Home Renovation, Family History of Atopy, and Respiratory Symptoms and Asthma Among Children Living in China

Guang-Hui Dong, MD, PhD, Zhengmin (Min) Qian, MD, PhD, Jing Wang, PhD, Edwin Trevathan, MD, MPH, Miao-Miao Liu, MD, Da Wang, MD, Wan-Hui Ren, PhD, Weiqing Chen, PhD, Maayan Simckes, MPH, and Alan Zelicoff, MD

Objectives. To investigate the association of indoor air pollution with the respiratory health of children, we evaluated the associations of children's respiratory symptoms with asthma and recent home renovation.

Methods. We conducted a cross-sectional survey in a school recruitment sample of 31 049 children aged 2 to 14 years in 25 districts of 7 cities of northeast China in 2008–2009. The children's parents completed standardized questionnaires characterizing the children's histories of respiratory symptoms and illness, recent home renovation information, and other associated risk factors.

Results. The effects of home renovation in the past 2 years were significantly associated with cough, phlegm, current wheeze, doctor-diagnosed asthma, and current asthma. The associations we computed when combining the status of home renovation and family history of atopy were higher than were those predicted from the combination of the separate effects. However, the interactions between home renovation and family history of atopy on a multiplicative scale were not statistically significant ($P > .05$).

Conclusions. Home renovation is associated with increases in the prevalence of respiratory symptoms and asthma in children. The effects of different renovation materials on child respiratory health should be studied further. (*Am J Public Health.* 2014;104:1920–1927. doi:10.2105/AJPH.2013.301438)

Over the past decade, because of its rapid economic development and urbanization, China has been experiencing more construction and home renovation. Substantial evidence has shown that the components or constituents of the materials used for interior finish materials, furnishings, and consumer products and accessories, such as phthalates, organic and inorganic particles, and other chemicals, result in higher concentrations of formaldehyde, volatile organic compounds (VOCs), and various chemical pollutants in indoor air.[1–4] Perhaps even more important over time, the pattern and chemical composition of emissions from those materials during their use change as a function of temperature, humidity, and human time–activity patterns in homes or microenvironments; this includes particles resuspension. Furthermore, a recent study has shown that despite the presence of new ventilation systems in renovated homes, there has been no significant decrease in the organic compound levels of indoor air, and many pollutant concentrations are still high 3 years after renovation.[3]

Jaakkola et al. assessed the effects of indoor materials on respiratory health and reported an increased risk of developing respiratory symptoms and illness among adults when exposed to recent home renovation materials.[5] There have been intensive studies on indoor concentrations of various volatile organic compounds (VOCs) in homes.[6–16] For example, Ho et al. studied the VOCs emission characteristics of 5 types of common furniture products including dining room table, sofa, desk chair, bedside table, and cabinet.[6] Their results indicated a large distinction in the emission characteristics of VOCs between different furniture products in terms of relative dominance between different chemicals, including aromatic, terpenes, carbonyl, other paraffins, olefin, and halogenated paraffin. Cox et al. validated a model for predicting the rate at which a VOC is emitted from a diffusion-controlled material for 3 contaminants (*n*-pentadecane, *n*-tetradecane, and phenol) found in vinyl flooring.[7] Wilke et al. measured emissions of VOCs and semivolatile organic compounds from flooring materials and adhesives and showed that the determination of semivolatile organic compound emissions from materials is important because after a few weeks their emission rates might be higher than are those of VOCs.[14] However, there is little information about how home renovation or indoor emissions affect respiratory health in children. To our knowledge, there are no reports on the potential effects of recent home renovation on children's respiratory health in Asian countries, including China, where the indoor environment differs from those in Europe and the United States.

In urban areas of China, most people live in concrete apartment buildings in small apartments and use coal gas for cooking, and in the past decade, the majority of the population has moved to new homes in which materials were used for interior design to improve the quality of the buildings. Additionally, when young people get married in China they usually buy or rent an apartment where renovation is usually done before they move in. The couples often have a baby within 2 years of moving in. Children live with their parents in an apartment even during renovations. These home renovation and remodeling activities potentially, on the basis of time–location–activity patterns, put children at a great risk of exposure to dangerous chemicals and toxic substances.

