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Environmental factors, parental atopy and atopic eczema in primary-school children: a cross-sectional study in Taiwan

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Summary

Background Parental atopy and environmental exposure are recognized risk factors for atopic eczema (AE) in childhood. However, the relative contributions of specific risk factors and the overall contributions of hereditary and environmental exposure remain unexplored.

Objectives To identify risk factors, estimate the population attributable risk (PAR) of environmental exposure, and compare the AE data for boys vs. girls in primary-school children.

Methods During a February to June 2001 cross-sectional, Taiwan-based questionnaire survey, we investigated 23 980 children from 22 primary schools, all located within 1 km of an air-monitoring station.

Results The 12-month prevalence of AE was reported as 6·1% in boys and 4·9% in girls. In both sexes, the risk of AE was strongly associated with parental atopy and perceived ambient air pollution. The presence of cockroaches [odds ratio (OR) 1·18, 95% confidence interval (CI) 1·00–1·40] and visible mould on walls at home (OR 1·46, 95% CI 1·22–1·70) were also significantly related to AE for girls; however, only visible mould on walls (and not the presence of cockroaches) at home was related to AE for boys (OR 1·40, 95% CI 1·18–1·66). While mutually adjusted models were applied, we found adjusted ORs and PARs were similar in boys and girls in hereditary and outdoor environmental factors. The PAR of indoor environmental factors was higher in girls (8·4%) than in boys (5·5%). There was no interaction between parental atopy and environmental factors.

Conclusions Parental atopy contributed more to AE than indoor or outdoor environmental factors. Girls may be more susceptible to indoor environmental factors than boys.

Atopic eczema (AE) is now the most common inflammatory skin disease in children,[1,2] and recently the prevalence of childhood AE has increased substantially in many countries.[3–7] This increase has been too rapid to be accounted for by changes in gene frequencies. It is also unlikely to be accounted for totally by changes in either clinical diagnostic patterns or increased recognition of associated symptoms by the general population.[8] It does, however, suggest a role for environmental factors in the aetiology of this evolving epidemic.[9–11]

Many factors are proven to be associated with AE, including personal factors (smoking habits, genetics, age, sex, nutritional status, number of siblings, lifestyle, allergy status, family history and occupation) and environmental stimuli (house dust-mite, animal danders, moulds, cockroach infestation, occupational exposure, environmental tobacco smoke (ETS), indoor/outdoor air pollution, heating systems, aeroallergens and climate).[9–20] Both hereditary and environmental factors are believed to contribute to the relationship.[21] However, epidemiological evidence concerning different effects in boys and girls in relationships between environmental factors and AE was insufficient and thought to warrant further investigation.

To date, factors contributing to childhood AE have not been clearly documented in Taiwan. In this study, the relationship between AE and selected risk factors in a population-based sample of Taiwanese school children between the ages of 6 and 12 years was investigated. The population attributable risk (PAR) of each factor was estimated and compared for boys and girls. We also tested the hypothesis that the joint effects

of genetic predisposition and environmental factors on the risk of AE are greater than expected on the basis of their independent effects.

Materials and methods

Population and study design

The International Study of Asthma and Allergies in Childhood (ISAAC) is a multinational collaborative project developed to investigate variations in childhood atopic diseases at the population level.[22] Between February and June 2001, we modified the ISAAC protocol and conducted a national, cross-sectional, school-based survey of primary-school children. Classroom incentives but not individual incentives were used to encourage participation. The study protocol was approved by the Respiratory Health Screening Steering Committee of the Taiwan Department of Health and the Institutional Review Board at our university hospital, and it complied with the principles outlined in the Helsinki Declaration.[23] Parents of the school children consented to provide information by questionnaire.

Whether or not a child was deemed to suffer from AE was determined by positive responses to the questions: 'Has your child ever had an itchy rash which was coming and going for at least 6 months?' and 'Has your child had this itchy rash at any time in the past 12 months?' If both answers were 'yes', the parent would be further asked: 'Has this itchy rash at any time affected any of the following places: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes?' In our study, children who were reported to suffer from a skin rash in the previous year occurring at specific locations were defined as having AE. The ISAAC questions for symptoms of AE used in the present study have been validated in different parts of the world.[24–26]

