

Prevalence and relationship between allergic diseases and infectious diseases

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In order to determine the prevalence of childhood allergic diseases, infectious diseases, and the relationship between them, 8723 children from three junior high schools in Tou-Cheng City, Taipei County, were studied using questionnaires developed according to the International Study of Asthma and Allergies in Childhood (ISAAC) criteria combined with supplementary questions about infectious diseases. Students and their parents completed the questionnaires at home. The age of the children ranged from 10 to 18 years old (14.12 ± 0.89 years), the majority (96.03%) was aged from 13 to 15 years old. The 12-month prevalences of self-reported allergic disease symptoms were: asthma symptom 8.2%, allergic rhinitis symptom 39.6%, and atopic dermatitis symptom 5.9%. The prevalences of diagnosis of the allergic diseases were: asthma 8.7%, allergic rhinitis 24.1%, and atopic dermatitis 3.9%. The 12-month prevalences of diagnosis of infectious diseases were: pneumonia 0.6%, bronchitis 7.2%, sinusitis 7.2%, purulent conjunctivitis 2.5%, otitis media 4.3%, encephalitis or meningitis 0.4%, gastroenteritis 14.5%, acne 23.9%, purulent dermatitis 1.3%, and other infectious diseases 1.2%. Lifetime admission rates of children due to infectious diseases were: pneumonia 1%, bronchitis 1.8%, sinusitis 0.3%, purulent conjunctivitis 0.2%, otitis media 0.3%, encephalitis or meningitis 0.3%, gastroenteritis 2.1%, and other infectious diseases 0.6%. The prevalence of infectious diseases was significantly higher in children with allergic disease symptoms (defined as asthma, allergic rhinitis, or atopic dermatitis). These results demonstrated the presence of a link between allergic diseases and infectious diseases, which may have some important clinical implications.

Key words: Allergic diseases, infectious diseases, prevalence, relationship

The allergic diseases (including asthma, allergic rhinitis, and atopic dermatitis) are the most common chronic diseases among children and adolescents. In the past three decades, dramatic increases in their prevalence have been reported around the world, particularly in developed and industrializing countries. These diseases can have a profound effect on the quality of life. Infectious diseases including pneumonia, bronchitis, meningitis, otitis media, sinusitis, gastroenteritis and acne attack children and adolescents frequently and can be severe.

Various infectious diseases also have shown to be related to allergic diseases. For example, respiratory syncytial virus (RSV), adenovirus, rhinovirus, parainfluenza virus, influenza virus, corona virus, *Mycoplasma pneumoniae*, and *Chlamydia pneumoniae* are important factors in the occurrence of asthma [1-

4]. There is a higher prevalence of chronic *C. pneumoniae* infection in asthmatic children [5-7]. Sinusitis is common in children and adolescents, most frequently as a complication of a viral upper respiratory tract infection or allergic rhinitis [8]. The most frequent complication of atopic dermatitis is a secondary infection caused by *Staphylococcus*, herpes simplex virus, or vaccinia virus [9].

Previous allergic disease studies have been based on a variety of methodological approaches, making it difficult to compare their results. This situation led a group of international researchers to prepare a standardized self-administered questionnaire to carry out cooperative international studies for the International Study of Asthma and Allergies in Childhood (ISAAC) [10]. The ISAAC questionnaires have been used as an international standardized protocol in order to create a reliable global map of childhood allergy in the world. The primary objective of this study was to use the ISAAC criteria in our own questionnaire combined with supplementary questions about

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infectious diseases in order to evaluate the prevalence of childhood allergic disease and infectious disease in schoolchildren in Taipei. The secondary objective was to investigate the relationship between childhood allergic diseases and infectious diseases.

Materials and Methods

In order to determine the prevalence of childhood allergic diseases, infectious diseases, and the relationship between them, we distributed 9000 questionnaires via school nurses to the children in three junior high schools at Tou-Cheng City in Taipei County during the period from September to October 1999.