Our hypothesis—that a family history of atopy modifies the effect of home renovation on the prevalence of respiratory symptoms and asthma—has been supported by other studies that have assessed the relationship between the presence of renovation in the home and respiratory health in children, although in these studies the time of the materials' installation was not reported. In a population-based cross-sectional study of 2568 Finnish children (aged 1–7 years), the prevalence of persistent wheezing, cough, phlegm, weekly nasal congestion or excretion, and respiratory infection was related to the presence of plastic wall materials.[17] A matched pair case–control study derived from a cohort of 3754 newborns in Norway who were followed for 2 years showed that the risk of bronchial obstruction was related to the presence of polyvinyl chloride (PVC)-flooring (adjusted prevalence odds ratio [POR] = 1.89; 95% CI = 1.14, 3.14) and textile wall materials (POR = 1.58; 95% CI = 0.98, 2.54).[18]

Further analyses have suggested that in homes with low air change the relationship between bronchial obstruction and exposure to a plasticizer was stronger than that in homes with high air change.[19] Also, a cohort study examined the associations between the presence of PVC flooring in the homes of 4779 children (aged 1–3 years) and the incidence of asthma rhinitis and eczema during the following 5-year period. The investigators found that the incidence of asthma among children was associated with PVC flooring in the children's homes, and there was also a positive relationship between the number of rooms with PVC flooring and the cumulative incidence of asthma.[20] However, in contrast to the results found among children, a recent study among adults assessed the relationships between asthma and different types of interior surface materials at home and at work. There was no statistically significant association between the risk of asthma and the presence of unspecified (or uncategorized) surface materials at home ($P > .05$), but the risk of asthma was significantly related to the presence of plastic wall materials (adjusted POR = 2.43; 95% CI = 1.03, 5.75) and wall-to-wall carpet at work.[5]

We performed a cross-sectional study to assess the association of home renovation in the previous 2 years (2006–2007) with the prevalence of respiratory symptoms and asthma among children aged 2 to 12 years. In addition, we evaluated the potential joint effects of home renovation and family history of atopy and tested the hypothesis that a family history of atopy modifies the effect of home renovation on the prevalence of respiratory symptoms and asthma.

METHODS

Our study is part of the Seven Northeastern Cities study, and the design of this cross-sectional study and the participants contributing to the current analysis were described previously.[17] Briefly, 31 049 children (aged 2–12 years) in the Seven Northeastern Cities study, a population-based evaluation of outdoor and indoor air pollution and respiratory health, were recruited from 50 kindergartens and 25 elementary schools in 25 districts of 7 cities in northeast China during 2008–2009. We employed a validated questionnaire from the American Thoracic Society Epidemiologic Standardization Project that was designed to gather information about a child's personal characteristics, health information, and socioeconomic factors.[18–20] The questionnaire, translated into Chinese, has been used in previous studies in other Chinese cities.[21,22] After signing an informed consent form, parents completed the questionnaire at home and returned it (via their child) to the teacher in an envelope.

We focused on doctor-diagnosed asthma, current asthma, current wheeze, cough, and phlegm and defined these as follows:

- Doctor-diagnosed asthma: the child had been diagnosed with asthma by a physician.
- Current asthma: the child had been diagnosed with asthma by a physician plus had asthma attacks in the past year.
- Current wheeze: the child (1) had a wheezy or whistling sound from the chest, either with or without a cold; and (2) experienced 2 or more such episodes in the past year.
- Cough: the child had experienced a cough on most days (≥ 4 days per week) during at least 3 months of the past year, either with or without a cold.
- Phlegm: the child had mucus produced by the chest and particularly that which is expelled by coughing (sputum) on most days (≥ 4 days per week) during at least 3 months of the past year, either with or without a cold.

We defined having a family history of allergies as there being 1 or more biological parent or grandparent who had been diagnosed with hay fever or allergies (including allergic dermatitis, allergic conjunctivitis, and eczema). We defined having a family history of asthma as there being 1 or more biological parent or grandparent who had been diagnosed with asthma or bronchial asthma. If participants answered yes to a family history of allergies or a family history of asthma, then we considered them as having an allergic predisposition. We determined secondhand smoke exposure from a yes answer to the question "Does anyone living in the same house with the child smoke cigarettes daily in this child's home?"

We determined home renovation assessment from the following question: "Have you made any of the following renovations in your home within the past 2 years?" The list of options provided with this question included but was not limited to installation of PVC flooring, hardwood flooring, wallpaper, paints or plastic wall materials, new furniture, new synthetic carpet, the application of oil-based paints, and others (including an aluminum-framed sliding glass window or door, aluminum or iron grills, a change of roof tiles, or plumbing or electrical works). We chose these types of renovations for 2 reasons. First, they were recommended in the literature as the most common home renovation activities. Second, we found each type of home renovation significant in our univariate analysis.

