a potential drawback because recognition of AR symptoms is subjective and may differ among individuals. Recall bias may occur because the month of AR attack was reported by parents instead of using medical records. Considering that the questionnaire survey was conducted in September, bias could have been introduced towards over-reporting of the summer/fall subtype of AR. Finally, the study was based on a self-report design. Objective assessment of AR diagnosis, attack frequency and other risk factors including home environment should be incorporated in future studies.

Conclusion

Using PCA, seasonal AR subtypes could be categorised according to monthly symptomatic occurrence. Although not all environmental factors were assessed in this study, different risk factors appear to have contributed to different AR seasonal subtypes. Children with perennial and winter AR suffered more severe symptoms and had lower QOL. Elimination of environmental allergens and improvement of symptom management might improve the physical and emotional well-being of children with severe AR. Further investigations that identify and control aetiological factors according to AR seasonal subtypes are important for AR prevention and treatment.

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Supporting information

Additional supporting information may be found in the online version of this article.

Figure E1. 3-D Scatter plots of factor score, with the seasonal AR subtypes.

Table E1. Factor loading for the monthly attack score.

Table E2. The symptomatic severities among children with current allergic rhinitis by age group.

Table E3. The quality of life (QOL) among children with current allergic rhinitis by age group.

Table E4. The symptomatic severities among children with current allergic rhinitis by condition of parental allergic disease.

Table E5. The quality of life (QOL) among children with current allergic rhinitis by condition of parental allergic disease.

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