In order to compare outdoor air pollution data with questionnaire results, the study population was limited to children attending schools located within 1 km of Taiwan Environmental Protection Agency (EPA) air-monitoring stations. Complete monitoring data for the air pollutants sulphur dioxide (SO_2), nitrogen oxides (NOx), ozone (O_3), carbon monoxide (CO) and particles with an aerodynamic diameter of 10 μm or less (PM_{10}) were available from the Taiwan EPA. Twenty-two of the 2604 primary schools in Taiwan's 22 counties were investigated. Stratified sampling by grade was applied in each school. We believe our study population based on 22 different areas covering diverse parts of Taiwan to be representative of Taiwanese primary-school children.[27,28]

Genetic and environmental determinants

Literature was reviewed on the causes of childhood AE in order to identify the hereditary and environmental risk factors. Our focus was residential factors affected by climate and not directly related to human behaviour, including cockroaches, water damage or visible mould on walls at home. Parental perception of ambient air pollution level was also considered as an outdoor factor. Parental atopy was a measure of genetic predisposition and defined by reports of the father or mother of the child ever having been diagnosed with AE, asthma or allergic rhinitis. To adjust for possible confounding, we also included host-related variables: the child's age and sex, maternal smoking during pregnancy, the number of siblings at home and the educational level of the household head. Unfortunately, neither blood samplings nor skin tests could be performed in this large, nationwide study.

Statistical analysis

Previously reported analyses of ecological outcomes have demonstrated a larger intercity variation than would be predicted by interindividual variation.[28,29] We used two-stage methods to correct for any excess between-site variability. In the first step, a logistic regression model was used to control for individual-level confounders. In the second step, the community-specific adjusted prevalences of perceived air pollution levels were regressed against the community-specific air pollutants; the regression used weights inversely proportional to the sum of the between-site and within-site variances.

Bivariate logistic models with community clustering were performed to determine associations with AE. All risk factors were categorized into three subgroups of factors—hereditary, indoor environmental and outdoor environmental factors—and we then developed multiple logistic regression models to assess the relative effectiveness of each on AE. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated after adjustment for potential confounders. PARs were also calculated to estimate the contribution of various risk factors for AE. The PAR represents the preventable AE cases if children were not exposed to specific agents or risk factors. PAR was calculated using the formula $P(R-1)/[P(R-1)+1]$, where P is the prevalence of the exposure and R is the relative risk due to the exposure.[30]

We assessed potential effect modification by parental atopy by comparing effect estimates for children with and without atopic parents. Individual and joint effects of environmental factor and parental atopy on AE were estimated using indicator variables created for each category, omitting the hypothesized low–low risk category. Estimates for each of the three exposure categories with the reference group were derived from the same logistic regression model, after adjustment for confounders. Statistical significance was set at $P < 0{\cdot}05$ based on a two-sided calculation.

Results

Our study surveyed 23 980 children from 22 primary schools. The total response rate was 88·8% (10 951 boys and 10 340 girls and their parents). All subjects were between 6 and 12 years old. Overall, 6·1% of boys and 4·9% of girls were reported to have had AE in the previous year. Younger subjects, higher parental education level, and maternal smoking

during pregnancy were found to be associated with the occurrence of childhood AE (Table 1). In the year 2000 in Taiwan, there were approximately 1·04 million boys and 0·95 million girls between the ages of 6 and 12 years, and these proportions suggest that nationwide about 109 990 children of this age group are affected by AE.

After adjustment for parental education level, the effects of each outdoor air pollutant on parentally perceived ambient air pollution levels were assessed separately, and also expressed as ORs for a change by 1 SD (Table 2). In the regression model where P-values were calculated, statistically significant associations were found for SO_2, CO, PM_{10} and NOx in prevalences of any ambient air pollution and moderate to severe ambient air pollution in the 22 target communities. Relatively weak and nonsignificant associations were noted for O_3. Levels of all outdoor air pollutants had relatively stronger predictive effects on the prevalence of perceived moderate to severe air pollution than on the prevalence of perceived mild to severe air pollution level (Table 2).

After adjustment for host factors such as age, parental education level and maternal smoking during pregnancy, we found parental AE, parental asthma/allergic rhinitis, and parentally reported ambient air pollution were strongly related to AE in both sexes (Table 3). Girls who lived in homes with cockroaches present were 1·18 times (95% CI 1·00–1·40) more likely to develop AE. The presence of visible mould on walls at home was also significantly related to AE with OR 1·40 (95% CI 1·18–1·66) for boys and OR 1·46 (95% CI 1·22–1·70) for girls. However, water damage at home showed positive but not statistically significant effects for both sexes. When mutually adjusted models were applied, we found adjusted ORs and PARs were similar in boys and girls in hereditary and outdoor environmental factors (Table 3). Stronger association between indoor factors—defined as visible cockroaches, water damage or visible mould on walls at home—and AE was noted in girls (OR 1·18, 95% CI 0·96–1·45) compared with boys (OR 1·11, 95% CI 0·89–1·38). The PAR of indoor environmental factors was higher in girls (8·4%) than in boys (5·5%). For all the hereditary and environmental factors we identified, the total PARs were 50·7% in the girls and 49·8% in the boys of our population.