We reported continuous variables (e.g., age) as the mean ±SD and categorical variables (e.g., gender) as the percentage in each subgroup. To examine differences between continuous variables, we performed the *t* test. We used contingency tables and the χ^2 test to test the associations between categorical variables. We calculated adjusted POR with 95% CI for each of the 5 outcome measures (doctor-diagnosed asthma, current asthma, current wheeze, cough, and phlegm) using unconditional logistic regression (Proc Logistic in SAS version 9.2; SAS Institute, Cary, NC). We included the following covariates in the models: age; gender; parental education; whether the child was breastfed; whether the child had low birth weight; whether the child was obese; a family history of atopy; a family history of asthma; area per person of urban Chinese homes; whether the house was close to a main road, a factory, a chimney, an industrial plant smokestack, or a heating plant that burns coal to produce steam or for residential heating; use of domestic cooking and heating fuels; whether there was a ventilation device in the kitchen, air exchange in winter, or humidifier use; whether pets lived in the home; whether there was home mold, home pests, or passive smoking exposure; and study districts. We chose these covariates on the basis of recommendations according to different literature resources and the preliminary univariate analysis we had conducted, which suggested the significance of the test for each covariate. We also conducted a series of sensitivity analyses and found that the results we have reported were stable.

There were significant differences in characteristics between children without home renovation and children with home renovation (data available as a supplement to the online version of this article at http://www.ajph.org). For example, the number of rooms in the house and parental education were the strongest indicators of the socioeconomic status of the family. As a result, we included these covariates in the subsequent multivariate analysis to control for their confounding effect on the relationship between home renovation and outcome.

We also studied the independent and joint effects of family atopic disease history and home renovation by comparing the prevalence of respiratory symptoms and asthma in 4 groups: (1) neither having a family history of atopic conditions nor having home renovation in the past 2 years (reference category), (2) not having a family history of atopic conditions but having home renovation in the past 2 years, (3) having a family history of atopic conditions and not having home renovation in the past 2 years, and (4) having both a family history of atopic conditions and home renovation in the past 2 years. Although we could not address the temporal relationship between the atopic status and home renovation in this cross-sectional study, we hypothesized that family history of atopy status might be driving the renovation.

We calculated the PORs, comparing each of the 3 nonreference categories with the reference category. After adjusting for covariates, we estimated the independent and joint effects of family history of atopy and home renovation using the same logistic regression model. All statistical tests were 2-tailed, and we measured statistical significance using a *P* value of .05.

RESULTS

Of the 35 527 eligible participants, 31 049 returned the medical questionnaire, an overall participation rate of 87.4%, and home renovation in the past 2 years was present in 34.0% of the children. (Characteristics of the study population stratified by home renovation are available as a supplement to the online version of this article at http://www.ajph.org.) Compared with children living in an apartment without renovation in the past 2 years, children living in a renovated apartment had a higher prevalence of low birth weight, family history of atopy, allergic predisposition, high parental education levels, ventilation devices in the kitchen, humidifier use, pets at home, and secondhand smoke exposure; they had lower percentages of homes being located close to a factory or industrial chimney, home coal use, and home pests in the past 12 months.

The prevalence of doctor-diagnosed asthma, current asthma, current wheeze, cough, and phlegm among children were 6.6%, 2.3%, 6.3%, 9.6%, and 4.6%, respectively. As shown in Table 1, the prevalence of respiratory morbidities was significantly higher among children with home renovation. When stratified by the type of home renovation, analysis of results showed that the prevalence of doctor-diagnosed asthma was the highest in children living in homes that had new PVC flooring (11.1%) and another renovation (11.8%). Also, the highest prevalence of current asthma was seen in the children living in homes that had new synthetic carpet (5.2%).

We performed logistic regression analyses to evaluate the associations between home renovation and respiratory outcomes (Table 2). After adjusting for a set of other covariates, we found home renovation to be positively associated with doctor-diagnosed asthma (POR = 1.35; 95% CI = 1.22, 1.49), current asthma (POR = 1.32; 95% CI = 1.13, 1.55), current wheeze (POR = 1.26; 95% CI = 1.14, 1.39), cough (POR = 1.36; 95% CI = 1.25, 1.47), and phlegm (POR = 1.62; 95% CI = 1.45, 1.82). When analyzed by the type of renovation materials, there were also statistically significant associations between different renovation materials and respiratory outcomes, notably for new PVC flooring with doctor-diagnosed asthma (POR = 1.87; 95% CI = 1.35, 2.59) and with phlegm (POR = 2.02; 95% CI = 1.38, 2.95), new synthetic carpet with doctor-diagnosed asthma (POR = 1.76; 95% CI = 1.28, 2.41) and with current asthma (POR = 2.56; 95% CI = 1.64, 3.99), where each POR compared children living in houses that had a type of renovation material with children living in houses that had not had any home renovation activities. Similar findings are also shown in Table 3, where each POR compared children living in houses that had a particular type of renovation material with children living in houses that did not have that particular type of renovation material.