The ISAAC written questionnaire was translated from English into Chinese. It consisted of questions about allergic symptoms and illness (including asthma, allergic rhinitis, and atopic dermatitis). Questions included whether these conditions had ever been diagnosed, and whether the children had experienced infectious symptoms and illness or had ever been admitted to a hospital for such symptoms. To assess the prevalence of disease and early childhood exposure, students and their parents were asked to describe and write down the allergic symptoms clearly on the questionnaires. The relationship between childhood allergic diseases and infectious diseases was investigated by analyzing the relationship between 12-month prevalence of self-reported symptoms of three allergic diseases and 12-month prevalence of diagnosed

infectious diseases.

We performed all statistical analyses of results from the questionnaire with the SPSS 8.0 for Windows software and conducted Pearson Chi-square analyses to determine statistically significant differences between allergic diseases and characteristics of interest. The frequencies procedure was used for cross tabulation and the odds ratios for the relationship between allergic and infectious diseases were estimated by Logistic Regression, together with the Pearson Correlation.

Results

Response rates

A total of 8754 questionnaires were completed (overall response rate 97.2%) and 31 invalid questionnaires were excluded due to unclear answers, missing or illogical information. Among the 8723 schoolchildren, 4350 (49.9%) were girls and 4373 (50.1%) were boys. Their ages ranged from 10 to 18 years old (14.12 ± 0.89 years), with the majority (96.03%) in the range from 13 to 15 years old. The sample was equally distributed by sex and age (Table 1).

Prevalence rates

The prevalence of allergic diseases is summarized in Table 1. A total of 762 (8.7%) children had a previous diagnosis of asthma, 2098 (24.1%) of allergic rhinitis, and 340 (3.9%) of atopic dermatitis. There was a

Table 1. Age distribution of children participating in the survey, prevalence of current prior diagnosis of allergic disease, and 12-month prevalence of allergic symptoms according to sex

	Girls	Boys	Total	<i>p</i>
	n (%)	n (%)	n (%)	
Age (year)				
10	2 (0.05)	3 (0.07)	5 (0.06)	
11	2 (0.05)	2 (0.05)	4 (0.05)	
12	15 (0.34)	20 (0.46)	35 (0.40)	
13	1193 (27.43)	1316 (30.09)	2509 (28.76)	
14	1450 (33.33)	1398 (31.97)	2848 (32.65)	
15	1545 (35.52)	1475 (33.73)	3020 (34.62)	
16	139 (3.20)	148 (3.38)	287 (3.29)	
17	4 (0.09)	10 (0.23)	14 (0.16)	
18	0 (0.00)	1 (0.02)	1 (0.01)	
Total	4350 (49.87)	4373 (50.13)	8723 (100.00)	
Prevalence of current or prior diagnosis of allergic disease				
Asthma	304 (6.99)	458 (10.47)	762 (8.74)	< 0.05
Allergic rhinitis	904 (20.78)	1194 (27.30)	2098 (24.05)	< 0.05
Atopic dermatitis	176 (4.05)	164 (3.75)	340 (3.90)	> 0.05
12-month prevalence of allergic symptoms				
Asthma	344 (7.91)	371 (8.48)	715 (8.20)	> 0.05
Allergic rhinitis	1711 (39.33)	1745 (39.90)	3456 (39.62)	> 0.05
Atopic dermatitis	267 (6.14)	249 (5.69)	516 (5.92)	> 0.05

