

## Are maternal psychosocial factors associated with cord immunoglobulin E in addition to family atopic history and mother immunoglobulin E?

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### Summary

**Background** Atopy in maternal and family histories is known to be a risk factor for elevated umbilical cord immunoglobulin E (cIgE). However, the association between cIgE and psychosocial factors remains under investigation.

**Objective** To explore whether psychosocial factors in addition to atopy contribute to elevated cIgE.

**Methods** Four private maternity hospitals fitting the quantile levels of SO<sub>2</sub> in 2000 cooperated with us by recruiting participants for this study: pairs of mothers and neonates living within 3-km catchment areas of air-monitoring stations. We used a questionnaire to collect exposure data, and the Pharmacia UniCap IgE assay test system to determine the levels of IgE in gravidas and cord blood.

**Results** Between July 2001 and March 2003, 334 mother and neonate pairs participated in this study. The frequencies of sensitization, serum IgE (sIgE) > 100 IU/mL, or cIgE ≥ 0.35 IU/mL were not different between the four different hospitals. By multi-variate logistic regression analysis adjusted for environmental factors, genetic factors, and psychosocial factors, the risk factors for elevated cIgE were being a male neonate (odds ratio (OR) = 3.5, 95% confidence interval (CI) = [1.5, 8.5]), carpets at home (OR = 3.0, 95% CI = [1.02, 8.4]), maternal allergy to dog dander (OR = 9.7, 95% CI = [1.2, 98.8]), maternal total serum IgE > 100 IU/mL (OR = 5.1, 95% CI = [2.2, 12.8]), maternal regularly/mostly/often self-reported nervousness (OR = 4.0, 95% CI = [1.3, 12.8]), family income \$11 574–17 361/year (OR = 3.7, 95% CI = [1.3, 11.5]), incense burning (OR = 4.0, 95% CI = [1.4, 13.3]), and atopy in maternal grandparents (OR = 4.8, 95% CI = [1.7, 14.0]). By principle component analysis and logistic regression, psychosocial stress ( $\beta \pm$  standard error =  $0.26 \pm 0.13$ ,  $P = 0.04$ ) was associated with increased cIgE.

**Conclusion** Psychosocial factors are potentially important risk factors for elevated cIgE.

**Keywords** allergen-specific IgE, atopic disease, cord IgE, environmental factor, pets, principal component analysis, psychosocial factors, risk factor

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### Introduction

For the past few decades, the prevalence of atopic diseases such as asthma and atopic dermatitis has been increasing quickly in developed countries [1]. Environmental, psychosocial, and genetic factors are proposed to be associated with atopic disease [2]. The environmental risk factors for atopic diseases include air pollutants, smoking, diet, allergens, and occupational exposures [3–7]. Psychosocial risk factors for atopic diseases include family income, parental education, emotional stress, depression, and anxiety [8, 9]. Genetic susceptibility to immunoglobulin E (IgE) production and family atopic histories have also been associated with atopic diseases [10, 11]. An increase in umbilical cord IgE (cIgE) was used as a predictor for atopic disease in early childhood [12].

Maternal atopic diseases and family atopic histories have been proposed as two important risk factors for elevated cIgE in neonates [13–15]. However, the association between cIgE and psychosocial factors remain under investigation. In order to detect such an association, the present study was conducted to (i) recruit participants among pregnant women living within a 3-km catchment area of Taiwan air-monitoring stations, (ii) measure in their serum the levels of serum IgE (sIgE) and allergen-specific IgE (specific to five allergens common in Taiwan), and of cIgE in the serum of their neonates, (iii) complete a questionnaire collecting possible environmental factors, disease histories and personal data, and (iv) statistically analyse the risk factors for an increase in cIgE.