We also examined how home renovation was modified by having a family history of atopic conditions (Table 4). We observed the largest effects among children with both home renovation and a family history of atopy. For example, compared with participants of the reference category, participants that had no family history of atopy and home renovation had a significantly increased prevalence of doctor-diagnosed asthma, with an adjusted POR of 1.38 (95% CI = 1.23, 1.55). The effect of having a family history of atopy was significant among participants who had no home renovation, with an adjusted POR of 2.73 (95% CI = 2.40, 3.12). However, given both home renovation and family history of atopy, the adjusted POR for diagnosed asthma reached 3.52 (95% CI = 3.00, 4.11). We observed a similar pattern in current asthma, current wheeze, cough, and phlegm. However, the interactions in a multiplicative scale were not statistically significant at $P < .05$.

DISCUSSION

Consistent with our hypothesis, the prevalence of respiratory symptoms and asthma among Chinese children living in an urban environment was associated with home renovation in the previous 2 years. Although the effects from home renovation and family history of atopy seemed stronger than did those predicted from the combination of the separate effects on respiratory symptoms and asthma among children, the interactions in a multiplicative scale were not statistically significant ($P > .05$).

The sample size in this community-based study is large. The proportion of participants with the outcomes of interest in a community-based sample is low. Without a sufficiently large sample size, there would not be enough power to estimate the true associations. The

TABLE 1—Prevalence of Respiratory Symptoms and Asthma by Home Renovation: 7 Northeastern Cities Study, 25 Districts in Northeast China, 2008–2009

Home Renovation	No.	Cough, No. (%)	Phlegm, No. (%)	Doctor-Diagnosed Asthma, No. (%)	Current Asthma, No. (%)	Current Wheeze, No. (%)
Home renovation in recent 2 y						
No	20 484	1784 (8.7)	800 (3.9)	1207 (5.9)	404 (2.0)	1180 (5.8)
Yes	10 565	1193[b] (11.3)	621[b] (5.9)	828[b] (7.8)	294[b] (2.8)	785[b] (7.4)
Type of renovation[a]						
Oil-based paint						
No	29 051	2723 (9.4)	1310 (4.5)	1847 (6.4)	629 (2.2)	1811 (6.2)
Yes	1998	254[b] (12.7)	111[b] (5.6)	188[b] (9.4)	69[b] (3.5)	154[b] (7.7)
New PVC flooring						
No	30 643	2930 (9.6)	1390 (4.5)	1990 (6.5)	686 (2.2)	1933 (6.3)
Yes	406	47 (11.6)	31[b] (7.6)	45[b] (11.1)	12 (3.0)	32 (7.9)
New particleboard						
No	26 450	2417 (9.1)	1127 (4.3)	1681 (6.4)	566 (2.1)	1659 (6.3)
Yes	4599	560[b] (12.2)	294[b] (6.4)	354[b] (7.7)	132[b] (2.9)	306 (6.7)
New synthetic carpet						
No	30 588	2914 (9.5)	1393 (4.6)	1987 (6.5)	674 (2.2)	1924 (6.3)
Yes	461	63[b] (13.7)	28[b] (6.1)	48[b] (10.4)	24[b] (5.2)	41[b] (8.9)
New wall covering						
No	27 890	2610 (9.4)	1250 (4.5)	1778 (6.4)	606 (2.2)	1734 (6.2)
Yes	3159	367[b] (11.6)	171[b] (5.4)	257[b] (8.1)	92[b] (2.9)	231[b] (7.3)
New wooden furniture						
No	28 500	2665 (9.4)	1273 (4.5)	1821 (6.4)	617 (2.2)	1784 (6.3)
Yes	2549	312[b] (12.2)	148[b] (5.8)	214[b] (8.4)	81[b] (3.2)	181 (7.1)
Other renovation						
No	30 761	2929 (9.5)	1389 (4.5)	2001 (6.5)	690 (2.2)	1941 (6.3)
Yes	288	48[b] (16.7)	32[b] (11.1)	34[b] (11.8)	8 (2.8)	24 (8.3)

