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Factors Associated with Increased Respiratory Symptoms among Asthmatic Children in Singapore

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SUMMARY **Asthma is a common cause of childhood morbidity. The objective of the present study was to evaluate the factors associated with increased asthma morbidity among asthmatic children in Singapore. A cohort of primary school children (n = 6,404, aged 6-13 years) were evaluated using the American Thoracic Society and the Division of Lung Diseases of the National Heart, Lung and Blood Institute, USA (ATS-DLD) respiratory questionnaire. A total of 2,222 of 6,404 children (34.8%) was found to have reported symptoms of wheezing. Of these, 899/2,222 (40.5%) reported symptoms of "increased asthma morbidity". This was associated with the younger age group, male sex and higher socio-economic status. In addition, concurrent or past allergies were strongly associated with increased asthma morbidity, while premature birth and a history of prior childhood respiratory illnesses and infections were predictive of greater asthma morbidity. No association was found between increased morbidity and presence of domestic pets, parental smoking, childcare attendance, and the season of birth.**

Asthma is a common chronic disorder. It affects a significant proportion of the children in Singapore. In the last thirty years, we have witnessed a progressive increase in its prevalence from 3.8% in 1967[1] to 20% in 1994.[2] Currently, asthma ranks second only after accidents and injuries as the leading childhood condition with the highest number of discharges from all hospitals in Singapore.[3] At the general practitioner and primary health care clinics, this disease ranks second only after upper respiratory tract infections as the leading condition seen at these clinics by children under the age of 15 years.[3] Taken together, the total cost of asthma in Singapore was estimated to be US$36.57 million per annum.[4]

Many asthmatic patients experience considerable amount of morbidity. These may manifest as frequent exacerbation of symptoms, limitation in daily activities or functions, reduced lung functions or other physiological abilities, and/or increased utilisation of healthcare services or medication. A number of factors have been reported to be associated with increase asthma morbidity. Among the adults in Singapore, a recently study showed that the most significant independent predictors of increased asthma morbidity were current keeping of pets or carpets, and current high-risk occupations.[5,6] The continued exposure to allergenic and other environmental factors, such as cigarette smoke, were also said to result in more frequent exacerbations and greater restriction of daily activities among asthmatics.[7,8] With this background, this study examined the factors associated with increased asthma morbidity among Singapore children.

METHODS

The respiratory questionnaire developed by the American

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Thoracic Society and the Division of Lung Diseases of the National Heart, Lung and Blood Institute, USA (ATS-DLD) was used in this study.[9] A cohort of primary school children, aged 6-13 years old, from four schools was evaluated. The multistage cluster sampling method was used. Individual schools with large populations (> 1,000) were the sampling units. A randomly selected school from a particular region of Singapore that consented to participate was surveyed followed by another in another region stepwise. The sequence of which regions the schools were from was randomised *a priori*. The parents of these school children were the respondents. All students in the schools were asked to participate. A letter describing the study and the questionnaire were distributed to the students based on the schools' registers and collected back within one week by the respective class teachers. Efforts were made to enrol those who were absent from school during the survey period. It was a concern that absent children may be away from school due to asthma. Additionally, if the initial questionnaire was not returned within one week, the information letter and questionnaire were sent again. In the case where individual consent was refused (n = 132, 2%), demographic data from the school registers was sought. Questions pertaining to socio-economic factors were also included. Socio-economic status was evaluated based on the respondents' type of residence (public housing/flats, private condominium, or landed houses), parental educational levels and occupation. The influence of each socio-economic parameter was analysed individually to avoid problems with collinearity. A total of 6,404 respondents or a response rate of 98% was achieved.

The asthmatic population used in the analysis was a subset of the total group surveyed. The selection was based on those who reported any 'symptom of asthma' (predominantly symptoms of wheezing). These included positive responses to questions on coughing apart from cold or flu, wheezing apart from cold or flu, wheezing with shortness of breath, or exercise induced wheezing (see Table 1; symptoms marked with an asterisk). A total of 2,222/6,404 (34.8%) satisfied these criteria. Table 1 shows the prevalence of the individual reported respiratory symptoms among these children.