### Methods

#### Subjects and population

Although the relationship between air pollution and asthma has not been conclusive, we practiced precaution to select

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representative stations considering the levels of pollutants. However, there were many kinds of air pollutants, and we had to choose among these. SO<sub>2</sub> were considered to be at least as important as other pollutants, and therefore chosen. However, we cannot exclude the possible association between other pollutants and cIgE. The air pollutant data for 2000 were supplied by the Taiwan Environmental Protection Administration. The Association of Obstetrics and Gynecology of the Republic of China on Taiwan provided a list of names and communication data for hospitals near air-monitoring stations. In 2000, four hospitals were selected from each quartile of SO<sub>2</sub> levels and they cooperated with us by inviting pairs of mothers and neonates to participate in this study. The four air-monitoring stations were Annan (Tainan city), and Hsin Ying (Tainan county), Hsin Juang (Taipei county), and Taitung (Taitung city). We checked the yearly average levels of SO<sub>2</sub> in 2001. The levels of SO<sub>2</sub> in the four air-monitoring stations were concordant with those located within the same quantile levels in 2000 and 2001.

Pregnant women and their neonates born after July 2001 who lived within a 3-km catchment area of air-monitoring stations were recruited for this study. Between July 2001 and March 2003, 353 families were initially invited to participate in the present study. A total of 334 (94.6%) mother-and-neonate pairs participated in this study. No differences in demographic data were found between participated subjects and those unable to participate in the present study. One month before each infant's predicted birth, we collected the informed consent, questionnaire, and peripheral blood of each gravida. Each neonate's cord blood was collected immediately after birth. Our protocols were approved by the National Cheng Kung University Hospital Institutional Review Board.

### Questionnaire

The gravidas were asked about their age, neonate's birth order (the number of live birth), smoking before pregnancy, environmental tobacco smoking (ETS) before pregnancy, smoking during pregnancy, ETS during pregnancy, parental occupations, parental education levels, family income, history of atopic diseases (asthma, allergic rhinitis, and atopic dermatitis) in their maternal and paternal families, pets at home, self-reported environmental pollutants, and self-reported psychosocial stress (vitality, vigour, happiness, anxiety, nervousness, exhaustion, tiredness, working stress, and discouragement). The levels of self-reported psychosocial stress were 'never', 'seldom', 'occasionally', 'often', 'mostly', and 'regularly'. The questions of self-reported psychosocial stress were selected from the 'modified Chinese version of Short Form 36 Health Survey' (IQOLA SF-36 Taiwan standard Version 1.0; Copyright© 1995 New England Medical Centre Hospital, Inc. All rights reserved.). Information about dampness of the house, carpets at home, and the use of dehydration devices (dehumidifiers) was also included in the questionnaire. From the records of the cooperating hospitals, we also collected neonate health data at birth: head circumference, weight, height, and weeks of gestation. None of the women had any complications during pregnancy.

### Immunoglobulin E determination

Serum was obtained by centrifugation and stored in a liquid nitrogen tank until analysed. The Pharmacia UniCap IgE assay test system (Pharmacia Diagnostics, Uppsala, Sweden) was used to determine the levels of sIgE, cIgE, and IgE against five common allergens in Taiwan, including *Derma-tophagoides farinae* (Der f), *Blatella germanica* (cockroach), cat dander, dog dander, and *Candida albicans*. CAP test results  $\geq 0.7$  IU/mL were regarded as a positive indicator of the specific allergens. We excluded those cIgE data suspected to be contaminated by the mother's blood (sIgE/cIgE  $\leq 50$ ).

### Statistical analysis

Data analysis was done using JMP version 5.0 (SAS Institute Inc., Cary, NC, USA) for MS Windows. Statistical analysis consisted of determinations of mean and standard error (SE) of numeric variables. Group differences were compared by ANOVA and Tukey's tests. The Pearson  $\chi^2$ -test was used to determine the difference of frequency between two or more groups. Multi-variate logistic regression analysis was done to detect the association between dependent and independent variables. Variables with a *P*-value  $< 0.2$  were kept in the logistic regression analysis. The data-missing rate for each variable was not the same. The variables were included in the multi-variate logistic regression analysis step by step according to the data-missing percentage from low to high. Principal component analysis was used to identify the major responses of psychosocial stress factors. *P*-values were determined by a two-tailed test, and statistical significance was set at  $P < 0.05$ .