[a]Compared with the group that had no home renovation activities in recent 2 y.
[b]We tested the association between categorical variables with the χ^2 test (yes vs no; $P < .05$).

large sample size allows us to conduct stratified analysis, ensures that the logistic regression model with a comprehensive list of confounding variables is identified, and improves the precision of the parameter estimates, which is evident from narrow 95% CIs. In addition, because environmental hazards are common in China, even a small effect size could affect a large number of people in a community. The public health implication from a large sample cannot be underestimated. For example, we found that the odds of having current wheeze increased 21% for new furniture and 25% for new wall covering. The implication of those associations may be limited in practice. However, in our study, the majority of statistically significant PORs, as shown in Tables 2 and 4, represent at least a 50% increase in the outcome.

It is difficult to compare these results with other studies because little literature exists regarding the effect of recent home renovation on respiratory symptoms and illness among children. We have identified only 2 previous human studies examining the effect of home renovation on respiratory responsiveness. One was a cross-sectional study of 5951 Russian children (aged 8–12 years) in 9 Russian cities. In that study, home renovation was defined as an affirmative answer when asked whether they had made any renovations in their homes within the past 12 months. The results showed that the installation of new linoleum flooring, synthetic carpet, wall coverings, and hardwood flooring as well as recent painting and the presence of new furniture were determinants of 1 or more examined health outcome: current asthma, wheezing, and allergy.[23]

The second was a population-based case–control study to assess the relations between different types of interior surface material and recent renovation in homes during the previous 12 months and the risk of asthma onset in 1453 adults (aged 21–63 years) in Finland.[5] The results suggested home renovation during the preceding 12 months was not related to an overall increased risk of asthma, but when compared with no renovation, floor leveling with plaster was found to significantly increase the risk of asthma, with an adjusted POR of 1.81 (95% CI = 1.06, 3.08). Compared with results from Russia[23] and Finland,[5] we observed significant associations between home renovation in the previous 2 years and 5 studied respiratory health outcomes among children.

TABLE 2—Association of Children's Respiratory Symptoms and Diseases With Home Renovation: 7 Northeastern Cities Study, 25 Districts in Northeast China, 2008–2009

Home Renovation	Cough, POR (95% CI)	Phlegm, POR (95% CI)	Doctor-Diagnosed Asthma, POR (95% CI)	Current Asthma, POR (95% CI)	Current Wheeze, POR (95% CI)
Home renovation in recent 2 y					
No (Ref)	1.00	1.00	1.00	1.00	1.00
Yes	1.36 (1.25, 1.47)	1.62 (1.45, 1.82)	1.35 (1.22, 1.49)	1.32 (1.13, 1.55)	1.26 (1.14, 1.39)
Type of renovation[a]					
Oil painting	1.62 (1.40, 1.89)	1.68 (1.35, 2.10)	1.66 (1.39, 1.97)	1.60 (1.21, 2.12)	1.28 (1.06, 1.55)
New PVC flooring	1.35 (1.00, 1.85)	2.02 (1.38, 2.95)	1.87 (1.35, 2.59)	1.40 (0.77, 2.54)	1.38 (0.95, 2.01)
New hardwood floor	1.57 (1.41, 1.76)	1.93 (1.65, 2.25)	1.35 (1.18, 1.54)	1.36 (1.09, 1.69)	1.14 (1.00, 1.32)
New synthetic carpet	1.72 (1.30, 2.28)	1.69 (1.13, 2.52)	1.76 (1.28, 2.41)	2.56 (1.64, 3.99)	1.55 (1.10, 2.18)
New wall covering	1.47 (1.29, 1.67)	1.59 (1.32, 1.91)	1.42 (1.22, 1.65)	1.34 (1.05, 1.72)	1.25 (1.06, 1.46)
New wooden furniture	1.58 (1.37, 1.81)	1.78 (1.46, 2.18)	1.51 (1.28, 1.79)	1.52 (1.16, 1.98)	1.21 (1.01, 1.44)
Others[b]	2.10 (1.52, 2.90)	3.01 (2.04, 4.44)	1.91 (1.31, 2.79)	1.26 (0.61, 2.59)	1.47 (0.95, 2.28)

Note. CI = confidence interval; POR = prevalence odds ratio; PVC = polyvinyl chloride. The sample size was n = 31 049. We estimated PORs with 95% CIs by logistic regression adjusting for age, gender, parental education, breast feeding, low birth weight, child's obesity, family history of atopy, family history of asthma, area per person, house close to main road, house close to a factory, house close to a smokestack, use of domestic cooking and heating fuels, ventilation device in kitchen, air exchange in winter, humidifier use, keeping pets in the home, home mold, home pests, passive smoking exposure, and study districts.