Increased asthma morbidity among these children was determined by responses to questions on moderate to severe respiratory symptoms. These include chronic coughing (4 or more times a week, or for 3 or more months a year),

Table 1 Prevalence of reported respiratory symptoms

Respiratory symptoms	n	(%)
***Any symptom of asthma**, n =*	2,222	(100.0)
Increased asthma morbidity, n =*	899	(40.5)
***Cough apart from cold/flu**	1,365	(61.4)
***Wheeze apart from cold/flu**	579	(26.1)
***Wheeze with shortness of breath**	705	(31.7)
***Exercise induced wheezing**	454	(20.4)
****Chronic cough (4 or more times a week; or 3 or more months a year)**	385	(17.3)
****Wheeze most days and nights**	272	(12.2)
****Frequent episodes of breathless wheezing (3 or more times a year)**	505	(22.7)
****Breathless wheezing requiring treatment/hospitalisation**	618	(27.8)

*A positive response to any of the following conditions: coughing apart from cold or flu, wheezing apart from cold or flu, wheezing with shortness of breath, or exercise induced wheezing (respiratory symptoms marked with an asterick [*]), was used as the working definition for '*any symptom of asthma*'.

**A positive response to any of the following conditions: chronic cough (4 or more times a week, or 3 or more months a year), wheezing most days and nights, frequent episodes of breathless wheezing (3 or more times a year), and breathless wheezing requiring treatment/hospitalisation (respiratory symptoms marked with two astericks [**]), was used as the working definition for '*increased asthma morbidity*'.

wheezing most day and night, frequent episodes of breathless wheezing (3 or more times a year), and breathless wheezing requiring treatment or hospitalisation. A total of 899/2,222 (40.5%) were found to have fulfilled the above criteria indicating "increased morbidity".

The data were initially analysed by cross-tabulation using the Chi-Squared or Fisher's Exact Test (where appropriate). Further statistical analyses were performed by the computation of the Prevalence Rate Ratios (PRRs) and 95% Confidence Intervals (95% CI) via the modified Cox Propotional Hazard Regression Model, with the assumption of a constant risk period.[10-12] Multiple regression analysis was employed to control simultaneously for potential confounders (in particular, demographic and socio-economic factors), and to select variables which are significant independent predictors of increased morbidity. Procedures from the SAS software package version 6.12 were used.[13]

RESULTS

Table 2 shows the bivariate comparison between demography and increased asthma morbidity among these children. Increased morbidity was observed to be more frequent in the younger age-group (6-8 year olds) ($p < 0.01$), males ($p < 0.001$), higher socio-economic groups or those with better educated parents ($p < 0.001$) and in households with working mothers ($p < 0.01$). Ethnic differences were not found to be statistically significant.

When analysed via multiple regression analysis, younger children were found to have a 1.25 times significantly higher risk of increased morbidity compared to children in the reference group (aged 11-13 years old), while males had 1.32 times significantly higher risk of increased morbidity compared to females (Table 3). The higher socio-economic groups and those with working mothers also had significantly higher risk of increased asthma morbidity compared to those with lower socio-economic status and home-bound mothers, respectively, even after controlling for other demographic factors (see individual models in Table 3).

A comparison of various antecedent or concurrent factors which may be associated with increased morbidity is shown in Table 4. The Prevalence Rate Ratios for increased asthma morbidity associated with these factors, adjusted for demography, are shown in Table 5. Past or concurrent allergies, parental history of asthma and allergic rhinitis, and the majority of past childhood illnesses, were found to be highly associated with increased asthma morbidity. They remained significant even after adjusting for demographic and socio-economic factors.