Table 2. Twelve-month prevalence and admission for diagnosed infectious diseases

	Pneumonia		Bronchitis		Sinusitis		Purulent conjunctivitis		Otitis media		Encephalitis or meningitis		Gastroenteritis		Acne		Purulent dermatitis		Tinea pedis		Other	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
12-month prevalence																						
No	7961 (91.3)	7383 (84.6)	7383 (84.6)	7796 (89.4)	7641 (87.6)	7981 (91.5)	6747 (77.3)	5928 (68.0)	7897 (90.5)	7699 (88.3)	7905 (90.6)											
1-2 times	34 (0.4)	346 (4.0)	265 (3.0)	153 (1.8)	266 (3.0)	19 (0.2)	850 (9.7)	582 (6.7)	57 (0.7)	112 (1.3)	53 (0.6)											
3-5 times	3 (0.0)	116 (1.3)	135 (1.5)	23 (0.3)	42 (0.5)	4 (0.0)	183 (2.1)	104 (1.2)	11 (0.1)	25 (0.3)	18 (0.2)											
> 5 times	6 (0.1)	98 (1.1)	130 (1.5)	8 (0.1)	25 (0.3)	5 (0.1)	93 (1.1)	82 (0.9)	7 (0.1)	10 (0.1)	16 (0.2)											
Hard to count	5 (0.1)	68 (0.8)	98 (1.1)	32 (0.4)	38 (0.4)	4 (0.0)	140 (1.6)	1314 (15.1)	41 (0.5)	166 (1.9)	21 (0.2)											
Overall	48 (0.6)	628 (7.2)	628 (7.2)	216 (2.5)	371 (4.3)	32 (0.4)	1266 (14.5)	2082 (23.9)	116 (1.3)	313 (3.6)	108 (1.2)											
Missing	714 (8.2)	713 (8.2)	713 (8.2)	712 (8.2)	711 (8.2)	711 (8.1)	711 (8.1)	713 (8.2)	711 (8.1)	712 (8.2)	711 (8.1)											
Admission rates ever																						
No	8052 (92.3)	7984 (91.5)	8116 (93.0)	8125 (93.1)	7953 (91.2)	7959 (91.2)	7796 (89.4)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7927 (90.9)
1-2 times	78 (0.9)	125 (1.4)	17 (0.2)	10 (0.1)	24 (0.3)	16 (0.2)	154 (1.8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41 (0.5)
3-5 times	3 (0.0)	12 (0.1)	0 (0.0)	1 (0.0)	0 (0.0)	1 (0.0)	12 (0.1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5 (0.1)
> 5 times	6 (0.1)	17 (0.2)	6 (0.1)	3 (0.0)	6 (0.1)	6 (0.1)	18 (0.2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9 (0.1)
Overall	87 (1.0)	154 (1.8)	23 (0.3)	14 (0.2)	30 (0.3)	23 (0.3)	184 (2.1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55 (0.6)
Missing	585 (6.7)	586 (6.7)	584 (6.7)	585 (6.7)	741 (8.5)	742 (8.5)	744 (8.5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	742 (8.5)

significant statistical difference between the prevalence of asthma and allergic rhinitis between the sexes, with higher rates in boys than in girls. Table 1 showed the 12-month prevalence of symptoms of allergic diseases. Within 12 months prior to the completion of the questionnaire, the prevalence rates of allergic diseases symptoms were: asthma symptoms 8.2%, allergic rhinitis symptoms 39.6%, and atopic dermatitis symptoms 5.9%. There was no significant difference in the prevalence of the three allergic diseases symptoms between the sexes. Over one-third (38.39%), that is, 3349 of all children had experienced symptoms of at least one of the three allergic diseases during the preceding 12 months; 614 (7%) had experienced symptoms of two of the three diseases, and 90 (0.93%) had experienced symptoms of all three diseases (data not show). Table 2 shows the 12-month prevalence of diagnosed infectious diseases and lifetime admission rates.

Relationship

Pearson correlational analyses and the odds ratios revealed that the likelihood of developing infectious disease was significantly positively correlated with allergic disease number, especially for bronchitis, sinusitis and tinea pedis (data not show). As shown in Table 3, the presence of allergic disease symptoms was highly positively correlated with the presence of infectious disease. The absence of any allergic disease symptoms was inversely correlated with the presence of pneumonia, bronchitis, sinusitis, purulent conjunctivitis, otitis media, gastroenteritis, acne, purulent dermatitis, tinea pedis, and other infectious diseases except for encephalitis and meningitis. Asthma symptoms were significantly associated with pneumonia, bronchitis and tinea pedis. Allergic rhinitis symptoms were significantly associated with sinusitis, otitis media and tinea pedis. Atopic dermatitis symptoms were significantly associated with sinusitis, acne, purulent dermatitis, and tinea pedis. Children with symptoms representative of all three allergic disease categories were more likely to develop bronchitis, sinusitis, purulent conjunctivitis, gastroenteritis, encephalitis and meningitis, purulent dermatitis, and other infectious diseases, except pneumonia, otitis media, and tinea pedis. The odds ratios of developing allergic diseases symptoms and infectious diseases are shown in Table 4.