[a]Each POR compared children living in houses that had a particular type of renovation material with children living in houses that did not have any home renovation activities in recent 2 y.

[b]Other types of renovation include aluminum sliding glass window frames or doorframes, aluminum and iron grills, change of roof tiles, plumbing, and electrical works.

The differences between children and adults suggest children are particularly vulnerable to respiratory conditions because of their developmental stage and physical differences from adults.[24–25] Children's lungs and airways are immature and especially susceptible to effects from pollution. The developing lungs present a large surface area through which pollutants may be easily absorbed. Children breathe faster and therefore inhale and absorb a relatively greater volume of contaminants than do adults. Another possible reason for the difference is that, in general, children spend more time at home than do adults, which could result in higher exposure levels in children. Our results, along with those from the previous studies, allow us to suggest that relatively recent installation of home renovation materials is associated with an increased prevalence of respiratory symptoms and asthma, especially in children.[26–27]

The underlying mechanism increasing the effects of home renovation on respiratory health is unclear. However, some explanations have been hypothesized. Substantial evidence suggests that many renovation materials, including paints, furniture varnish, synthetic carpets, wallpaper, and PVCs can emit multiple chemical substances.[1–3] Some of these chemicals have been shown to have adjuvant effects on Th2 differentiation and Th2 cytokine production and have also been shown to provoke the enhancement of mast cell degranulation and eosinophilic infiltration, which influence airway inflammation early on and, therefore, could have an effect on some of the fundamental mechanisms that trigger respiratory symptoms and illness.[28–31] For example, PVC typically contains 30% to 40% di(2-ethylhexyl) phthalate (DEHP) by weight and has been identified as one of the important sources for phthalates (DEHP and BBzP) in indoor dust.[32,33] Oie et al. hypothesized that DEHP causes inflammation of the airways because its chemical structure is similar to some prostaglandins and thrombohexanes.[34] Using a subcutaneous injection model with BALB/c mice, Larsen et al. assessed the effects of DEHP, monoethylhexyl phthalate, and other phthalate monoesters.[35,36] The authors observed that monoethylhexyl phthalate, the primary metabolite of DEHP, produced a notable increase in both IgE and IgG1 levels. Some studies have reported that some monophthalates play important roles in inflammatory processes by promoting the production of interleukin-6 and -8[37] and tumor necrosis factor-α.[38] Kimber and Dearman performed a systematic review to synthesize the evidence of the ability of phthalates to influence immune and allergic response and found no consistent pattern.[39] Thus, the unclear mechanism about the renovation on asthma and asthma-related symptoms still warrants further study.

Individual responses to home renovation in childhood are also likely to be influenced by genetic susceptibility. After stratification by family history of atopy, we found that compared with no home renovation or family history of atopy, any of the renovation materials specified in our study was also associated with an increased prevalence of respiratory symptoms and asthma. The effects of having a family history of atopy were higher than were those of home renovation, strongly suggesting that genetic background is an important determinant of respiratory symptoms and asthma in children. Although we could not find a statistically significant interaction in a multiplicative scale between family history of atopy and home renovation on the respiratory symptoms and asthma in these Chinese children, the results showed that the joint effect of hereditary propensity to atopy and home renovation on respiratory symptoms and asthma was still stronger than expected on the basis of their independent effects (Table 4).

TABLE 3—Association of Respiratory Symptoms and Diseases With Home Renovation: 7 Northeastern Cities Study, 25 Districts in Northeast China, 2008–2009