## Results

### Serum levels of IgE

There were 71 pairs from Annan, 95 pairs from Hsin Ying, 111 pairs from Taitung, and 57 pairs from Hsin Juang. Neither the prevalence rates of cIgE  $\geq 0.35$  IU/mL and sIgE  $> 100$  IU/mL nor the rates of the gravidas sensitized to Der f, cockroach, dog dander, cat dander, or *C. albicans* were different between the four different hospitals (Table 1). No family had cat ownership alone. A total of 50% (6/12) pregnant women who were sensitized to dog dander were exposed to dog at home. To further compare the risk factors for elevated cIgE, we combined the four groups for a multi-variate logistic regression analysis.

### Demography of pregnant women and exposure data

No differences in demographic data were found between mothers regularly, mostly, and often self-reported psychosocial stress. For consideration of the number of each category, we grouped them as one group for further analysis. Demographic (maternal age and education levels), genetic (paternal and maternal grandparents' atopy), psychosocial (family income, psychosocial stress), and environmental factors (smoking, ETS, pesticide usage at home, carpets at home, incense burning at home, maternal self-reported environmental pollutants, and pets at home) information is listed in Table 2. From the questionnaire data, the frequency

**Table 1.** The levels of total IgE and allergen-specific IgE in mothers and cord IgE in neonates

|                                              | Annan<br>N = 71 | Hsin Ying<br>N = 95 | Taitung<br>N = 111 | Hsin Juang<br>N = 57 | P-value* |
|----------------------------------------------|-----------------|---------------------|--------------------|----------------------|----------|
| Sensitization to Der f (%)                   | 18.3            | 26.3                | 12.6               | 21.1                 | > 0.05   |
| Sensitization to cockroach (%)               | 5.6             | 9.5                 | 5.4                | 7.0                  | > 0.05   |
| Sensitization to cat dander (%)              | 1.4             | 1.1                 | 0.9                | 1.8                  | > 0.05   |
| Sensitization to dog dander (%)              | 4.2             | 5.3                 | 0.9                | 5.3                  | > 0.05   |
| Sensitization to <i>Candida albicans</i> (%) | 1.4             | 1.1                 | 0.9                | 0.0                  | > 0.05   |
| Total serum IgE > 100 IU/mL (%)              | 47.9            | 52.6                | 37.8               | 43.9                 | > 0.05   |
| Cord IgE ≥ 0.35 IU/mL (%)                    | 26.8            | 24.2                | 18.9               | 22.8                 | > 0.05   |

\*P-value was calculated by Pearson  $\chi^2$ -test. Sensitization stands for allergen-specific IgE ≥ 0.7 IU/mL.

of gravidas reporting dampness in the house was 6.3%, and using dehydration devices at home was 72.8%. The parental (gravidas and husband's) professions were business (34.1%), public service (30.2%), agriculture (5.1%), education (13.8%), others (11.4%), and missing data (5.4%). The percentage of missing data in each category was different (Table 2), but the differences were not significant between the other categories.

#### Demography of neonates

A total of 183 (54.8%) male and 151 (45.2%) female neonates were recruited into the present study (Table 2). The live birth orders of the neonates were 46.4% first-borns, 38.0% second-borns, and 14.7% were third-borns or higher. This information was missing for 0.7% of the neonates. The mean head circumferences, numbers of gestation weeks, birth height, and weight of neonates were  $33.3 \pm 0.1$  (cm),  $39.1 \pm 0.07$  (weeks),  $3160.7 \pm 22.9$  (g), and  $49.6 \pm 0.2$  (cm), respectively. In addition, there was no significant association between cIgE and neonate health (head circumference, height, weight, weeks of gestation, and live birth order) in this study. However, male neonates had higher prevalence rates of cIgE ≥ 0.35 IU/mL than did females ( $\chi^2 = 8.38$ ,  $P = 0.004$ ).

