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Time Trends and Seasonal Variations in Hospital Admissions for Childhood Asthma in Taiwan from 1990 to 1998

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SUMMARY **The aim of the study was to determine the trends and seasonal variations in hospital admissions for childhood asthma in a tertiary medical center since 1990. Data were collected according to the age and sex of patients and obtained from hospital registries between 1990 and 1998. Children between 2 and 14 years of age admitted with the diagnosis of asthma, or asthmatic bronchitis (ICD-9 code 493) were included. Age-specific and sex-specific hospital admission rates for asthma were calculated for each calendar year. The asthma admission rates were defined as the number of asthma admissions divided by the total number of all pediatric admissions in a year. Seasonal admission rates were calculated in a similar fashion. In addition, the number of readmissions was also calculated during the study period with comparisons of sex and age differences. The asthma admission rates showed a significant upward trend throughout the period studied, particularly among the 2-4 years of age group (relative risk = 2.08; $p = 0.0001$). Seasonal admission rates revealed a statistically significant increase during the October-December period, peaking in November or December of each calendar year (relative risk = 1.84; $p = 0.0001$). There was a male predominance in both age categories during the 9-year period. Comparisons of readmissions for asthma (at least three admissions) disclosed that girls were far more likely to be readmitted than boys among the 5-14 years of age group ($p = 0.01$). Our results indicate 1) an increased prevalence and severity of childhood asthma in Taiwan; 2) boys and younger children aged 2-4 years with asthma had increased risks of admission for asthma (relative risks were 1.22 and 1.96, respectively) and 3) girls among the older children with asthma tend to present with greater severity than boys owing to higher relative risks of readmission for asthma.**

Hospital admission rates for childhood asthma have been increasing over the past three decades in several countries.[1] This reflects either a change in prevalence and morbidity, or a modification of the management of childhood asthma, or both. In addition, seasonal variation in asthma admissions can be used as an indicator of trigger factors provoking asthma attacks in a particular area.[2] Furthermore, the number of previous admissions for asthma may relate to the risk of readmission and severity of asthma.[3]

The aim of this study was to determine the time trends, seasonal variations, and gender or age differences in severity of asthma in hospital admissions for childhood asthma in a medical center in Taiwan during a 9-year period between 1990 and 1998.

MATERIALS AND METHODS

Data were obtained from Chang Gung Children's Hospital registries during the period 1990 to 1998. Children admitted with a diagnosis of asthma or asthmatic bronchitis (ICD-9 code 493) were included. The diagnosis of asthma was based on recurrent episodes of wheezing, breathlessness, chest tightness, and nocturnal cough and was also associated with reversible airflow obstruction and airway hyperresponsiveness that were

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evaluated by lung function tests.[4] Age at admission was obtained and the children were classified into two age groups: 2-4 and 5-14 years of age. Those who were below 2 years of age and who were admitted with a diagnosis of acute bronchiolitis or asthma were excluded, because the younger wheezers aged below 2 years are usually easily confused with other underlying disorders, such as congenital airway anomaly, vascular ring, and gatroesophageal reflux [5,6]

The asthma admission rates were obtained by dividing the number of admissions for asthma by the total number of all pediatric admissions in that calendar year, and a 95% confidence interval was also included. Seasonal admission rates for asthma were also calculated in the same method. In addition, the number of age-specific and sex-specific previous admissions was also collected during the study period.

Statistical analysis

Poisson regression was used to compare the admission rates between groups. Chi-square test was made to assess an association between two categorical variables. Breslow-Day test was used to test whether an association between two categorical variables was different in the third variables. All *p*-values calculated were two-sided and the significant level was set below 0.05.

RESULTS

There were a total of 2,283 admissions for asthma in Chang Gung Children's Hospital during 1990-1998. Approximately 63.4% (1448) of these admissions were for patients 2-4 years of age, and 63.5% (1449) of these admissions were for boys. Table 1 shows the asthma admission rates among children according to year, season, age, and sex in our hospital during the study period. Poisson regression revealed that the interaction among year, season, age, and sex was not significant, and that asthma admission rates statistically increased between 1990 and 1998. The average annual increasing rate of asthma admissions was 0.31%, and the

Table 1 Trends in admission rates for childhood asthma by year, season, age, and sex in Chang Gung Children's Hospital during 1990-1998

