Lifetime prevalence of childhood eczema and the effect of indoor environmental factors: Analysis in Hispanic and non-Hispanic white children

Hyo-Bin Kim, M.D., Ph.D.,1 Hui Zhou, Ph.D.,2 Jeong Hee Kim, M.D., Ph.D.,3 Rima Habre, Ph.D.,2 Theresa M. Bastain, Ph.D.,2 and Frank D. Gilliland, M.D., Ph.D.2

ABSTRACT

Background: The prevalence of eczema varies markedly across the globe. It is unclear whether the geographic variation is due to race and/or ethnic differences, environmental exposures, or genetic factors.

Objective: We investigated the effects of ethnicity and environmental exposures on eczema in Hispanic white and non-Hispanic white children who participated in the Southern California Children’s Health Study.

Methods: We performed a cross-sectional study with sociodemographic predictors and environmental exposures among Hispanic white and non-Hispanic white children ages 4–8 years enrolled in the Children’s Health Study, 2002–2003.

Results: Eczema prevalence differed by ethnicity: Hispanic whites showed lower prevalence (13.8%) compared with non-Hispanic whites (20.2%), and adjustment for sociodemographic factors did not account for the ethnic difference (odds ratio [OR] 0.79 [95% confidence interval {CI}, 0.65–0.95]). Parental history of allergic disease had a larger effect in Hispanic whites than in non-Hispanic whites (p for interaction = 0.005). High maternal education level (OR 1.46 [95% CI, 1.14–1.87]), parental history of allergic disease (OR 2.21 [95% CI, 1.78–2.76]), and maternal smoking during pregnancy (OR 1.44 [95% CI, 1.06–1.95]) increased the risk of eczema. Indoor environmental factors (e.g., mold, water damage, humidifier use) increased the risk of eczema in non-Hispanic whites independent of a parental history of allergic disease, but, in Hispanic whites, increased risks were observed, primarily in children without a parental history of allergic disease.

Conclusion: Hispanic white children in southern California had a lower prevalence of eczema than non-Hispanic whites, and this ethnic difference was not accounted for by sociodemographic differences. The effects of a parental history of allergic disease and indoor environmental exposures on eczema varied by ethnicity, which indicated that the etiology of eczema may differ in Hispanic whites and in non-Hispanic whites.

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Exposure to mold can trigger allergic reactions in subjects who are allergic to mold, and, furthermore, a damp indoor environment and mold exposure may cause respiratory and skin symptoms independent of allergic status. There are many reports of investigations of the effect of indoor exposures in childhood on respiratory allergic diseases, but reports are limited for eczema.

In this study, we described the prevalence of eczema in southern California by using data from the Southern California Children’s Health Study and investigated the factors that underlie variation in prevalence in children of Hispanic white and non-Hispanic white ethnicity focusing on socioeconomic factors and environmental exposures, especially those in the indoor environment, e.g., mold-associated exposure.

METHODS

Study Subjects
Subjects (n = 5765) were recruited from kindergarten or first grade classrooms (5–7 years old) in the Southern California Children’s Health Study, from 2002 to 2003. A parent or guardian provided informed consent and completed a written questionnaire with demographic characteristics, ethnicity, personal and familial history of allergic disease, and environmental information of where they lived at baseline and each subsequent year of follow-up. Details about the study design and methods have been reported previously. Questionnaires were offered in English and Spanish. For the analysis, baseline information about age and sex, and parents who answered the English questionnaire for non-Hispanic white and Hispanic white children were included to perform a cross-sectional study to investigate the differences in response patterns for eczema between the English and Spanish version of the questionnaire (n = 3302) (Fig. 1).

Questionnaire
Personal demographic characteristics included age, sex, ethnicity, and socioeconomic status (parent’s education level, annual household income, current health insurance coverage of the child), and maternal smoking while pregnant with the child. A history of any lifetime eczema was defined by the answer to the question “Has your child ever had eczema?” Parental history of allergic disease was defined when at least one of the parents reported having physician-diagnosed asthma or allergic rhinitis.