Of the estimated 109 990 cases of atopic eczema in 6–12-year-old Taiwanese primary-school children, we estimated that more than 36 370 excess cases of AE were attributable to hereditary factors—defined as parental AE, asthma or allergic rhinitis. Exposure to ambient air pollution accounted for approximately 11 420 excess cases. Indoor factors accounted for 7400 excess cases (3489 boys and 3911 girls).

In order to elaborate the potential effect modification, we systematically conducted stratified analyses in categories of parental atopy. The stratum-specific relations were relatively consistent and no significant interaction was found between environmental factors and parental atopy on AE in both sexes (Table 4). This indicated that the environmental exposure and parental atopy both have independent effects on the prevalence of AE in childhood.

Discussion

The present large questionnaire survey for AE among 6–12-year-old school children in Taiwan linked to local air-monitoring data demonstrated that outdoor air pollutants were significantly associated with parentally perceived ambient air pollution. Although our study was cross-sectional, we analysed data using a case–control study method, which was very efficient compared with a cohort study yielding a similar amount of information. Both parental atopy and environmental exposure increased the risk of childhood AE but did not show significant interactive effects. In addition, it showed girls to be more susceptible to indoor factors than boys. We also found approximately 7400 excess cases of AE attributable to indoor factors, and 11 420 attributable to outdoor ambient air pollution.

Questionnaires have been widely used to assess the prevalence of chronic illness such as atopic eczema. By using ISAAC questions, researchers have had good results in predicting AE diagnosed by dermatologists in the U.K.,[24] Germany[25] and Ethiopia.[26] We used typical symptoms of AE during the past 12 months as the main outcome measurement in determining risk factors. The overall prevalences in our study were 6·1% in boys and 4·9% in girls, lower than that reported in other countries, such as Australia (16·3%),[31] Singapore (20·8%)[32] and Germany (10·5%).[33] The causality of these substantial differences is beyond the scope of this report, but some researchers hypothesize that a Western life style is responsible:[14,15] the higher the level of Westernization, the higher the prevalence of AE.

In our data, younger subjects seem to have a higher prevalence of AE, a finding consistent with a previous Australian study.[31] We also found parental education level to be associated with childhood AE (Table 1): the better educated the parents, the more concerned they were for the health of their children, and hence the more likely these children were to be reported as having AE.[16,17] Moreover, maternal smoking during pregnancy exposes the fetus to more allergens,[34] which would contribute to the occurrence of atopic diseases in later life. Because these factors were potential confounders in risk factor analyses, they were controlled as covariates in the following regression models. Number of siblings at home was not associated with the prevalence of AE in our study (Table 1). Some studies showed that it was not the number of siblings that mattered, but was the birth order that really had effects on the occurrence of AE in children.[9,17,35] Therefore, we did not consider number of siblings as a confounder in further analyses.

ETS and incense burning at home showed negative effects to the occurrence of AE (Table 1), a finding consistent with recent international studies.[14,36] One possible explanation could be that ETS and incense use might be reduced by families with children with AE. Exposure to tobacco or incense might also provide protective effects for atopic diseases through selection mechanisms, as shown in a cross-sectional study.[36] Unlike tobacco or incense exposures, the indoor

Table 1 Prevalence of atopic eczema among primary-school children and association with potential risk factors