Variables	Total admissions	Asthma admissions	Admission rates (%)	Crude RR	95% CI	*p*	Adjusted RR	95% CI	*p*
Year				1.13	1.11-1.15	0.0001	1.11	1.09-1.13	0.0001
1990	4,046	58	1.43						
1991	5,432	81	1.49						
1992	6,218	111	1.79						
1993	8,231	199	2.42						
1994	10,541	222	2.11						
1995	10,564	336	3.18						
1996	10,784	355	3.29						
1997	12,108	468	3.87						
1998	13,234	453	3.42						
Season						0.0001			0.0001
1-3m	20,144	475	2.36	1.00	reference		1.00	reference	
4-6m	19,262	509	2.64	1.12	099-1.27		1.13	0.99-1.28	
7-9m	23,378	501	2.14	0.91	0.80-1.03		1.01	0.89-1.15	
10-12m	18,375	798	4.34	1.84	1.64-2.06		1.88	1.68-2.10	
Age						0.0001			0.0001
2-4y	36,719	1,448	3.94	2.08	1.92-2.27		1.96	1.81-2.13	
5-14y	44,440	835	1.88	1.00	reference		1.00	reference	
Sex						0.0001			0.0001
Female	33,427	834	2.49	1.00	reference		1.00	reference	
Male	47,732	1,449	3.04	1.22	1.12-1.32		1.22	1.12-1.32	
Total	81,159	2,283	2.81						

Crude RR represents relative risk without other variables influences
Adjusted RR represents relative risk with other variables influences
95% CI= 95% confidence interval

adjusted relative risk was 1.11 (95% confidence interval, 1.09 to 1.13; $p = 0.0001$). Age-specific and sex-specific trends of asthma admission rates are illustrated in Fig. 1. The four categorical groups all presented significantly rising trends during the study period, particularly in the boy group aged 2-4 years of age. Regardless of previous admissions, younger children aged 2-4 years had a significantly increased risk of admission for asthma compared with older children aged 5-14 years (relative risk = 2.08; 95% confidence interval, 1.92 to 2.27; $p = 0.0001$). Likewise, boys had a higher risk of admission for asthma compared with girls (relative risk = 1.22; 95% confidence interval, 1.12 to 1.32; $p = 0.0001$). Seasonal variations in asthma admission rates were also uncovered (Table 1 and Fig. 2). The seasonality showed a statistically significant increase in October-December (relative risk = 1.84; 95% confidence interval, 1.64 to 2.06; $p = 0.0001$). The monthly admission rates almost showed distinct peaks in November or December for each year.

As the readmission rates in the two gender groups differed among the two age groups ($p = 0.035$), the relative risks of readmission for asthma by age and sex group were computed in Table 2. Among older children aged 5-14 years, girls had a significantly increased risk of readmission for asthma ($p = 0.01$). In contrast, there were no gender differences among younger children aged 2-4 years.

DISCUSSION

The present study found a steady upward trend in admission rates for childhood asthma in our hospital, except for a small decline in 1998, and a particularly rapid increase in the male group 2-4 years of age. In our study, children below 2 years of age admitted for asthma were excluded. Therefore, this result should not be considered as an artefact resulting from diagnostic problems.

There are several possible explanations for these trends:[1] (a) diagnostic transfer, (b) a change in medical management and admission criteria, (c) an increase in prevalence or severity of asthma. Several studies revealed diagnostic