Information on exposures and household characteristics was collected by the questionnaire and included age of the house, carpeting, pets inside the house, water damage or flooding, mold or mildew in the house since the child has lived there, use of an air conditioner and/or humidifier, second-hand tobacco smoke, and specific combustion sources for nitrogen dioxide in the home.

Statistical Analysis
Descriptive statistics on demographics and socioeconomic status were examined. Logistic regression was performed to investigate the effect of demographic and of socioeconomic and environmental factors on eczema. In addition, multivariate logistic regression was used to investigate the effect of environmental exposure on eczema prevalence when adjusting for age, sex, maternal education level, and maternal smoking during pregnancy. Variables were included to control for confounding and to assess for heterogeneity of effects based on external information. The interactions between ethnicity and parental history of allergic disease were tested by including the interaction terms in the models. Stratified analysis was performed to test the effects of multifactors among children with or without a family history by...
their ethnicity. Significance was defined as two-sided \( p < 0.05 \), and all analyses were conducted using the Statistical Analysis System (SAS version 9.2; SAS Institute Inc., Cary, NC).

### RESULTS

#### Characteristics of the Study Population

The study included 3302 children with 1616 non-Hispanic white and 1686 Hispanic white ethnicities (Table 1). The mean (standard deviation) age was 6.6 ± 0.7 years. There were no significant differences in age or sex between non-Hispanic whites and Hispanic whites (\( p = 0.40 \) and \( p = 0.49 \), respectively). The proportion of families with health insurance or higher education levels was lower in Hispanic whites compared with non-Hispanic whites. Household income was also lower in Hispanic white than in non-Hispanic white families (\( p < 0.001 \)). A parental history of allergic disease and maternal smoking during pregnancy were less common in Hispanic whites compared with non-Hispanic whites.

#### Socioeconomic Factors and Eczema Prevalence

The overall prevalence of eczema was 16.9%. High maternal education level and maternal smoking during pregnancy were associated with eczema (adjusted odds ratio [aOR] 1.46 [95% confidence interval [CI], 1.14–1.87], and aOR 1.44 [95% CI, 1.06–1.95], respectively) (Table 2). Parental history of allergic disease was also significantly associated with eczema (aOR 2.21 [95% CI, 1.78–2.76]).

We observed that lifetime prevalence of eczema was lower in Hispanic whites (13.8%) than in non-Hispanic whites (20.2%) (OR 0.63 [95% CI, 0.53–0.76]). Age, sex, health insurance, household income, maternal education level, parental history of allergic disease, and maternal smoking during pregnancy did not explain this ethnic difference (aOR 0.79 [95% CI, 0.65–0.95]). In addition, health insurance and household income were not associated with eczema in models that included ethnicity and other factors.

We found that the effect of parental history of allergic disease on eczema was greater in Hispanic white (OR 3.44 [95% CI, 2.45–4.83]) than in non-Hispanic white children (OR 1.83 [95% CI, 1.38–2.43]) (\( p \) for interaction = 0.005). When the subjects were stratified by ethnicity, the only sociodemographic factor that significantly increased the risk of eczema in non-Hispanic whites was parental history of allergic disease (aOR 1.72 [95% CI, 1.29–2.30]). In contrast, a high maternal education level, parental history of allergic disease, and maternal smoking during pregnancy were associated with increased risk in Hispanic whites (aOR 1.50 [95% CI, 1.07–2.12], aOR 2.99 [95% CI, 2.11–4.22], and aOR 1.86 [95% CI, 1.13–3.08], respectively) (Supplemental Table 1).