#### Multi-variate logistic regression

By multi-variate logistic regression analysis, the dependent variable was cIgE ≥ 0.35 IU/mL and the independent variables were environmental factors, genetic factors, psychosocial factors, and personal data. Because the P-values of ETS before pregnancy, smoking while pregnant, ETS during pregnancy, self-reported dampness in the house, self-reported environmental pollutants, usage of dehydration devices at home, paternal education levels, pets at home, and parental professions were > 0.2, we excluded them from the multi-variate analysis. After adjustment for maternal age, maternal sensitization to dust mite, cat dander, cockroach, and *C. albicans*, pesticide usage, maternal education levels, smoking before pregnancy, and paternal grandparents' atopy (Table 3), the significant risk factors for an increase of cIgE were being male neonates (odds ratio (OR) = 3.5, 95% confidence interval (CI) = [1.5, 8.5]), carpets at home (OR = 3.0, 95% CI = [1.02, 8.4]), maternal allergy to dog dander (OR = 9.7, 95% CI = [1.2, 98.8]), maternal total serum IgE > 100 IU/mL (OR = 5.1, 95% CI = [2.2, 12.8]),

maternal regularly/mostly/often self-reported nervousness (OR = 4.0, 95% CI = [1.3, 12.8]), family income \$11 574–17 361/year (OR = 3.7, 95% CI = [1.3, 11.5]), incense burning (OR = 4.0, 95% CI = [1.4, 13.3]), and atopy in maternal grandparents (OR = 4.8, 95% CI = [1.7, 14.0]).

#### Psychosocial stress and cIgE

Only one of the self-reported psychosocial stress factors, self-reported nervousness, was associated with elevated cIgE (Table 3). To further test this association, principal component analysis was applied to identify the major responses. Two factors (I and II) were found for psychosocial stress (Table 4). Factor I was positively associated with nervousness, exhaustion, anxiety, tiredness, working stress, and discouragement. Factor II was strongly associated with vitality, vigour, and happiness. No association was found between incense burning, maternal atopy and stress factor I or factor II by Student's unpaired *t*-test. Logistic regression analysis (Table 5) showed that an increase in cIgE was significantly associated with factor I ( $\beta \pm SE = 0.26 \pm 0.13$ ,  $P = 0.04$ ) but not with factor II.

#### Discussion

Our study demonstrated that family histories of atopy, maternal sensitization to dog dander, and sIgE > 100 IU/mL were all risk factors for elevated cIgE. In addition, psychosocial factors (family income and maternal self-reported nervousness) and incense burning were also risk factors for increased cIgE. The adjusted factors for the analysis were maternal age, sensitization to the other four allergens, maternal education levels, smoking before pregnancy, pesticide usage at home, and the atopy of paternal grandparents. No statistically significant differences were found in the rates of maternal sensitization, frequencies of sIgE > 100 IU/mL, and frequencies of cIgE ≥ 0.35 IU/mL when comparing IgE levels between Annan, Hsin Ying, Hsin Juang, and Taitung. However, male neonates had a higher frequency of cIgE ≥ 0.35 IU/mL than females did. None of the factors related to neonate health (weeks of gestation, head circumference, birth weight, and birth height) were associated with elevated cIgE.

The maternal smoking during pregnancy was known to be a risk factor for elevated cIgE [16]. However, no association