Discussion

Data on childhood allergic diseases reported from epidemiological studies worldwide in patients aged 13

Table 3. Relationship between allergic disease symptom and classification of infection

Classification of infection	Allergic disease symptom								
	NIL	D1 ^a	D2 ^b	D3 ^c	D4 ^d	D5 ^e	D6 ^f	D7 ^g	
Pneumonia	-0.0389 ^h	0.0297 ^h	0.0024	0.0016	0.0610 ^h	-0.0039	-0.0012	0.0079	
Bronchitis	-0.1734 ^h	0.0609 ^h	0.0278	-0.0072	0.2130 ^h	0.0328 ^h	0.0360 ^h	0.1040 ^h	
Sinusitis	-0.2027 ^h	-0.0135	0.1512 ^h	-0.0318 ^h	0.0956 ^h	-0.0055	0.0633 ^h	0.0537 ^h	
Purulent conjunctivitis	-0.0638 ^h	0.0149	0.0162	-0.0064	0.0308 ^h	0.0075	0.0608 ^h	0.0575 ^h	
Otitis media	-0.0748 ^h	-0.0158	0.0448 ^h	0.0034	0.0344 ^h	0.0007	0.0542 ^h	0.0159	
Encephalitis or meningitis	-0.0199	-0.0088	0.0046	0.0050	0.0303 ^h	-0.0034	-0.0106	0.0304 ^h	
Acne	-0.0896 ^h	0.0033	0.0509 ^h	0.0335 ^h	0.0365 ^h	0.0043	0.0291 ⁱ	0.0257 ⁱ	
Purulent dermatitis	-0.0490 ^h	0.0011	-0.0138	0.0709 ^h	0.0176	0.0379 ^h	0.0660 ^h	0.0391 ^h	
Tinea pedis	-0.0806 ^h	0.0299 ^h	0.0161	0.0342 ^h	0.0602 ^h	0.0030	0.0492 ^h	0.0222	
Other infectious diseases	-0.0239 ⁱ	-0.0067	-0.0121	0.0164	0.0146	0.0394 ^h	0.0252 ⁱ	0.0625 ^h	

Abbreviation: NIL = no history of allergic disease

^aAsthma; ^bAllergic rhinitis; ^cAtopic dermatitis; ^dAsthma and allergic rhinitis; ^eAllergic rhinitis and atopic dermatitis; ^fAsthma and atopic dermatitis; ^gAsthma, allergic rhinitis, and atopic dermatitis; ^hPearson Correlation is significant at the 0.01 level (2-tailed); ⁱPearson Correlation is significant at the 0.05 level (2-tailed).

to 14 years old, as has been compared in part of the ISAAC, revealed that the 12-month prevalence of asthma symptoms ranged from 1.6% to 36.8%, allergic rhinitis symptoms from 1.4% to 39.7%, and atopic dermatitis symptoms from 0.3% to 20.5% [10]. Compared with the above studies, 12-month prevalences of asthma and atopic dermatitis symptoms in this study were lower (8.2%; 5.9%), but the 12-month prevalence of allergic rhinitis symptoms was the highest (39.6%). The condition used in our study is the same as that in a study from Hong Kong [11]. This result confirmed that the prevalence of asthma was generally lower in the Asia Pacific area than that in western countries [10-13] and there is a trend towards higher prevalence of allergic rhinitis in regions with a warm climate and high humidity [14]. We conclude that discrepancies in reported allergic disease prevalence might be related to differences in racial composition, environment, climate, and health facilities.