Home Renovation	Cough, POR (95% CI)	Phlegm, POR (95% CI)	Doctor-Diagnosed Asthma, POR (95% CI)	Current Asthma, POR (95% CI)	Current Wheeze, POR (95% CI)
Home renovation in recent 2 y					
No (Ref)	1.00	1.00	1.00	1.00	1.00
Yes	1.36 (1.25, 1.47)	1.62 (1.45, 1.82)	1.35 (1.22, 1.49)	1.32 (1.13, 1.55)	1.26 (1.14, 1.39)
Type of renovation[a]					
Oil painting					
No (Ref)	1.00	1.00	1.00	1.00	1.00
Yes	1.47 (1.24, 1.66)	1.28 (1.04, 1.58)	1.50 (1.27, 1.78)	1.42 (1.09, 1.86)	1.18 (0.99, 1.42)
New PVC flooring					
No (Ref)	1.00	1.00	1.00	1.00	1.00
Yes	1.20 (0.88, 1.63)	1.61 (1.11, 2.35)	1.67 (1.21, 2.30)	1.24 (0.69, 2.24)	1.27 (0.87, 1.84)
New hardwood floor					
No (Ref)	1.00	1.00	1.00	1.00	1.00
Yes	1.47 (1.32, 1.63)	1.69 (1.46, 1.95)	1.25 (1.10, 1.42)	1.27 (1.03, 1.56)	1.05 (0.92, 1.20)
New synthetic carpet					
No (Ref)	1.00	1.00	1.00	1.00	1.00
Yes	1.48 (1.13, 1.95)	1.28 (0.86, 1.90)	1.55 (1.13, 2.12)	2.24 (1.45, 3.45)	1.41 (1.01, 1.98)
New wall covering					
No (Ref)	1.00	1.00	1.00	1.00	1.00
Yes	1.32 (1.16, 1.49)	1.27 (1.07, 1.51)	1.29 (1.12, 1.49)	1.22 (0.97, 1.55)	1.16 (0.99, 1.35)
New furniture					
No (Ref)	1.00	1.00	1.00	1.00	1.00
Yes	1.42 (1.24, 1.62)	1.40 (1.16, 1.69)	1.37 (1.17, 1.60)	1.38 (1.07, 1.77)	1.12 (0.94, 1.33)
Others[b]					
No (Ref)	1.00	1.00	1.00	1.00	1.00
Yes	1.83 (1.33, 2.52)	2.38 (1.62, 3.49)	1.69 (1.16, 2.45)	1.08 (0.52, 2.21)	1.33 (0.86, 2.04)

Note. CI = confidence interval; POR = prevalence odds ratio; PVC = polyvinyl chloride. The sample size was n = 31 049. We estimated PORs with 95% CIs by logistic regression, adjusting for age, gender, parental education, breast feeding, low birth weight, child's obesity, family history of atopy, family history of asthma, area per person, house close to main road, house close to a factory, house close to a smokestack, use of domestic cooking and heating fuels, ventilation device in kitchen, air exchange in winter, humidifier use, keeping pets in the home, home mold, home pests, passive smoking exposure, and study districts.

[a]Each POR compared children living in houses that had a particular type of renovation material with children living in houses that did not have that particular type of renovation material in recent 2 y.

[b]Other types of renovation include aluminum sliding glass window frames or doorframes, aluminum and iron grills, change of roof tiles, plumbing, and electrical works.

Limitations

Our study design does have some limitations. Like any cross-sectional study, we cannot address temporality between exposure and outcomes because of the nature of the study design. A cohort study with strengths of identifying the temporality is needed to confirm the results we observed. For example, because of the lack of a record of the date of asthma diagnosis, the potential bias is strongest for this exposure–outcome relationship. Reporting the odds ratio between doctor-diagnosed asthma and renovation suggests the relationship is causal, which cannot be determined from this study design.

In addition, we measured all outcomes using only questionnaire responses. However, it is a common procedure to gather self-report information on recent symptom history and physician diagnosis of asthma in large epidemiological studies: self-reported measures are practical and cost-efficient, and their repeatability tends to be good.[33,34] Furthermore, a family history of atopy is also likely to be related to both a risk of asthma and home renovation, so we adjusted for family history of atopy and elaborated the joint and independent effects of a family history of atopy and home renovation.

Our study was blinded, and the participants were prevented from knowing the potential effects of home renovation on respiratory symptoms and illness among children that might lead to conscious or subconscious bias on their part, which would invalidate the results. Approximately 36.0% of participants with a family history of allergic diseases reported having had their home renovated sometime during the previous 2 years, which was a higher rate than that for those without a family history of allergic diseases (33.7%).