**Table 2.** Demographic characteristics of pairs of mother and neonate and exposure data

|                                                     | Pairs of mother and neonate (N = 334) |
|-----------------------------------------------------|---------------------------------------|
| Maternal age (years)                                | 27.6 ± 0.3*                           |
| Maternal education (%)                              |                                       |
| 9 years                                             | 13.2%                                 |
| 10–12 years                                         | 56.7%                                 |
| 13 years                                            | 30.2%                                 |
| Missing                                             | 1.0%                                  |
| Environmental tobacco exposure before pregnancy (%) |                                       |
| Yes                                                 | 43.4%                                 |
| Missing                                             | 0.9%                                  |
| Smoking before pregnancy (%)                        |                                       |
| Yes                                                 | 9.6%                                  |
| Missing                                             | 0.3%                                  |
| Environmental tobacco exposure during pregnancy (%) |                                       |
| Yes                                                 | 40.7%                                 |
| Missing                                             | 1.2%                                  |
| Smoking during pregnancy (%)                        |                                       |
| Yes                                                 | 3.9%                                  |
| Missing                                             | 2.4%                                  |
| Maternal self-reported nervousness (%)              |                                       |
| Regularly/mostly/often                              | 10.5%                                 |
| Occasionally                                        | 45.2%                                 |
| Never/seldom                                        | 41.3%                                 |
| Missing                                             | 3.0%                                  |
| Pesticide usage at home (%)                         |                                       |
| Yes                                                 | 50.9%                                 |
| Missing                                             | 5.1%                                  |
| Carpets at home (%)                                 | 12.9%                                 |
| Incense burning (%)                                 |                                       |
| Yes                                                 | 74.3%                                 |
| Missing                                             | 1.2%                                  |
| Pets at home (%)                                    |                                       |
| Dog/cat                                             | 24.2%                                 |
| Others                                              | 5.7%                                  |
| Missing                                             | 2.4%                                  |
| Maternal self-reported environmental pollutants (%) |                                       |
| Yes                                                 | 28.7%                                 |
| Missing                                             | 9.9%                                  |
| Paternal grandparents' atopy (%)                    |                                       |
| Yes                                                 | 12.0%                                 |
| Unknown                                             | 15.9%                                 |
| Missing                                             | 12.7%                                 |
| Maternal grandparents' atopy (%)                    |                                       |
| Yes                                                 | 11.7%                                 |
| Unknown                                             | 9.9%                                  |
| Missing                                             | 10.2%                                 |
| Sex of neonates (%)                                 |                                       |
| Boy                                                 | 54.8%                                 |
| Girl                                                | 45.2%                                 |
| Head circumference (cm)                             | 33.26 ± 0.09*                         |
| Birth weight (g)                                    | 3160.7 ± 22.9*                        |
| Birth height (cm)                                   | 49.6 ± 0.2*                           |
| Live birth order (%)                                |                                       |
| First                                               | 46.4%                                 |
| Second                                              | 38.0%                                 |
| Third                                               | 14.7%                                 |
| Missing                                             | 0.7%                                  |
| Weeks of gestation                                  | 39.1 ± 0.07*                          |

\*Data are expressed as mean ± SE. Birth order is the number of the live birth.

between smoking during pregnancy and cIgE was found in the present study. The low percentage of mothers who smoke at this time could partially explain it. An increase of cIgE has been proposed as a predictor for the development of allergen sensitization [12, 17]. Many previous studies [13, 14, 16] have reported that gravidas with atopic disease, family histories of atopy, and high maternal sIgE were also important risk factors for the increased cIgE. Paternal histories of atopy, however, were not found to be a risk factor. Bergmann et al. and Bierke et al. also indicated that male infants had higher cIgE levels than females [14, 18]. In the present study, we found that being a male neonate, maternal sensitization to dog dander, sIgE > 100 IU/mL, carpets at home, and maternal but not paternal grandparents' atopy were all risk factors for an increase in cIgE. Our results are compatible with the findings of these previous studies. Carpets at home have also been recognized as an important source of allergen exposure, especially for infants with positive family histories of atopy [19]. The productions of cIgE were proposed to be associated with the interaction between genetics and environmental exposure. Thornton and Vance, and Holt and Jones indicated that allergen molecules could cross the placenta and associate with fetal allergen exposure and immune response [20, 21]. We suggest that small allergen molecules from carpets at home are transported into the cord blood and induce cIgE production.

The annual average income of Taiwanese families in 2000 was \$14019. Table 3 shows that annual family income ≥ \$11 574 was associated with an increase of cIgE, especially family income between \$11 574 and \$17 361. A study in the USA [22] found that the levels of dust mite, cockroach, cat dander, and dog dander in dust differed in the home environment according to socio-economic status. Holt and Jones [21] indicated that fetal immunity has limited ability to mount an immune response and antibody production. A cohort study in the USA [23] demonstrated that primary sensitization to common allergen can be found in the fetal immune system. Although no statistical significance was found, the higher family income had higher frequency of cat or dog ownership. In the present study, higher family income was associated with an increase in cIgE, and sensitization to dog dander in gravidas was a risk factor for an increase in cIgE. It is possible that family income was associated with an increase of cIgE by exposure to different allergens or environmental factors. These relationships, however, require more investigation.