Of the household factors analysed, a weak association between current household size and asthma morbidity was observed ($p < 0.05$). When analysed in a multivariate fashion, however, this factor was not found to be significantly associated with increased morbidity (not shown). Other factors, such as the presence of domestic pets, current or previous childcare attendance, or parental smoking, were not found to be significant.

Of the birth factors analysed, only premature birth or birth complications was found to have significant predictive association with increased asthma morbidity among the asthmatic children surveyed. The season of birth was not associated with increased morbidity.

DISCUSSION

The criteria used to define increased morbidity in this study were based on excessive symptoms (chronic coughs, wheeze most days and nights, or frequent breathless wheezing - 3 or more time a year) and the use of healthcare services for asthma exacerbation (breathless wheezing requiring treatment or hospitalisation). In this context, the patients categorized with increased morbidity would be considered to have moderate or severe asthma. With more than 40% of those who reported wheezing symptoms falling within this category, there seemed to be a considerable amount of morbidity among childhood asthmatic patients in Singapore. This, however, seems consistent with that of other studies.[2] Moderate to severe asthma made up between 30-70% of the asthmatics in other studies, with severe asthma affecting as few as 5% to as many as 30% of persons with asthma depending on the criteria used to define severity and the population in question.[14] Direct comparison between other population based studies is difficult as modifications on the questionnaire, different sampling methods and study objectives exist. This is also compounded by the varying criteria used to define what constitute 'increased morbidity'.

Table 2 Demographic and socio-economic profile

Variables	Increased morbidity		*p*-value*
	Yes, n (%)	No, n (%)	
Overall	899 (40.5)	1,323 (59.5)	-
Age-group			
6-8 year old	462 (51.4)	583 (44.1)	$p < 0.01$
9-10 year old	268 (29.8)	366 (27.7)	
11-13 year old	150 (16.7)	275 (20.8)	
not stated/missing value	19 (2.1)	99 (7.5)	
Sex			
Male	483 (53.7)	608 (46.0)	$p < 0.001$
Female	361 (40.2)	651 (49.2)	
not stated/missing value	55 (6.1)	64 (4.8)	
Racial groups			
Chinese	797 (88.7)	1126 (85.1)	NS
Malay	47 (5.2)	78 (5.9)	
Indian	39 (4.3)	39 (2.9)	
Others/not stated/missing value	16 (1.8)	80 (6.0)	
Type of housing			
Public housing/flats	501 (55.7)	874 (66.1)	$p < 0.001$
Private condominium	174 (19.4)	177 (13.4)	
Landed house	208 (23.1)	197 (14.9)	
not stated/missing value	16 (1.8)	75 (5.7)	
Father's highest education level			
Tertiary (college/university)	297 (33.0)	294 (22.2)	$p < 0.001$
Secondary (high school)	376 (41.8)	586 (13.4)	
Primary	77 (8.6)	164 (12.4)	
not stated/missing value	149 (16.6)	279 (21.1)	
Mother's highest education level			
Tertiary (college/university)	147 (16.4)	136 (10.3)	$p < 0.001$
Secondary (high school)	498 (55.4)	695 (52.5)	
Primary	106 (11.8)	216 (16.3)	
not stated/missing value	148 (16.5)	276 (20.9)	
Father's occupation**			
Professionals, legislators, senior officers, managers	248 (27.6)	264 (20.0)	$p < 0.001$
Technicians, associate professionals, clerical workers	298 (33.1)	375 (28.3)	
Service workers, shop and market sales workers	138 (15.4)	265 (20.0)	
Production, plant and machine operators, labourers	27 (3.0)	75 (5.7)	
unemployed/not stated/missing value	188 (20.9)	344 (26.0)	
Mother's occupation**			
Professionals, legislators, senior officers, managers	82 (9.1)	85 (6.4)	$p < 0.05$
Technicians, associate professionals, clerical workers	206 (22.9)	221 (16.7)	
Service workers, shop and market sales workers	79 (8.8)	120 (9.1)	
Production, plant and machine operators, labourers	21 (2.3)	48 (3.6)	
Unemployed/housewifes/not stated/missing value	511 (56.8)	849 (64.2)	
Housewife mother			
Yes (housewife mothers)	335 (37.3)	541 (40.9)	$p < 0.01$
No (working mothers)	388 (43.2)	474 (35.8)	
not stated/missing value	176 (19.6)	308 (23.3)	