We considered the overall role of genetic differences that may explain the ethnic variation by investigating the relationship of genetic admixture with eczema among Hispanic whites. We found that variation in genetic contributions of founding populations (Native American and European) was not associated with eczema and did not explain the differences in prevalence in Hispanic whites and non-Hispanic whites (Supplemental Table 2).
The presence of water damage or flooding (aOR 1.36 [95% CI, 1.09–1.71]); mold or mildew on the walls, ceilings, or floors (aOR 1.51 [95% CI, 1.22–1.86]); and ever used a humidifier (aOR 1.44 [95% CI, 1.18–1.75]) increased the risk of eczema after adjusting for age, sex, ethnicity, maternal education level, parental history of allergic disease, and maternal smoking during pregnancy (Table 3). When the subjects were stratified by ethnicity; water damage or flooding (aOR 1.39 [95% CI, 1.04–1.87]); mold or mildew on the walls, ceiling, or floors (aOR 1.41 [95% CI, 1.06–1.88]); and ever used humidifier (aOR 1.47 [95% CI, 1.14–1.90]) significantly increased the risk of eczema in non-Hispanic whites, whereas only mold or mildew on the walls, ceilings, or floors significantly increased the risk in Hispanic whites (aOR 1.68 [95% CI, 1.22–2.30]).
A parental history of allergic disease showed ethnic-specific modulation of environmental associations. In analyses that stratified children by their parental history of allergic disease within each ethnicity group (Table 4), water damage or flooding and mold or mildew on the walls, ceiling, or floors increased the risk of eczema in the subjects with a parental history of allergic disease in non-Hispanic white (aOR 1.49 [95% CI, 1.05–2.10] and aOR 1.43 [95% CI, 1.03–2.00], respectively), whereas the same exposures increased eczema in the subjects without a parental history of allergic disease in Hispanic whites (aOR 2.44 [95% CI, 1.14–5.24] and aOR 3.66 [95% CI, 1.93–6.93], respectively). Humidifier use increased the risk of eczema prevalence regardless of a parental history of allergic disease in non-Hispanic whites (aOR 1.59 [95% CI, 1.18–2.14] and aOR 1.78 [95% CI, 1.06–2.99], respectively) but did not have statistically significant effects in Hispanic whites (aOR 1.91 [95% CI, 0.97–3.77], respectively). The year when the house was constructed, use of air conditioning, musty odor, and carpeting did not show statistically significant associations with a risk of eczema that depended on ethnicity or a history of parental allergic disease.

**DISCUSSION**

In our Southern California Children’s Health Study, the eczema prevalence was 16.9% in 5- to 7-year-old children. Hispanic white children showed a significantly lower prevalence than non-Hispanic white children. The prevalence was higher in children who had a history of parental allergic disease or whose mothers had a high educational attainment, or who smoked during pregnancy. Exposure to indoor mold or humidity during childhood also affected eczema development, and the effects of these exposures differed by ethnicity, depending on the presence of a parental history of allergic disease. Genetic admixture did not explain the ethnic differences in eczema occurrence.

The overall lifetime eczema prevalence of 16.9% in our study was similar to other epidemiologic studies. The German Multicenter Atopy Study found that 17.2–20.5% of 5- to 7-year-old children had eczema. Similarly, other global studies found that 0.9–22.5% of 6- to 7-year-old children had eczema.
7-year-old children had eczema. Also, a study of the general population in the United States reported that the prevalence of empiric eczema was 17.1%. In our study, we found that eczema prevalence was 20.2% in non-Hispanic white children and 13.8% in Hispanic white children. Most previous studies that reported eczema prevalence rarely described the difference among Hispanic whites and non-Hispanic whites in the study population. Ethnicity appeared to be an important factor that should be considered in studies of eczema etiology.

Although the causes of eczema are still poorly understood, genetic predisposition with the incitement of environmental exposures is thought to be a main factor in eczema etiology. Our study demonstrated that maternal education level, parental history of allergic disease, and maternal smoking history during pregnancy increased the risk of childhood eczema. Similarly, two Polish population studies that searched for the risk factors of atopic dermatitis reported that atopic dermatitis was more common in subjects with parental atopy, higher education, and higher economic status. In studies based in Korea, a parental history of allergic disease was the most important risk factor for atopic dermatitis, but the other socioeconomic factors, such as parental education levels, were not. Based on results from these studies, a parental history of allergic disease would be the most important factor for the development of eczema, but some other studies showed an association only with a maternal history of allergic disease and not with a paternal history. The variability of the results may be due to the difference in the ethnicity of the enrolled populations, differences in eczema phenotype, or other factors. Ethnicity and a parental history of allergic disease indicate a genetic influence on the development of eczema; however, differences in genetic admixture do not support a major role for genetics in explaining the ethnic differences on the development of eczema.