In the present study, regularly/mostly/often self-reported nervousness vs. never reported was a risk factor for elevated cIgE. We are also the first to report that psychosocial stress is possibly associated with increased cIgE. Although the association between emotional stress and atopic disease is widely accepted, the mechanism remains unclear [8]. A study in Germany [8] showed that stress might associate with immunological change in atopic dermatitis patients by elevations of sIgE and eosinophil counts. Kimata [9] reported that computer-induced stress could increase the allergen-specific response. Kang and Fox [24] showed that baseline IL-2 levels (Th1 cytokine) were inversely correlated with mood scores. It is possible that nervousness can induce some unknown factors related to the immune response and pass through the placenta to associate with IgE production.

**Table 3.** Risk factors for elevated cord IgE by adjusted\* multiple logistic regression analysis

| Predictors                           | Cord IgE $\geq$ 0.35 IU/mL<br>(N = 60) | Cord IgE < 0.35 IU/mL<br>(N = 204) | Odds ratio | 95% CI      |
|--------------------------------------|----------------------------------------|------------------------------------|------------|-------------|
| Sex                                  |                                        |                                    |            |             |
| Male                                 | 41                                     | 102                                | 3.5        | [1.5, 8.5]  |
| Female                               | 19                                     | 102                                |            |             |
| Carpets at home                      |                                        |                                    |            |             |
| Yes                                  | 10                                     | 21                                 | 3.0        | [1.02, 8.4] |
| No                                   | 50                                     | 183                                | 1.0        |             |
| Maternal sensitization to dog dander |                                        |                                    |            |             |
| Yes                                  | 9                                      | 2                                  | 9.7        | [1.2, 98.8] |
| No                                   | 51                                     | 202                                | 1.0        |             |
| Maternal total IgE                   |                                        |                                    |            |             |
| > 100 IU/mL                          | 44                                     | 78                                 | 5.1        | [2.2, 12.8] |
| $\leq$ 100 IU/mL                     | 16                                     | 126                                | 1.0        |             |
| Maternal self-reported nervousness   |                                        |                                    |            |             |
| Regularly/mostly/often               | 14                                     | 19                                 | 4.0        | [1.3, 12.8] |
| Occasionally                         | 24                                     | 103                                | 1.1        | [0.5, 2.5]  |
| Never/seldom                         | 22                                     | 82                                 | 1.0        |             |
| Family income                        |                                        |                                    |            |             |
| \$17 361/year                        | 23                                     | 78                                 | 2.6        | [0.9, 8.6]  |
| \$11 574–17 361/year                 | 24                                     | 69                                 | 3.7        | [1.3, 11.5] |
| \$11 574/year                        | 13                                     | 57                                 | 1.0        |             |
| Incense burning                      |                                        |                                    |            |             |
| Yes                                  | 51                                     | 152                                | 4.0        | [1.4, 13.3] |
| No                                   | 9                                      | 52                                 | 1.0        |             |
| Maternal grandparents' atopy         |                                        |                                    |            |             |
| Yes                                  | 16                                     | 20                                 | 4.8        | [1.7, 14.0] |
| No                                   | 44                                     | 184                                | 1.0        |             |

\*Adjusted for maternal age, sensitization to dust mite, cat dander, cockroach, and *Candida albicans*, pesticide usage at home, maternal education levels, smoking before pregnancy, and atopic history of paternal grandparents.

CI, confidence interval; NT\$, new Taiwan dollars (US\$1 = NT\$34.56). The annual average income of Taiwanese families in 2000 was \$14 019.