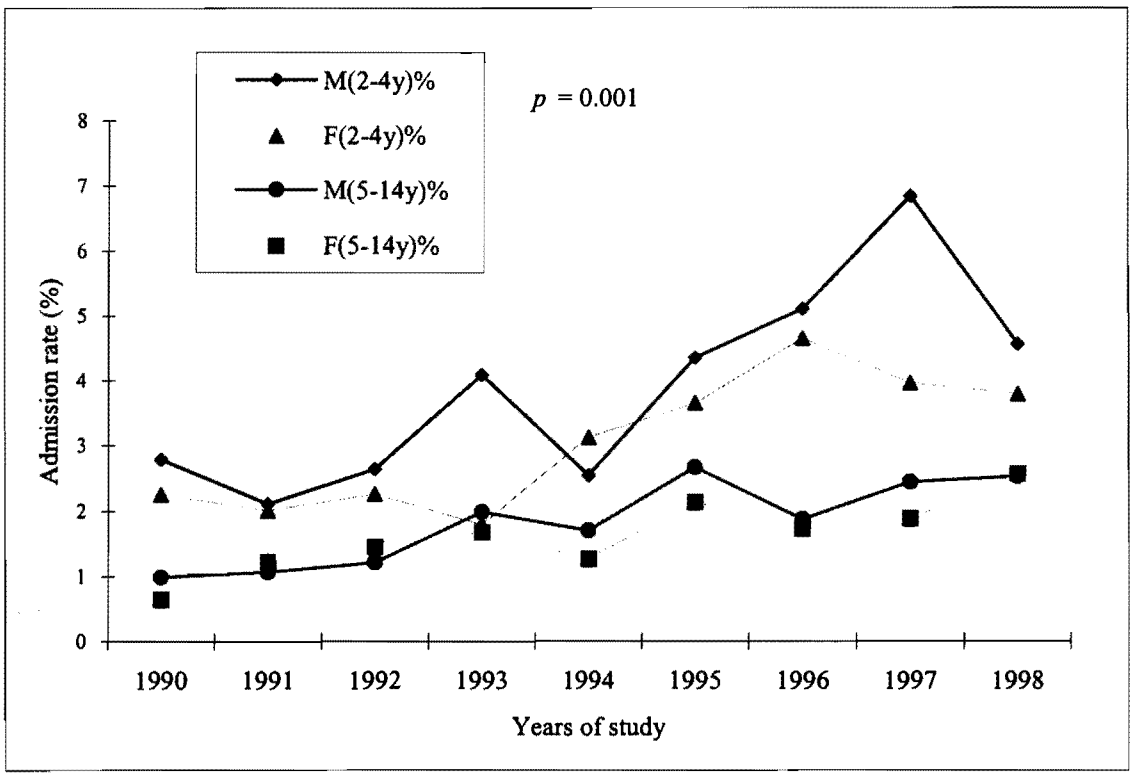

Fig. 1 Trends in asthma admission rates according to age, sex, and study year for children between 2 and 14 years of age in Chang Gung Children's Hospital during 1990-1998.

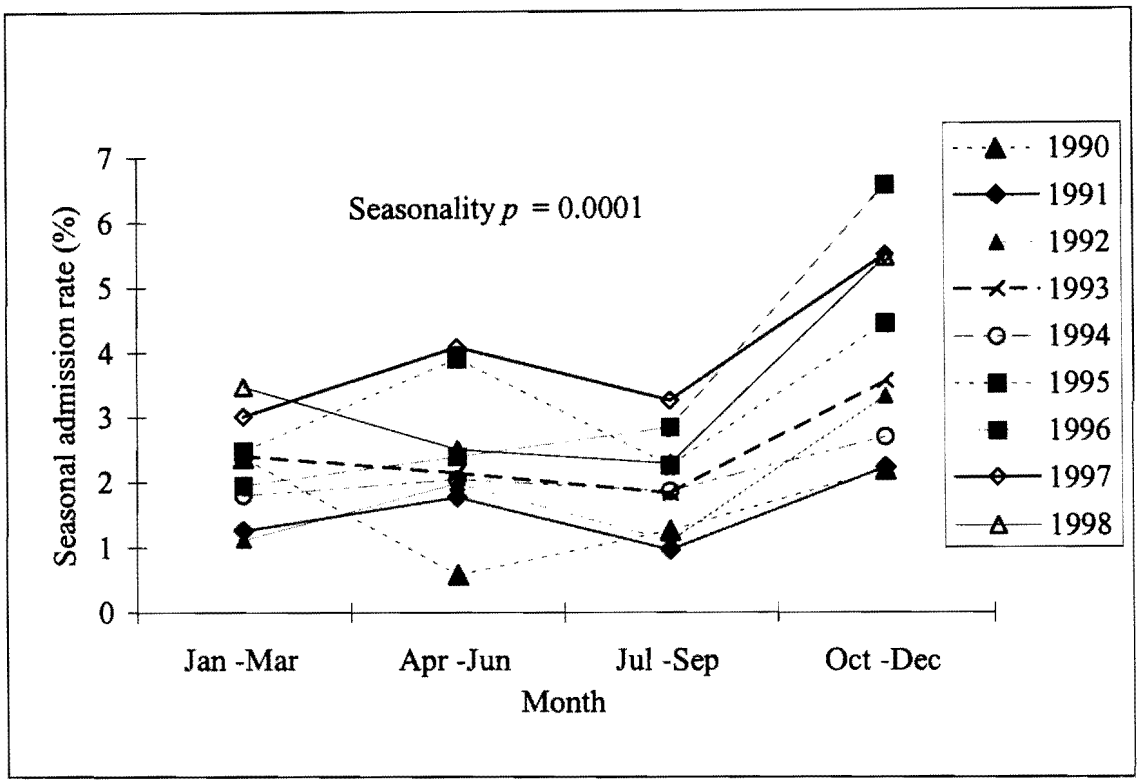

Fig. 2 Seasonal variation in asthma admissions for children between 2 and 14 years of age in Chang Gung Children's Hospital during 1990-1998.