Risk factor	% of subjects	N	% with AE	OR	95% CI
Sex					
Boys	51·4	10 951	6·1	1·00	
Girls	48·6	10 340	4·9	0·79	0·70–0·89
Age (years)					
6–7	21·7	4610	5·7	1·00	
8	16·4	3487	6·3	1·10	0·91–1·32
9	16·4	3494	5·2	0·90	0·74–1·09
10	17·3	3689	6·2	1·08	0·90–1·30
11	16·4	3492	4·9	0·84	0·69–1·03
12	11·8	2519	4·6	0·80	0·64–0·99
Parental education level (years)					
< 9	17·1	3637	4·0	1·00	
9–11	46·2	9837	4·7	1·17	0·97–1·42
≥ 12	36·7	7817	7·3	1·88	1·57–2·28
Mother smoking during pregnancy[a]					
No	97·9	20 733	5·5	1·00	
Yes	2·1	448	8·3	1·56	1·09–2·16
Number of siblings[a]					
0	11·7	2023	6·0	1·00	
1	40·3	6967	6·1	1·03	0·84–1·27
≥ 2	48·0	8304	4·7	0·78	0·63–0·96
AE in fathers[a]					
No	97·1	20 324	5·0	1·00	
Yes	2·9	597	22·5	5·51	4·48–6·72
AE in mother[a]					
No	97·5	20 418	5·1	1·00	
Yes	2·5	528	21·4	5·06	4·06–6·26
Asthma/AR in father[a]					
No	82·2	17 199	4·9	1·00	
Yes	17·8	3722	8·4	1·81	1·58–2·07
Asthma/AR in mother[a]					
No	84·8	17 752	4·8	1·00	
Yes	15·2	3194	9·7	2·14	1·87–2·45
ETS at home[a]					
No	45·9	9674	5·9	1·00	
Yes	54·1	11 421	5·2	0·88	0·79–0·99
Incense burning at home[a]					
No	54·5	11 346	6·0	1·00	
Yes	45·5	9458	5·1	0·85	0·75–0·95
Cockroaches seen monthly at home[a]					
0	20·5	4309	5·1	1·00	
1–2	44·2	9289	5·5	1·07	0·91–1·26
≥ 3	35·2	7397	5·9	1·17	0·99–1·38
Water damage at home[a]					
No	93·3	19 769	5·5	1·00	
Yes	6·7	1423	5·6	1·01	0·79–1·26
Number of walls with visible mould at home[a]					
0	74·8	15 536	5·0	1·00	
1	17·4	3605	6·6	1·34	1·15–1·55
≥ 2	7·8	1625	8·3	1·70	1·40–2·05
Perceived ambient air pollution level[a]					
No	30·6	6386	4·8	1·00	
Mild	63·0	13 145	5·8	1·22	1·06–1·40
Moderate to severe	6·5	1350	7·3	1·56	1·23–1·97

OR, odds ratio; CI, confidence interval; AE, atopic eczema; AR, allergic rhinitis; ETS, environmental tobacco smoke. [a]Numbers of subjects do not add up to total N because of missing data. Some percentages do not total 100 because of rounding. ORs are crude odds ratios for each risk factor.

Table 2 Odds ratios (ORs) and 95% confidence intervals (CIs) for the relationship between each outdoor air pollutant and prevalence rates of perceived ambient air pollution level in 22 communities

	Mild to severe air pollution			Moderate to severe air pollution		
	OR	95% CI	P-value	OR	95% CI	P-value
SO_2	1·42	1·16–1·73	0·002	1·62	1·24–2·13	0·001
CO	1·37	1·14–1·65	0·002	1·56	1·21–2·02	0·002
O_3	1·05	0·81–1·35	0·72	1·11	0·79–1·55	0·54
PM_{10}	1·34	1·10–1·63	0·006	1·50	1·14–1·99	0·006
NOx	1·42	1·21–1·66	< 0·001	1·56	1·23–1·99	< 0·001

Prevalence rates are adjusted for parental education level and results are obtained from single pollutant model. ORs are calculated by using those reporting no ambient air pollution as reference group, and expressed for a change in each pollutant by 1 SD (SO_2, 2·25 ppb; CO, 158 ppb; O_3, 3·44 ppb; PM_{10}, 17·9 μg m^{-3} and NOx, 8·60 ppb).

Table 3 Odds ratios (ORs) with 95% confidence intervals (CIs), mutually adjusted ORs and population attributable risks for parental atopy and environmental factors associated with atopic eczema in primary-school children