**Table 4.** Factor loading of the psychosocial factors

|                                   | Factor 1        | Factor 2        |
|-----------------------------------|-----------------|-----------------|
| Eigenvalue (% variance explained) | 3.3016 (36.7%)* | 1.4448 (16.1%)* |
| Self-reported vitality            | –0.0876         | 0.8423          |
| Self-reported nervousness         | 0.6517          | –0.0324         |
| Self-reported discouragement      | 0.6089          | –0.3614         |
| Self-reported vigour              | –0.1406         | 0.8550          |
| Self-reported anxiety             | 0.5800          | –0.4157         |
| Self-reported exhaustion          | 0.6815          | –0.3894         |
| Self-reported happiness           | –0.0978         | 0.4734          |
| Self-reported tiredness           | 0.6830          | –0.1879         |
| Self-reported working stress      | 0.6273          | 0.3119          |

\*Both factors have Eigenvalues > 1 and account for 52.7% of variance.

However, more studies are required to prove this and help us to understand how stress can induce an increase of cIgE. By principle component analysis and logistic regression, factor I (Table 5), representing psychosocial stress, was associated with increased cIgE. This supports the notion that psychosocial stress is a potential risk factor for elevated cIgE.

The present study shows that incense burning was a risk factor for elevated cIgE. It was also a common source of environmental exposure for these Taiwanese families. Lung et al. [25] reported that incense burning contributed a substantial amount of indoor particulate matter < 10  $\mu$ m (PM<sub>10</sub>).

**Table 5.** Logistic regression for determinant of factor loading of psychosocial stress in cord IgE  $\geq$  0.35 IU/mL

|                                       | $\beta \pm$ SE   | Odds ratio | 95% CI      | P-value* |
|---------------------------------------|------------------|------------|-------------|----------|
| Factor loading of psychosocial stress |                  |            |             |          |
| Factor I                              | 0.26 $\pm$ 0.13  | 7.7        | [1.1, 58.9] | 0.04     |
| Factor II                             | –0.05 $\pm$ 0.13 | 0.7        | [0.1, 4.0]  | > 0.05   |

SE, standard error; CI, confidence interval.

\*Wald's statistic.

Incense burning is also the major source of PMs in Taiwan's temples. Fang et al. [26] reported that concentrations of lead (Pb) were 0.14 and 0.21 mg/g in PM<sub>2.5</sub> and PM<sub>2.5–10</sub> at one temple in Taiwan. Comparing their previous studies [26, 27], the levels of Pb in PM<sub>10</sub> at temples were higher than in rural areas in Taiwan. Lead is known to pass through the placenta into cord blood [28]. Lutz et al. [29] indicated that lead exposure could stimulate the IgE production. In 2003, Annesi-Maesano et al. reported that cIgE was positively related to hair lead level at birth [30]. It is possible that incense burning contributed to indoor PM<sub>10</sub> and Pb within PM<sub>2.5</sub> and PM<sub>2.5–10</sub> could be transferred to fetal blood and modulate the fetal immune system with IgE production. Although the lead exposure and IgE production were verified, more studies are needed to prove the relationships between incense burning, cord blood lead, and cIgE.

In the present study, we found that the frequency of missing data and reported unknowns in family histories of atopic diseases was high. It seems that the gravidas we surveyed did not pay attention to or have substantial information and background knowledge about atopic diseases. In addition, Tsuang et al. [31] found that the prevalence of asthma in Taiwan was increasing in this decade. Many prevention studies have been designed and executed in different countries in order to decrease the current prevalence of atopic diseases [1, 7, 32–35]. They also reported that prevention could reduce the sensitization rate during childhood. However, Tariq et al. [12] reported that cIgE was not a good predictor for atopy following the children development. Until now, no similar prevention study was reported from Taiwan. Because of our findings and the association between cIgE and atopy found in the previous studies, we suggest that easily accessible information and information dissemination about atopy provided by hospitals and public health centres could be designed and executed for gravidas to reduce the atopic prevalence of the next generation in Taiwan. More studies are required to verify the effect of prevention to decrease the sensitization rate.

In conclusion, the risk factors for an increase in cIgE found in this study were similar to the factors reported to be associated with atopic diseases in previous studies. In addition to family histories of atopy, sIgE > 100 IU/mL, and maternal sensitization, we suggest that psychosocial factors are potentially associated with elevated cIgE.

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