There are significant variations in prevalence rates of allergic disease not only among different geographical locations but also within the same populations at different times [13]. For example, compared with other previous studies in Taipei from 1985 to the date when this study was conducted [15], asthma increased about 1.7-fold (8.7% vs 5.08%), allergic rhinitis increased 3-folds (24.1% vs 7.84%), and atopic dermatitis increased 1.7-fold (3.9% vs 2.3%). Although there is a lack of a universally accepted definition of allergic diseases, and differences in survey methodology do exist, the prevalence rates of allergic diseases in children seem to increase progressively. Compared with a recent study, in which survey methodology was adapted from the same ISAAC questionnaire in 1996 [16], the prevalence of diagnosed asthma in Taipei County was similar to that of our study (8.8% vs. 8.7%).

The precise reasons of why the number of allergic patients have grown to such an extent are still somewhat unclear, but many environmental factors such as air pollution (both indoor and outdoor), higher population densities, more advanced urbanization and industrialization, changes in living conditions and lifestyles such as diet or nutrition, and an increase in socioeconomic and emotional stress, may all be jointly involved [17-18]. Since allergic disease is a preventable and controllable chronic inflammatory disease, awareness of the prevalence as well as patient education will be of great importance in its management.

The prevalence rates of many types of infectious diseases in Taiwan and in other countries are not available. Since there is no universally accepted

Table 4. Odds ratios of allergic disease symptoms for different types of infection

Classification of infection	Allergic disease symptom													
	D1 ^a /NIL (n = 135/4224)		D2 ^b /NIL (n = 2356/4224)		D3 ^c /NIL (n = 154/4224)		D4 ^d /NIL (n = 398/4224)		D5 ^e /NIL (n = 20/4224)		D6 ^f /NIL (n = 196/4224)		D7 ^g /NIL (n = 90/4224)	
	OR	95% CI for OR	OR	95% CI for OR	OR	95% CI for OR	OR	95% CI for OR	OR	95% CI for OR	OR	95% CI for OR	OR	95% CI for OR
Pneumonia	7.36 ^h	2.07-26.12	1.93	0.91-4.12	2.12	0.28-16.27	8.34 ^h	3.63-19.15	0.09	0.00-2.83E+10	1.66	0.22-12.75	3.64	0.47-28.10
Bronchitis	6.52 ^h	4.15-10.24	2.57 ^h	2.07-3.18	1.81	0.94-3.51	12.37 ^h	9.50-16.11	8.70 ^h	3.12-24.23	4.17 ^h	2.69-6.45	13.04 ^h	8.18-20.80
Sinusitis	1.75	0.80-3.82	5.20 ^h	4.21-6.42	0.64	0.20-2.02	7.43 ^h	5.47-10.10	1.68	0.22-12.68	7.20 ^h	4.82-10.77	8.57 ^h	5.01-14.64
Purulent conjunctivitis	2.61 ^h	1.12-6.11	1.77 ^h	1.27-2.46	1.11	0.35-3.58	2.81 ^h	1.68-4.71	2.95	0.39-22.35	5.33 ^h	3.08-9.22	7.01 ^h	3.50-14.07
Otitis media	0.67	0.21-2.12	1.91 ^h	1.51-2.43	1.61	0.78-3.35	2.48 ^h	1.66-3.72	1.55	0.21-11.64	3.91 ^h	2.45-6.23	2.48 ^h	1.13-5.46
Encephalitis or meningitis	0.00	0.00-2.07E+17	1.52	0.68-3.40	2.12	0.28-16.30	4.12 ^h	1.46-11.63	0.00	0.00-1.56E+49	0.00 ^h	0.00-1.30E+14	7.37 ^h	1.64-33.13
Gastroenteritis	1.35	0.84-2.18	1.75 ^h	1.53-2.02	2.01 ^h	1.35-2.98	2.00 ^h	1.54-2.58	4.90 ^h	1.99-12.05	2.72 ^h	1.96-3.78	4.26 ^h	2.74-6.60
Acne	1.28	0.87-1.88	1.43 ^h	1.27-1.60	1.95 ^h	1.39-2.73	1.68 ^h	1.35-2.09	1.45	0.56-3.78	1.76 ^h	1.30-2.38	1.96 ^h	1.27-3.02
Purulent dermatitis	1.70	0.41-7.13	1.31	0.80-2.16	8.70 ^h	4.35-17.41	2.62 ^h	1.25-5.46	12.57 ^h	2.82-56.12	7.38 ^h	3.78-14.38	6.65 ^h	2.55-17.35
Tinea pedis	3.48 ^h	1.82-6.64	1.78 ^h	1.35-2.34	3.62 ^h	1.98-6.59	3.78 ^h	2.54-5.63	2.06	0.27-15.57	4.21 ^h	2.53-7.02	3.31 ^h	1.49-7.33
Other infectious diseases	0.69	0.10-5.07	1.04	0.64-1.68	2.48	0.88-6.98	1.91	0.89-4.07	10.32 ^h	2.33-45.79	2.93 ^h	1.24-6.96	7.83 ^h	3.43-17.88