Another limitation of the study lies in its lack of assessment of the potential influence of

TABLE 4—Adjusted Prevalence of Respiratory Symptoms and Illness in Relation to the Joint Effect of Family History of Atopy and Home Renovation: 7 Northeastern Cities Study, 25 Districts in Northeast China, 2008–2009

Characteristics	No.	Cough, POR (95% CI)	Phlegm, POR (95% CI)	Doctor-Diagnosed Asthma, POR (95% CI)	Current Asthma, POR (95% CI)	Current Wheeze, POR (95% CI)
No family history of atopy and no home renovation (Ref)	17 595	1.00	1.00	1.00	1.00	1.00
No family history of atopy and home renovation[a]	8951	1.37 (1.25, 1.51)	1.65 (1.45, 1.88)	1.38 (1.23, 1.55)	1.40 (1.15, 1.71)	1.24 (1.10, 1.39)
Family history of atopy and no home renovation[b]	2889	1.81 (1.60, 2.04)	2.04 (1.73, 2.41)	2.73 (2.40, 3.12)	3.74 (3.03, 4.61)	2.74 (2.39, 3.13)
Family history of atopy and home renovation[c]	1614	2.33 (2.01, 2.70)	2.94 (2.42, 3.58)	3.52 (3.00, 4.11)	4.33 (3.39, 5.53)	3.44 (2.93, 4.03)
Family history of atopy and home renovation vs family history of atopy and no home renovation	1614	1.31 (1.10, 1.56)	1.55 (1.22, 1.96)	1.28 (1.06, 1.53)	1.18 (0.90, 1.54)	1.30 (1.08, 1.56)

Note. CI = confidence interval; POR = prevalence odds ratio. The sample size was n = 31 049. POR adjusted for age, gender, parental education, breast feeding, low birth weight, child's obesity, area per person of urban Chinese homes, house close to main road, house close to a factory, house close to a smokestack, use of domestic cooking and heating fuels, ventilation device in kitchen, window use in winter, humidifier use in winter, keeping pets in the home, home mold, home pests, secondhand smoke exposure, and study districts.

[a]Having no family history of atopy but having home renovation in recent 2 y.

[b]Having family history of atopy but having no home renovation in recent 2 y.

[c]POR comparing families with atopy history and home renovation with families with atopy history and no home renovation, which evaluates the effect of home renovation among children with family history of atopy.

multiple renovations in 1 home because we considered 7 home renovations in the study, which would yield too many combinations of renovations (a total of 27 128 combinations) to include in 1 study.

Conclusions

This study provides new evidence that home renovation is associated with an increased prevalence of respiratory symptoms and asthma in children. Although the combined effect of home renovation and a family history of atopy are greater than expected on the basis of their independent effects, the interactions in a multiplicative scale were not statistically significant at $P < .05$.

These findings underline the need to consider the health aspects of renovated materials used on floor, wall, and other surfaces in indoor environments during indoor renovation that may be of special significance in light of the present-day economic growth and coincident housing boom in China as well as in other countries worldwide, particularly after natural disasters. ■

About the Authors

Guang-Hui Dong, Miao-Miao Liu, and Da Wang are with the Department of Biostatistics and Epidemiology, School of Public Health, China Medical University, Shenyang, China. Zhengmin (Min) Qian, Edwin Trevathan, and Maayan Simckes are with the Department of Epidemiology, School of Public Health, St. Louis University, St. Louis, MO. Jing Wang is with the Department of Biostatistics, School of Public Health, St. Louis University. Wan-Hui Ren is with the Department of Ambient Air Pollution Monitoring, Shenyang Environmental Monitoring Center, Shenyang, China. Weiqing Chen is with the Department of Epidemiology, School of Public Health, Sun Yat-sen University, Guangzhou, China. Alan Zelicoff is with the Department of Environmental and Occupational Health, School of Public Health, St. Louis University.

Correspondence should be sent to Zhengmin (Min) Qian, MD, PhD, Associate Professor, Department of Epidemiology, School of Public Health, Saint Louis University, Salus Center/Room 473, 3545 Lafayette Avenue, Saint Louis, MO 63104 (e-mail: zqian2@slu.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

This article was accepted May 6, 2013.

Contributors

G.-H. Dong wrote the article. G.-H. Dong and Z. Qian conceptualized and designed the experiment. G.-H. Dong and J. Wang analyzed the data. G.-H. Dong, J. Wang, M.-M. Liu, D. Wang, and W.-H. Ren contributed to the reagents, materials, and analysis tools. Z. Qian, M.-M. Liu, and D. Wang performed the experiments. Z. Qian, J. Wang, E. Trevathan, W. Chen, M. Simckes, and A. Zelicoff revised the article. M.-M. Liu, D. Wang, and W.-H. Ren contributed to the investigation.

Acknowledgments

The China Environmental Protection Foundation supported this work (grant CEPF2008-123-1-5).

The authors gratefully acknowledge the cooperation of the 7 cities and the school principals, teachers, students, and their parents in Liaoning province.

Note. The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the China Environmental Protection Foundation.

Human Participant Protection

Institutional review board approval was received from the China Medical University Research ethics board.

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