Table 2 Comparisons of the number of readmissions for asthma by sex and age in Chang Gung Children's Hospital during 1990-1998

Age	Sex	Readmissions		*P* (≥ 3)
		1-2	≥ 3	
2-4 y	female	404	17 (4.0%)	0.915
	male	736	32 (4.2%)	
5-14 y	female	258	15 (5.5%)	0.01*
	male	449	9 (2.0%)	

*P< 0.05

transfers do not contribute to rising admission rates for asthma parallel to a concomitant decline in other respiratory diseases.[1,2,7,8]

It has been suggested that the increase in asthma admission rates resulting in a greater use of hospital services might be a reflection of changing patient management. For example, the rise in referrals to hospitals which can provide nebulised salbutamol therapy.[9]

Although changing admission criteria have also been considered, most studies have concluded that they do not play a major role in increasing asthma admissions.[7-11] The general conclusions of studies seeking to explain upward trends in admission for asthma have been that the severity[7,12] or the prevalence[13,14] of asthma were increasing.

Changes in prevalence or severity may be due to a number of factors including environmental pollutants or aeroallergens. The prevalence of asthma in developing countries has increased in recent years.[15] For example, the prevalence of asthma in schoolchildren in Taipei increased from 1.3% in 1974 to 5.1% in 1985 [14] and to 10.8% in 1994.[17]

Consistent with other studies,[8,18-21] we found a higher risk of admission for asthma among younger children aged 2-4 years than among older children aged 5-14 years. Likewise, boys had a higher risk of admission for asthma compared with girls in our observation.

In this study, the asthma admission rate displayed statistically significant seasonality, showing a rapid increase in the October-December period with a peak in November or December for each year.

Asthma morbidity is known to show seasonal periodicity in different regions.[22-29] Various factors responsible for this seasonality have been reported, including changing weather, variation in mite allergen levels, viral infections, and pollution.[24] Taiwan has a subtropical climate, and high relative humidity throughout the year. House dust mites are the most important allergens in this subtropical area.[25] As sensitization to inhalant allergens usually starts after 2 years of age,[26,27] seasonal variation of asthma admission rate in our study was similar to the seasonal variation of house dust mite allergens in Taiwan in the previous study,[25] which revealed that the highest house dust mite concentrations were observed in November and December, and the lowest concentrations occurred in February.

An important finding in the present study was that the relative risk of readmissions for asthma was higher among girls than boys aged 5-14 years from 1990 to 1998. One explanation for this finding in children aged 5-14 years is that, while asthma may be more prevalent among boys than girls as judged by admission rates, its severity may be greater for girls than boys in this age group. The reasons for these differences are not known. Similar results have been reported in other studies.[30-32]

Despite a lack of data about the standard specific age of the population in Taiwan, the present study provided valid information owing to the fact that our hospital is a tertiary teaching medical center treating approximately 12% of all overall admissions in Taiwan. Therefore, trends in hospital admissions for asthma in this study are representative for some of the real trends in Taiwan.

In conclusion, despite the fact that we could not determine the overall real trends in admission rates for asthma in Taiwan, the present study still provided the following important information about the epidemiology of childhood asthma: (1) the prevalence or severity of childhood asthma may be increasing; (2) seasonal variations in admissions for asthma may correspond to seasonal variation of house dust mites in Taiwan, especially in the October-December period; (3) boys and younger children aged 2-4 years with asthma have an elevated risk of admission for asthma; (4) girls among the children aged 5-14 years with asthma appear to present with greater severity than boys based on their higher risk of readmission for asthma. Further multivariate analysis and clinical studies such as a national prevalence of asthma survey, trends in severe acute asthma in pediatric intensive care unit and seasonal variations of viral infections in Taiwan are necessary to confirm these findings.

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