

## Housing Environment without a Driveway Associated with Early Allergic Symptoms and Allergic Sensitization

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**Abstract.** Background and Aims: Prevalence of allergic diseases has dramatically increased over the recent decades, especially in children. Children living in urban area have a higher risk to allergic diseases than those living in rural area, and most studies implied the environmental exposure such as indoor and outdoor air pollutions as the main logical mechanism. This study aims to investigate whether housing with different patterns of driveway was associated with the development of allergic sensitization and allergic symptoms in childhood. Methods: A birth cohort was recruited in southern Taiwan. We enrolled 1124 infants with information of residential architecture from the 18month questionnaire. The questionnaire information of allergic diseases from both parents, and infants at 6-month (N=967) and 18-month (N=1124) and 36 months (N=924) were collected. The sensitization of common allergens and total IgE levels were measured by Phadia CAP system at the age of 18-month (N=713) and 36-month (N=652). We divided the driveway patterns of the housing into 3 groups including no driveway, 2-lane driveway and 4-lane driveway. We compared the outcomes of allergic symptoms and allergic sensitization among children living in different driveway patterns of the housing at age of 6, 18 and 36 months. Results: Children living in housings without a driveway had a higher risk to develop eczema ( $p=0.001$ ), sneezing ( $p=0.049$ ) at age of 6 and 18 months, and frequent cough or bronchiolitis ( $p<0.001$ ) at age of 18 months than those living in the housing with 2-lane or 4-lane driveway. Children living in the housing without driveway also had higher total IgE levels and allergic sensitization to food allergen or aeroallergen at age of 6 and 18 months. The fact that both mothers and children living in a housing without driveway had significantly higher total IgE levels and allergic sensitization implies that people living in a housing without driveway are prone to the development of allergic sensitization and IgE production. Conclusion: Infants living in a housing without driveway had a higher risk to have allergy sensitization and to develop eczema and allergic respiratory symptoms than those living in the housing with 2-lane or 4-lane driveway. The housing building without driveway may have different constructing materials and may be much more enclosed which may contribute to low home ventilation and recycling of indoor pollutants and allergens for early development of allergic symptoms and allergic sensitization.

**Keywords:** housing, driveway, allergic sensitization, eczema, rhinitis, asthma

### 1. Introduction

Prevalence of allergic diseases has dramatically increased over the recent decades, especially in children [1,2]. Children living in urban area have a higher risk to allergic diseases than those living in rural area [3,4]. The environmental exposure, such as indoor and outdoor air pollutions in the urban area is proven to be

related to the childhood allergy [5]. Many studies support the concept that proximity to major roadways is associated with an increased risk of wheeze illness, and allergic sensitization [6,7].

In consideration of different countries having different buildings and driveway designs, we are interested in whether infants living in housing with different driveways have different risks to allergic sensitization and allergic symptoms. In a birth cohort study, we have previously shown that gene-environment interaction on IgE production begins in prenatal stage [8,9], and partial protein-hydrolyzed infant formula decreased milk allergy sensitization, but not allergic diseases [10]. In this study, we analyzed the contribution of housing with different driveways to the development of allergic symptoms and allergic sensitization in childhood at 6, 18 and 36 months of age in the prospective birth cohort study including 1444 infants in southern Taiwan.

## **2. Method and Materials**

### **2.1. Study Design and Subjects**

To study the interactive influence of genetic and environmental factors on prenatal and postnatal IgE production and development of allergic diseases, a longitudinal birth cohort study was conducted at Kaohsiung Chang Gung Memorial Hospital, Taiwan, as reported previously [11,12]. A total of 1424 pregnant women, corresponding to 1444 newborns were prenatally recruited for this study after informed consent was obtained. A research nurse was trained to explain the purpose of this study to eligible pregnant women as they visited our obstetric clinic. Of the enrolled newborn infants, 967, 1124 and 924 returned for the 6-month, 18-month, and 36-month follow-up visit, at which a questionnaire was used to assess the driveway types, and symptoms of allergic diseases. Parental atopy was defined as any positive allergic history (atopic dermatitis, allergic rhinitis or asthma), with at least one allergen specific IgE  $\geq 0.35$  KU/I. The study protocol was reviewed and approved by the Institutional Review Board committees of the study hospital. Written informed consent was obtained from the parents or guardians before enrollment.

### **2.2. Questionnaire Contents at 0, 6, 18 and 36 Months of Age**

In the first survey at the time of the infant birth, infant gender, parental allergic history including asthma, allergic rhinitis and atopic dermatitis and tobacco smoke exposure were collected via questionnaire. At 18 months of age, questionnaires were administered to collect the information on the motorway patterns of the living house. Besides, parents were also asked about the symptoms of allergic disease in children such as eczema, frequently sneeze in the morning/night, frequently cough in the morning/night, and if the infant had been diagnosed as bronchiolitis by a physician. At 36 months of age, parents were asked if their child had been diagnosed as eczema or atopic dermatitis, allergic rhinitis and/or asthma by a physician.