*Fisher's Exact test was use in instances when Chi-squared test was not valid (ie. when one or more of the expected counts were five or less). Missing values were not included in the cross-tabulation. NS - Not significant. - = Not tested or no test.
**Standard occupations were categoried into the four groups based on the Ministry of Labour's Singapore standard occupational classification.

Table 3 Influence of demographic and socioeconomic factors on increased asthma morbidity analysed by multivariate analysis using the modified Cox proportional hazard model

Independent variables	Prevalence Rate Ratio	95% Confidence Interval	*p*-value
Inclusion of demographic factors (age group, sex and race) into the model			
Age group: 11-13 years old (reference group)	1	-	-
9-10 years old	1.20	0.98-1.46	NS, $p = 0.07$
6-8 years old	1.25	1.04-1.51	$p < 0.05$
Sex: Female (reference group)	1	-	-
Male	1.32	1.15-1.50	$p < 0.001$
Race: Chinese (reference group)	1	-	-
Malay	0.91	0.68-1.22	NS
Indian	1.21	0.88-1.66	NS
Inclusion of socio-economic indices into different models (controlled for age group, sex, and race)*			
Model 1: inclusion of housing variables			
Public housing/flats (reference groups)	1	-	-
Private condominium	1.36	1.15-1.62	$p < 0.001$
Landed homes	1.41	1.20-1.66	$p < 0.001$
Model 2: inclusion of father's highest education level			
Primary (reference group)	1	-	-
Secondary	1.22	0.96-1.56	NS, $p = 0.1$
Tertiary	1.57	1.22-2.02	$p < 0.001$
Model 3: inclusion of mother's highest education level			
Primary (reference group)	1	-	-
Secondary	1.27	1.03-1.56	$p < 0.05$
Tertiary	1.58	1.23-2.03	$p < 0.001$
Model 4: inclusion of father's occupation			
Production, plant and machine operators (reference group)	1	-	-
Service workers, shop and market sales workers	1.29	0.86-1.95	NS
Technicians, associate professionals, clerical workers	1.67	1.13-2.48	$p < 0.05$
Professionals, legislators, senior officers, managers	1.83	1.23-2.72	$p < 0.01$
Model 5: inclusion of mother's occupation			
Production, plant and machine operators (reference group)	1	-	-
Service workers, shop and market sales workers	1.30	0.81-2.11	NS
Technicians, associate professionals, clerical workers	1.59	1.01-2.48	$p < 0.05$
Professionals, legislators, senior officers, managers	1.61	1.00-2.61	$p < 0.05$
Model 6: inclusion of variable differentiating housewife mothers			
Working mother (reference group)	1	-	-
Housewife mother	0.85	0.73-0.98	$p < 0.05$

*Each socio-economic indice was analysed separately in different models to avoid problems with collinearity. NS - Not significant.
- = Not tested or no test.

Table 4 Bivariate comparison of factors evaluated for their associated with increased asthma morbidity