	Boys							Girls						
	Prevalence (%)	OR	95% CI	PAR (%)	aOR	95% CI	PAR (%)	Prevalence (%)	OR	95% CI	PAR (%)	aOR	95% CI	PAR (%)
Hereditary factors														
AE in father	3·0	6·20	4·75–8·04	10·8				2·7	4·38	3·12–6·03	7·4			
AE in mother	2·7	5·35	4·00–7·07	8·5				2·4	4·09	2·85–5·74	6·0			
Asthma/AR in father	18·0	1·73	1·44–2·07	11·3				17·6	1·69	1·37–2·07	10·5			
Asthma/AR in mother	15·5	1·98	1·64–2·37	12·7				15·0	2·22	1·80–2·73	14·9			
Any parental atopy	32·5	2·65	2·26–3·11	33·9	2·60	2·21–3·05	33·2	31·6	2·63	2·19–3·16	33·1	2·61	2·17–3·14	32·9
Indoor environmental factors														
Cockroaches	79·4	1·08	0·89–1·33	6·0				79·5	1·18	1·00–1·40	12·5			
Water damage	6·6	1·10	0·79–1·48	0·7				6·9	1·01	0·74–1·39	0·1			
Visible mould	25·5	1·40	1·18–1·66	9·1				24·9	1·46	1·22–1·70	10·1			
Any indoor factor	83·4	1·11	0·89–1·38	8·4	1·07	0·86–1·34	5·5	83·6	1·18	0·96–1·45	13·1	1·11	0·90–1·39	8·4
Outdoor environmental factor														
Perceived ambient air pollution	69·4	1·26	1·06–1·52	15·2	1·18	0·98–1·42	11·1	69·4	1·25	1·02–1·54	14·8	1·15	0·93–1·41	9·4

All ORs are adjusted for age, parental education level and maternal smoking during pregnancy. The risk factors are not mutually exclusive and PARs are not additive in this table. PAR, population attributable risk; aOR, mutually adjusted odds ratio; AE, atopic eczema; AR, allergic rhinitis.

environmental factors we chose, including cockroaches, water damage and visible mould on walls at home, would not be easily changed by human behaviours and would not show negative effects on AE.

A family history of allergic diseases was associated with an increased risk of AE, suggesting that genetic factors play a central role in the development of childhood AE.[9,17] Genetic markers could also increase susceptibility of children to the effects of environmental factors.[9] A recent German cross-sectional study[17] revealed that paternal and maternal histories of AE were equally strong determinants of AE in children. Besides AE in parents, maternal and paternal atopy were also found to be significantly associated with childhood AE in the U.K.[9] Our study demonstrated that paternal and maternal AE were stronger risk factors for childhood AE in both sexes than were asthma and allergic rhinitis in parents (Table 3). Children with a parent carrying any atopic disease were also found to have a higher probability of developing AE in later life than those who lived at home with the selected environmental factors. In the mutually adjusted models, hereditary factors—defined as parental AE and asthma/allergic rhinitis—also possessed the highest attributable risks, which were consistent with 36 370 excess cases annually in Taiwan.

The ecological exposure assessment had many advantages in our study. The density of primary schools in Taiwan is very high, and almost all the surveyed children attended schools within 1 km of their homes. Monitoring stations located near the schools were therefore also likely to be near the children's homes, and thus provided good indicators for both school and home exposure. A Taiwanese study has suggested that parental ranking of the air pollution level was a good predictor for childhood asthma,[27,37] which also demonstrated an

Table 4 Prevalence (%) of atopic eczema (AE) and association with environmental factors in primary-school children, stratified by parental atopy

		Boys					Girls				
Environmental factor	Parental atopy	AE (%) with factor	AE (%) without factor	OR	95% CI	P-value for interaction	AE (%) with factor	AE (%) without factor	OR	95% CI	P-value for interaction
Cockroaches	Yes	10·5	10·2	1·05	0·79–1·40	0·88	8·6	8·3	1·08	0·79–1·50	0·48
	No	4·1	4·0	1·02	0·77–1·37		3·4	2·7	1·28	0·91–1·84	
Water damage	Yes	10·6	10·3	1·06	0·66–1·62	0·83	7·4	8·6	0·91	0·52–1·47	0·59
	No	4·5	4·0	1·14	0·71–1·74		3·4	3·2	1·10	0·63–1·79	
Visible mould	Yes	12·8	9·5	1·39	1·10–1·75	0·37	9·2	8·4	1·13	0·86–1·47	0·07
	No	4·7	3·9	1·19	0·90–1·54		4·6	2·9	1·62	1·21–2·16	
Any indoor factor	Yes	10·5	10·0	1·08	0·80–1·50	0·84	8·5	8·7	1·03	0·73–1·48	0·43
	No	4·1	4·0	1·03	0·76–1·43		3·4	2·7	1·27	0·89–1·89	
Perceived ambient air pollution	Yes	10·5	10·0	1·06	0·83–1·38	0·25	8·7	8·3	1·06	0·80–1·42	0·49
	No	4·5	3·4	1·32	1·02–1·72		3·4	2·8	1·22	0·91–1·65	
Any environmental factor	Yes	10·6	5·3	2·13	1·10–4·78	0·70	8·6	7·3	1·20	0·67–2·39	0·59
	No	4·2	2·4	1·75	1·02–3·33		3·3	2·2	1·52	0·86–2·98	