### **2.3. Detection of Total IgE and Allergy Sensitization**

In this cohort follow up, 668, 713 and 652 infants received blood collection for measurement of total IgE and specific IgE levels ( $\geq 0.35$ KU/I) to common allergens. Allergy sensitization was defined by at least one aeroallergen or food-allergen specific IgE level  $\geq 0.35$ KU/I.

### **2.4. Data Analysis and Statistics**

Demographic data including gender, tobacco smoke exposure, parental allergic diseases, parental allergic sensitization and parental atopy were described in percentage, compared and analyzed by chi-square tests between the infants living in the apartment buildings and those living in the houses. The allergic sensitization status by specific IgE test, and the allergic symptoms or diseases diagnosed by a physician at 6 months, 18 months, and 36 months of age were compared and analyzed by chi-square tests between the infants living in buildings with different motorway patterns including no driveway, 2-lane driveway and 4-lane-driveway. The log transformed total IgE levels at 6 months, 18 months, and 36 months of age were analyzed by Student t test.  $P < 0.05$  is defined as being significant statistically.

## **3. Results**

### **3.1. Allergic Symptoms and Diseases between Infants Living among Different Driveway Patterns**

To investigate whether housing with different driveway has an impact on allergic sensitization and allergic diseases of infants, we analyzed the allergic symptoms in infants living at housing with no driveway, 2-lane driveway or 4-lane driveway. As shown in Table 1, we found that eczema (21.4 vs. 9.2 and 9.4%, respectively) and sneezing (42.9 vs. 30.5 and 31.7%, respectively) were more frequently found in infants living in housing without driveway than those living in 2-lane driveway or 4-lane driveway at 6 months of age. We found that eczema (31.4 vs. 21.5 and 27.3%, respectively), sneezing (34.3 vs. 17.2 and 17.7%, respectively) and frequent cough or bronchiolitis (18.1 vs. 4.4 and 4.3%, respectively) were more frequently found in infants living in housing without driveway than those living in 2-lane driveway or 4-lane driveway at 18 months of age. While growing up to 3 years old, the prevalence of atopic dermatitis, allergic rhinitis and asthma were not significantly different among 3 groups.

### **3.2. Profiles of Allergic Sensitization between Infants Living among Different Driveway Patterns**

We also analyzed whether different driveway patterns were associated with allergic sensitization in childhood. As shown in Table 2, we found that both food sensitization rate (55.7 vs. 36.1 and 41.9%, respectively) and aeroallergen sensitization rate (20 vs. 10 and 11%, respectively) were higher in infants living in no driveway housing than those living in 2-lane driveway or 4-lane driveway at age of 18 months of age. The increase of aeroallergen and food allergen sensitization rates remained into 3 years of age, but not reached significant difference. These results imply that infants living in a housing without driveway are prone to allergy sensitization and allergic symptoms in early infancy.

### **3.3. Total IgE Levels in Children Living with and without Driveways**

Analysis is next performed to study whether different driveway patterns were associated with IgE production in childhood. We found that the total IgE levels were significantly higher in infants living in housing without driveway than those living with 2-lane or 4-lane driveway housing at 6 months of age (1.30 vs. 1.13 log-transformed KU/L,  $p=0.017$ ) and at 18 months of age (1.90 vs. 1.70, log-transformed KU/L,  $p=0.004$ ). The higher IgE production remained higher in 3 years of age, but not reached significant difference (1.92 vs. 1.81 log-transformed KU/L,  $p=0.167$ ). This suggests that the housing environment without driveway in early infancy increases allergic reaction with higher IgE production and food allergy sensitization.

### **3.4. Multivariate Analyses of the Association of Demographic Characteristics in the Housing with and without Driveway**

We included the demographic data including gender, tobacco smoke exposure, parental allergic history, parental allergic sensitization, and parent atopic diseases for the multivariate analysis of its association of the housing with and without driveway. We found there were no significant differences of infant gender and tobacco smoke exposure between the housing with and without driveway. Interestingly, we found that maternal atopic features such as elevation of total IgE  $>150$ KU/L and allergic sensitization were significantly associated with the housing without driveway ( $P<0.05$ ). In contrast, paternal atopic features such as elevation of total IgE  $\geq 150$ KU/L or allergic sensitization were not significantly associated with the housing with and without driveway ( $P>0.05$ ). The fact that both infants and mothers but not fathers living in the housing without driveway are associated with allergic sensitization and higher IgE production suggests that people stay longer in the housing without driveway are prone to allergic sensitization.