Variables	Increased morbidity		*p*-value*
	Yes, n (%)	No, n (%)	
Overall	899	1,323	
Any doctor diagnosed allergies	439 (48.8)	343 (25.9)	$p < 0.001$
Allergy to food	124 (13.8)	84 (6.3)	$p < 0.001$
Allergy to drugs	105 (11.7)	83 (6.3)	$p < 0.001$
Allergy to dust	304 (33.8)	196 (14.8)	$p < 0.001$
Allergy to chemicals	81 (9.0)	68 (5.1)	$p < 0.001$
Had eczema before 2 years	138 (15.4)	93 (7.1)	$p < 0.001$
Attended (or currently attending) formal childcare facilities	855 (95.1)	1233 (93.2)	NS
Household size**			
2-3 individuals	68 (7.6)	124 (9.4)	$p < 0.05$
4-5 individuals	603 (67.1)	856 (64.7)	
6-8 individuals	196 (21.8)	230 (17.4)	
> 8 individuals	16 (1.8)	32 (2.4)	
Any domestic pet at home (cats, dogs, birds)	173 (19.2)	243 (18.4)	NS
Has cats	19 (2.1)	16 (1.2)	NS
Has dogs	110 (12.2)	133 (10.1)	NS
Has birds	69 (7.7)	124 (9.4)	NS
Smoker at home	160 (17.8)	268 (20.3)	NS
Father ever smoked	156 (17.4)	262 (19.8)	NS
Mother ever smoked	6 (0.7)	13 (1.0)	NS
Current Smoker at home	126 (14.0)	168 (12.7)	NS
Father currently smokes	122 (13.6)	160 (12.1)	NS
Mother currently smokes	5 (0.6)	11 (0.8)	NS
Family history of (doctor-diagnosed) asthma	147 (16.4)	126 (9.5)	$p < 0.001$
Paternal history	91 (10.1)	68 (5.1)	$p < 0.001$
Maternal history	88 (9.8)	74 (5.6)	$p < 0.001$
Family history of (doctor-diagnosed) allergic rhinitis	114 (12.7)	75 (5.7)	$p < 0.001$
Paternal history	72 (8.0)	53 (4.0)	$p < 0.001$
Maternal history	81 (9.0)	43 (3.3)	$p < 0.001$
Season of birth**			
1st quarter (Jan - Mar)	183 (20.4)	266 (20.1)	NS
2nd quarter (Apr - Jun)	207 (23.0)	300 (22.7)	
3rd quarter (Jul - Sep)	215 (23.9)	303 (22.9)	
4th quarter (Oct - Dec)	280 (31.1)	362 (27.4)	
Premature birth or birth complications	96 (10.7)	88 (6.7)	$p < 0.001$
Childhood illnesses			
Had chest illnesses (for >3 days in the last 3 years)	292 (32.5)	89 (6.7)	$p < 0.001$
Had chest illnesses (before the age of 2 years)	66 (7.3)	40 (3.0)	$p < 0.001$
Had ever been hospitalised for severe chest illnesses	60 (6.7)	31 (2.3)	$p < 0.001$
Had been diagnosed as having heart illnesses	96 (10.7)	88 (6.7)	$p < 0.001$
Had measles	238 (26.5)	338 (25.5)	NS
Had sinus trouble	164 (18.2)	115 (8.7)	$p < 0.001$
Had bronchitis	137 (15.2)	76 (5.7)	$p < 0.001$
Had others – (either bronchiolitis, or pneumonia, or whooping cough, or croup, or otitis externa, or middle ear infection, or grommets, or operation on tonsils or adenoids)***	209 (23.6)	123 (11.4)	$p < 0.001$

*Fisher's Exact test was use in instances when Chi-squared test was not valid (ie. when one or more of the expected counts were five or less). NS - Not significant. - = Not tested or no test.
**Missing values were not included in the cross-tabulation.
***These categories were combined, as the individual numbers were small and may overlap with one another. Further, it was unsure if the lay person would validly distinguish between these categories.