OR, odds ratio; CI, confidence interval. All ORs are adjusted for age, parental education level and maternal smoking during pregnancy.

apparent dose–response relationship. In this study, we also proved that the parentally perceived ambient air pollution level was associated with outdoor air pollutants and the association was stronger if a more severe air pollution level was reported (Table 2). Limited studies have been conducted on the effect of air pollution on AE and the results were still inconclusive,[14,19] but in our study, outdoor air pollution was found to play an important role in the occurrence of AE in childhood (Table 3). The greater the ambient air pollution perceived by parents, the higher the risks of AE in children.

Indoor dampness markers, such as visible mould and water damage, increase the risks of AE in childhood.[17,20] A German study demonstrated that water-related damage at home was associated with the amount of house dust-mite antigen in the dust vacuumed from the children's mattresses.[38] In Finland, children exposed to mould in a school building were found to have higher risks of IgE elevation.[39] Our results also showed significant associations between AE and visible mould at home after adjustment for covariates in both sexes. Although boys had a higher prevalence of AE than girls, when we estimated the effect of any indoor environmental factor on childhood AE, a stronger relationship was noted in girls than in boys (Table 3). The mechanism of such female-led susceptibility is not well understood. One possible explanation considered was that girls might have more extensive exposures because they are relatively inactive and spend more time at home and, therefore, are more influenced by the indoor environment. Sex-differences in the pathogenesis of AE might be partly due to difference in lifestyle, or differences in skin morphology and physiology.

Our data did not show any significant interactive effect between parental atopy and environmental factors on the prevalence of AE (Table 4). In a recent questionnaire survey of Finnish adolescents, Kilpelainen *et al.* also found that no interactive effects existed between indoor dampness and parental atopic diseases.[20] Parental atopy would not modify the effects of environmental factors on the risk of AE in childhood.

It is difficult to target preventative efforts on childhood AE. Environmental factors showed a relatively small but substantial effect on childhood AE in our study. Only 10·4% boys and 8·5% girls with parental atopy were reported as having AE. If such efforts were to target only families with a history of atopy, then only 9·5% children could potentially benefit. However, it seems easier to eliminate such exposures on a national scale than to attempt to counter hereditary factors. Additional research is necessary to prove that the elimination of indoor/outdoor environmental exposures will result in lower rates of childhood AE.

Our study has some limitations. This is a cross-sectional study with relatively weak inference in causal relationship. The questionnaire-based assessment based on symptom reporting is not as precise as doctors' diagnoses. However, in the presence of a true association, misclassification of AE that was random with respect to other study variables would weaken the observed association rather than lead to false-positive results. In addition, this report is a prevalence study, rather

than an incidence study. A small number of families relocated, and some of the factors we studied might have affected the prevalence of AE through effects on disease duration rather than disease incidence. However, our findings are interesting and real, regardless of whether or not the observed associations were caused by effects arising from incidence or duration. In fact, if factors were found to be associated with the prevalence of AE, then they are of major interest in themselves, irrespective of whether the aetiological mechanism involved the increase in disease incidence or in duration.

Because we were unable to measure personal environmental exposures or sensitization to various allergens, such as dust mites, fungi or cockroaches, we might have underestimated the effects of these indoor factors on childhood AE. Outdoor environmental factors were measured only by perceived air pollution level, which must be an imprecise way of measuring the influence of environmental exposure. Another potential source of bias was in the interpretation of parental history for atopy as an indicator of a genetic predisposition to childhood AE. Although the importance of parental history as a predictor of disease has been demonstrated,[9,17] not every child in the family inherits the allergic tendency. Ecological confounders such as urbanization and socialization actually could exist in data analysis and there might be incomplete adjustment and residual confounding. However, more complete personal risk factors are very difficult to obtain in such a large-scale survey. Investigators decided not to try to obtain more personal information as it would have reduced the participation rate and introduced greater bias into the study.

In conclusion, we identified a number of hereditary and environmental factors associated with AE in 6–12-year-old primary-school children in Taiwan. Parental atopy contributed more to childhood AE than environmental factors. Exposure to environmental factors increased the risk of AE in children regardless of the coexisting hereditary factors. Girls may be more susceptible to indoor environmental factors than boys. The present findings suggest that public health policies for eliminating certain environmental factors are needed, which could contribute not only to children's health but also to medical costs in Taiwan.

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