## **4. Discussion**

It is previously known that proximity to major roadways is associated with an increased risk of wheeze illness, asthma and atopy. In this study, we however demonstrated that living in the housing condition without driveway is significantly associated with the development of allergic symptoms and sensitization in early childhood at 6 months and 18 months of age. Further analysis revealed that both mothers and children living in housing without driveway had a significantly higher total IgE level and allergic sensitization. This implies that housing conditions with different indoor and outdoor environments have an impact on the development of allergic sensitization and IgE production, particularly mothers and infants who stay longer time at home.

Hesselmar *et al* demonstrated that children living in houses with a basement and natural ventilation (without mechanical) had more frequent wheezing symptoms, and children living in apartment building were less often infested with house dust mite when compared to non-ventilated houses [13]. Dampness and ventilation system might have much impact on the aeroallergen concentration, fungal, and bacterial growth, and contributing to the development of the allergic reaction and/or bronchial hyperactivity of occupants. Different countries have different housing patterns. In developing countries, old houses are replaced by apartments quickly and old low-level buildings are surrounded by tall buildings. In our study, the housing without driveway might have less motor pollution but its stuffy environment may have poor ventilation and increase the exposure to more allergens and germs. This might have contributed to the higher allergic sensitization and symptoms in early infancy.

It is possible that a housing without driveway is much more enclosed and stuffy environment, possibly contributing to low home ventilation and recycling of indoor pollution and allergens exposure, which are known to increase the risk to the development of allergic symptoms and sensitization [14,15]. Another possibility is that housing without driveway may have different building materials that could cause different chemical emissions from building materials, and promote allergic sensitization.

In summary, infants and mothers living in no driveway house had a significantly higher risk to higher IgE production and allergic sensitization. The limitation of the study is the study was done in a birth cohort of infants in southern Taiwan. We acknowledge that caution must be considered in generalizing these results to other populations since different countries have different culture on housing environment and constructing materials. Further studies on other birth cohort studies are needed.

## 5. Acknowledgements

The authors thank the staff of the delivery room and outpatient clinics of Kaohsiung Chang Gung Memorial Hospital for their collection of blood samples. This study was supported by funding from grants NSC98-3112-B-182-004 and 99-3112-B-182-004 from the National Science Council, and grants CZRPG880253 from Chang Gung Memorial Hospital, Taiwan. All authors have declared that they have no conflicts of interest.

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Table 1: No driveway housing associated with infant atopy

Diseases	No driveway	2-lane driveway	4-lane driveway	P value
6m eczema	21/98 (21.4%)	64/695 (9.2%)	17/180 (9.4%)	0.001
6m sneezing	42/98 (42.9%)	212/695 (30.5%)	57/180 (31.7%)	0.049
6m bronchiolitis	13/98 (13.3%)	52/695 (7.5%)	12/18 (6.7%)	0.110
18m eczema	33/105 (31.4%)	176/819 (21.5%)	57/209 (27.3%)	0.028
18m sneezing	36/105 (34.3%)	141/819 (17.2%)	37/209 (17.7%)	<0.001
18m bronchiolitis	19/105 (18.1%)	36/819 (4.4%)	9/209 (4.3%)	<0.001
3y atopic dermatitis	13/88 (14.8%)	73/666 (11%)	22/177 (12.4%)	0.536
3y allergic rhinitis	6/88 (6.8%)	86/666 (12.9%)	21/177 (11.9%)	0.256
3y asthma	4/88 (4.5%)	30/666 (4.5%)	14/177 (7.9%)	0.184

Notes: Abbreviations used are: 6m, 6-month old; 18m, 18-month old; 3y, 3-year old. P values are determined by Chi-square test.

Table 2: No driveway housing associated with early infant allergic sensitization

Diseases	No driveway	2-lane driveway	4-lane driveway	P value
18m aeroallergen	14/70 (20%)	51/512 (10%)	15/136 (11%)	0.043
18m food allergen	39/70 (55.7%)	185/512 (36.1%)	57/136 (41.9%)	0.005
3y aeroallergen	21/61 (34.4%)	148/480 (30.8%)	33/117 (28.2%)	0.689
3y food allergen	32/61 (52.5%)	199/480 (41.5%)	51/117 (43.6%)	0.259

Notes: Aeroallergen sensitization is defined by detectable specific IgE to house dust mite and/or German cockroach; food allergen sensitization is defined by detectable specific IgE to egg white, cow's milk, peanut, and/or shrimp. P values are determined by Chi-square test.