Table 5 Adjusted Prevalence Rate Ratio (PRR) and 95% Confidence Intervals (CI) of factors evaluated for their associated with increased asthma morbidity

Variable*	PRR**	95% CI**	*p*-value**
Any doctor diagnosed allergies	1.57	1.37-1.81	$p < 0.001$
Allergy to food	1.50	1.23-1.83	$p < 0.001$
Allergy to drugs	1.34	1.08-1.65	$p < 0.01$
Allergy to dust	1.56	1.1.38-1.81	$p < 0.001$
Allergy to chemicals	1.30	1.03-1.65	$p < 0.05$
Had eczema before 2 years	1.44	1.19-1.73	$p < 0.001$
Family history of asthma (one or both parents)	1.35	1.10-1.67	$p < 0.01$
Paternal history	1.38	1.06-1.81	$p < 0.05$
Maternal history	1.40	1.08-1.81	$p < 0.05$
Family history of allergic rhinitis (one or both parents)	1.40	1.09-1.80	$p < 0.01$
Paternal history	1.35	1.00-1.83	$p < 0.05$
Maternal history	1.48	1.12-1.97	$p < 0.01$
Childhood illnesses (sorted by PRR)* **			
Had chest illnesses last 3 years	2.11	1.82-2.45	$p < 0.001$
Had bronchitis	1.62	1.33-1.99	$p < 0.001$
Hospitalised for chest illnesses	1.57	1.19-2.06	$p < 0.01$
Had chest illnesses before 2 yrs	1.56	1.21-2.02	$p < 0.001$
Had sinus trouble	1.44	1.19-1.74	$p < 0.001$
Diagnosed with heart illnesses	1.25	0.71-2.21	NS
Had measles	1.06	0.90-1.24	NS

*Reference categories: (1) for allergies : no allergy to the triggers specified or no doctor diagnosis of eczema or allergy; (2) for family history of asthma or allergic rhinitis: no family history (paternal or maternal); (3) for childhood illnesses: never had (the respective) illness/condition.

**Adjusted Prevalence Rate Ratio (PRR) and 95% Confidence Intervals (CI) corrected for demographic influences (age group, sex, race, and socio-economic [type of housing] - as listed in Table 3) are shown. NS - Not significant. - = Not tested or no test.

***Other categories not included due to their small numbers, but had a PRR of between 1.78 (whooping cough) to 1.29 (otitis externa).

Concerning potential biases, population selection is unlikely to cause any problem as the target populations were ***all*** students in the school surveyed and as the response rates were high (more than 95%). Further, great efforts were made to ensure students who were not present during the survey be given opportunities to participate. The major concern focuses on the validity of reported asthma and how severity was classified. It was intended to increase the validity of both asthma and its severity by asking multiple questions for asthma. Under-reporting in this instance is unlikely, but over-reporting may be a problem in particular since a history of these symptoms does not really distinguish between asthma and other wheeze-related conditions. However, validation and developmental work done by the ATS-DLD study group has shown that the 'wheezing' questions used in the questionnaire were very sensitive and moderately specific for asthma.[9]

As for biases due to the over-representation of one demographic group over another, this does not seem to raise a significant problem as none of the demographic variables seem to have been over-represented. Further, the asthmatic population in this study seem to be comparable to that obtained in our previous study[2] and is probably representative of the heterogeneous population of childhood asthmatics found in the school setting in Singapore.

Differences by age group, sex, race groups and socio-econo-

mic status were observed in the proportion of childhood asthmatics with increased asthma morbidity. Age and sex, play an important role in modifying other known or potential risk factors. Children at the younger age may exhibit greater symptom severity or frequency due to a number of factors. Studies have shown that almost half of the asthmatic children reported cessation of symptoms with increasing age[15] while majority of those who continue to wheeze become less severe.[16] Males have frequently been reported to have more asthma than females both in terms of prevalence and severity during childhood.[17] Several studies have shown that a 2:1 male to female ratio exist during childhood, and this may be due to the advantage that girls enjoy in resistance to respiratory infections, which often masks the onset of asthma, which then disappears in the light of adverse environmental conditions later in life.[18-20] This same influence may be at play when it comes to increased asthma severity among asthmatics. Host susceptibility may be greater in boys, and a higher incidence of respiratory distress syndrome and other respiratory illnesses suggest that boys may have more vulnerable airways.[21] The absolute peripheral airway diameter is also smaller in young boys than girls.[22] Further, it was previously postulated that hormonal differences might be responsible for the differences in asthma severity between the sexes.[23]

Racial differences may not have been very obvious in this study but previous studies showed that Indian children were found to have more severe asthma compared to Malays, and to a greater extend the Chinese. This racial difference was ascribed to lower lung function values among Indian boys compared to other race groups in Singapore.[24] This may not have been seen in this study due to the small numbers of non-Chinese children surveyed.