Abbreviations: NIL = no history of allergic disease; OR = odds ratio

^aAsthma; ^bAllergic rhinitis; ^cAtopic dermatitis; ^dAsthma and allergic rhinitis; ^eAllergic rhinitis and atopic dermatitis; ^fAsthma and atopic dermatitis; ^gAsthma, allergic rhinitis, and atopic dermatitis;^h*p* < 0.05

definition of infectious diseases, we have studied infectious diseases by using questionnaire to estimate the infectious disease prevalence. Our study is thus a pilot survey of the prevalence of childhood infectious disease in Taiwan. Our study results show that the most common infectious disease diagnosed within the past year were acne (23.9%), gastroenteritis (14.5%), bronchitis (7.2%), and sinusitis (7.2%). The most common infectious diseases resulting in any prior admission were gastroenteritis (2.1%) and bronchitis (1.8). More epidemiological data of childhood infectious diseases will be gathered in the future, so that the mechanism between the important diseases (such as allergic diseases) and infectious diseases could be understood in greater detail. The overall results can serve a powerful reference for the health units of the government to provide a disease-controlling services.

Analysis of the results of the present study revealed that there is a positive relationship between childhood self-reported allergic diseases symptoms and diagnosed infectious diseases.

Recently, a review paper [19] suggested that when infections with virus or intracellular pathogens occur at the same site after the allergic phenotype has fully developed and become chronic, they may actually increase the severity of allergic diseases. This may depend upon the strength of the T-helper type 2 (TH₂) response and thus the amount of interleukin (IL)-4 being produced. During T-cell priming IL-4 may deviate the normally dominant T-helper type 1 (TH₁) response induced by the infectious agent into a mixed TH₁/TH₂ response, resulting in an exacerbation of the atopic disorder. If there is a weak allergic response with low levels of IL-4, the TH₁ response against the infection will probably not be deviated to a mixed TH₁/TH₂ response [19]. A different finding in our study is that the relationship between allergic disease and infection disease can occur at different sites in the body. Our data also revealed that infectious pathogens lead children with allergic diseases symptoms not only to increase the morbidity of allergic diseases but also to increase the morbidity of infectious diseases. Children with allergic diseases have an increased tendency to develop infections. In this study, most common infectious diseases were discussed, not only infections with virus or intracellular pathogens.

These results demonstrate the presence of a link between allergic diseases and infectious diseases, which may have some important clinical implications. We consider that if we could control allergic diseases well, we should be able to decrease the incidence of infectious diseases in advance and if we could control infectious

diseases well, we should also be able to decrease the incidence of allergic diseases.

Both childhood allergic diseases and infectious diseases are important public health problems in Taiwan. Analysis of the present study revealed that allergic diseases are highly related to infectious diseases. We also demonstrated that childhood allergic diseases may complicate the clinical course in children suffering frequent infectious diseases. However, the reasons of why respiratory infections were related not only to respiratory allergic diseases but also atopic dermatitis; and why respiratory allergic diseases were related not only to respiratory infectious diseases but also to other infectious diseases remain undetermined. Repeated clinical check-ups and examination of biopsy specimens can possibly provide a more reliable method for confirming allergic diseases, infectious diseases, and the real prevalences and inter-relationships between these two.

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