The rates of reported asthma morbidity differed significantly across the socio-economic status strata. Nevertheless, unlike reports from other countries which stated that lower socio-economic status was associated with increased morbidity, the situation in Singapore seem to be reversed. Irregardless of whether socio-economic status was defined by the type of housing, occupation or parental education level, the higher socio-economic groups seem to have greater proportion of asthmatic children suffering from increased morbidity. A paradox however exists in that based on the Census of Population in Singapore (in 1990),[25] the Chinese tended to make up the majority of the higher socio-economic class while the Malays and Indians tended to fall within the lower socio-economic groups, but in terms of asthma morbidity the Malays and Indians seem to show greater asthma severity. This situation may be due to the two separate issues (race and socio-economic influence on asthma morbidity) being unrelated in entirety. It may be that asthmatic Malays and Indians, regardless of their socio-economic status, were inherently more likely to suffer greater morbidity probably due to smaller lung resulting in lower lung function,[24] while those in the higher socio-economic groups regardless of race were more likely to recognize the symptoms of asthma and more willing to act upon them, leading to the presumption that they suffer greater asthma morbidity. Nevertheless, lifestyle and behavioural factors associated with socio-economic status which predispose these asthmatics to increased exposure to environmental stimuli or irritants cannot be excluded.

In studies elsewhere, an association between lower socio-economic status and severe asthma were reported and possible explanation given was the accessibility to medical treatment.[14] In Singapore, however, this may not be so as the data showed that children from the higher socio-economic groups reporting greater morbidity. Further evaluation, however, would be necessary to determine whether this observation is not due to just differential diagnostic labelling or greater symptom recognition among the higher social classes.

Atopy or allergy was found to be strongly associated with increased asthma morbidity among asthmatic children. This was not surprising that a favourable prognosis in children were found mainly among those with negative skin tests or those with positive tests to only a small number of allergens.[26] Common indoor allergens, such as those of dust mites, cockroach and of domestic pets, were found to be widely distributed in Singapore and perennially present.[27] Those sensitisated to these allergens are constantly exposed to these potential triggers of exacerbation and thus, would likely experience more frequent or even more severe attacks.

Household factors analysed in this study were not found to be significantly associated with frequent or severe exacerbations.

There was however slight indication that children households with 6-8 individuals experience slightly higher percentage of increased morbidity compared to those with smaller household sizes but this was not significant when analysed in a multivariate fashion. This factor may be linked demographically as Malays, which tended to have more severe asthma, also tended to have larger nucleus household size [based on the Singapore, Census of Population, 1990[25]] compared to the other race groups. Studies elsewhere have shown that modern but poorly ventilated living conditions, particularly in temperate regions, may increase the risk of allergy and also increase asthma morbidity.[28] In Singapore, however, this may not be a problem as the majority of the population live in well ventilated high-rise public homes (flats).

There have been numerous reports on the increased risk of respiratory tract illnesses associated with childcare attendances.[29-30] As viral upper respiratory tract infections are one of the most common cause of asthma exacerbation in children, it is likely that asthmatic children attending such facilities would be at risk of increased morbidity. The data, however, showed that both those currently attending childcare and those who had previously attended such facilities were not associated with increased morbidity. This data, however, has to be taken cautiously as the low prevalence of non-attendance may have resulted in reduced statistical power to identify any difference. Further, a previous study has shown that among asthmatic children, referred to a specialist respiratory clinic, attendance at a daycare centre was associated with an increased frequency of lower respiratory symptoms compared to those looked after at home.[31]

The presence of domestic pets was not found to be associated with increased asthma morbidity among asthmatic children in this study. However, when the individual respiratory symptoms were analysed, the data showed that current pet ownership was associated with increased prevalence of certain respiratory symptoms, in particular, those in association with cold or flu and with exercise [data not shown here but published elsewhere].[32] There is, however, a general impression that pet ownership is more closely associated with chronic asthma symptoms, than with acute asthma symptoms associated with flu or exercise, such as those seen in this study. Various studies have reported an absence or inverse association between respiratory symptoms and having pets at home.[33-34] These studies, however, included families, which had given up their pet after developing allergic symptoms, and allergic subjects who consciously avoided having pets at home in their comparisons. These inclusions could have biased the results.

Cigarette smoke is known to aggravate asthma symptoms.[35] However, the data showed no significant relationship between parental smoking and the child's asthma morbidity. Those with parents who currently smoke did not have significantly more symptoms than those without any smoker at home, while households with past smokers had even lower proportion of asthmatic children with increased asthma morbidity (not shown). One explanation for this is that those who had previously smoked, stop smoking in view of their children's deteriorating health condition, while those who carry on smoking could likely be those who modify their smoking habits such that the children were not affected or that their children's health status were not in the first place serious enough to justify them quitting the habit.

Family history of asthma, and allergic rhinitis were shown to be significantly associated with increased asthma morbidity. Studies elsewhere have also shown that a positive family history of atopy is associated with unfavourable asthma prognosis.[36] However, in other studies family history was not found to affect prognosis adversely.[37-38] They reason that although the development of asthma may be genetically linked, the severity of asthma is not genetically determined, and suggest that the environment is probably the most important factor. From the stepwise multivariate examination of our data, the selection procedure consistently included a personal history of allergy as a significant predictor of increased morbidity and excluded the family history from it. This occurs possibly because a personal history of allergy is more strongly associated with asthma morbidity, and that, a personal history of allergy and a family history are colinearly related. This suggests that allergy may be the reason behind the association between family history and asthma morbidity, and the environment, as oppose to genetic determinants, may thus be the more important component in determining the severity of asthma.

Prematurity and/or birth complications were observed to be associated with increased asthma morbidity at a later age. Several

studies have also reported increased prevalence of cough and wheeze symptoms, along with reduction in lung function in children who were born prematurely or who were of low birth weight.[39-40] Studies elsewhere have shown that there were no difference in atopic sensitivity of premature and full term children.[41] Thus, increased wheezing and coughing in premature children may be attributed to persistent anatomical abnormalities of the airways or parenchyma.

Almost all childhood respiratory illness history analysed were found to be predictive of or associated with increased asthma morbidity, with the exception of measles. It is interesting to note that a recent report suggested that such infection may actually prevent allergic sensitization.[42] They suggested that such viral or bacterial infections could actually prevent atopy by the activation of Th1-type cells and production of gamma-interferon and alter the differentiation of allergen-specific T cells, otherwise destined to be of the Th2 type, towards a less atopic Th0/Th1 type.[43]

As for the other childhood respiratory illnesses and infections, a combination of both structural and allergic changes may have occurred due to these diseases and may have thus caused these children who develop asthma later to suffer increased asthma morbidity. Infantile wheezing, bronchitis, croup, bronchiolitis and other lower respiratory viral illnesses were said to lead to increased bronchial reactivity acutely and possibly chronically.[44]

In conclusion, this study has shown that: [1] a total of 34.8% (2,222/6,404) of the children surveyed had symptoms of current wheezing, with approximately 40% (899/2,222) of these children with current wheezing found to suffer from moderate to severe symptoms; [2] increased asthma morbidity was associated with the younger age group, male sex and higher socioeconomic status; and [3] concurrent or past allergies were strongly *associated with* increased asthma morbidity, while premature birth and a history of prior childhood respiratory illnesses and infections were *predictive of* increased asthma morbidity among asthmatic school children in Singapore.

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