Recent studies that searched for the developmental origins of allergic disease focused on early life risk factors. The influence of environmental exposure that occurred during critical developmental periods of the immune systems may increase the likelihood of allergic disease. Prenatal exposures may influence the programming and development of neonatal immune response. Maternal smoking is a frequently cited early life exposure that has been shown to have an effect on the development of atopic disorders. Tobacco smoke exacerbates the T-helper 2 response by increasing production of interleukin 4, interleukin 5, and other proinflammatory cytokines that result in increased allergic responses, whereas it reduces the T-helper 1 response by altering natural killer T-cell function and suppressing interferon-γ production. There are a few studies that do not show an association between maternal smoking during pregnancy and eczema. In our study, maternal smoking during pregnancy increased the risk of eczema more in Hispanic white children, especially those who did not have a parental history of allergic disease. The discrepancies between the results may have occurred because it is difficult to pinpoint the critical window of exposure and because many prenatal exposures, e.g., heavy maternal smoking in pregnancy, tend to coexist with other environmental and socioeconomic factors.

Environmental factors that relate to the hygiene hypothesis are thought to have protective effects on atopic dermatitis. The parental education level may be considered as one of the factors of hygiene hypothesis, such as daycare attendance or the number of siblings. As in previous epidemiologic studies, we found that high maternal education level was associated with eczema, which may reflect, in part, a bias; mothers with a high education level are more informed about the health of their children and visit the hospital then this may increased opportunities for eczema diagnosis.

Exposures in the indoor environment during pregnancy and early life may increase risks of allergic disease. Many studies reported that housing condition, dampness, and mold growth in the house are associated with respiratory symptoms, but studies related to eczema are scarce. The mechanism that mediates damp housing effects on asthma could be its relation to indoor mold, which serves as an allergenic protein or through its relation to house-dust mite. Besides acting as an allergen, dampness and/or mold may also operate through nonallergic mechanisms. Studies compared the effects of dampness between subjects with atopy and subjects without atopy, and observed the association of dampness with respiratory symptoms in subjects without atopy as well as subjects with atopy. Furthermore, an international study reported the association between a damp house condition and/or visible molds and eczema as well as respiratory allergy in both children with atopy and children without atopy. In the present study, we found that water damage or flooding, mold exposure in the house, and humidifier use increased the risk of eczema in the non-Hispanic white children with a parental history of allergic disease, whereas water damage or flooding and mold exposure increased the risk of eczema in Hispanic whites with no parental history of allergic disease. For the development of eczema, dampness or mold exposure may have different mechanisms, depending on the ethnicity and genetic background.

Our results must be interpreted in light of the study design. This study was a cross-sectional study, so it had limitations in establishing a cause-and-effect relationship between indoor exposures and eczema development. Socioeconomic and environmental factors that
occurred in early life exposures may be affected by recall bias, which attenuated the reported effects. Therefore, further prospective observation of eczema and measurement are needed. Another limitation may be our case definition for eczema. We based our questions about eczema on the International Study of Asthma and Allergies in Childhood questionnaire, commonly used worldwide for epidemiologic studies, but we condensed it to make it short and simple for the convenience of the participants. A case definition that uses more detailed questions or with a physical examination by physicians would likely improve the definition of eczema. However, we think it unlikely that the misclassification of eczema is related to exposure status in a manner that would produce a major bias in our results.

CONCLUSION

Eczema prevalence was lower in Hispanic white children compared with non-Hispanic white children. Socio-demographic and genetic admixture did not explain the ethnic differences in prevalence. The effects of indoor environmental exposures on eczema varied by ethnicity as well as parental history of allergic disease. Further studies are needed to determine why eczema varied by ethnicity and to determine whether environmental factors have difference effects in Hispanic white and non-Hispanic white children.

REFERENCES

1. Asher MI, Montefort S, Bjorksten B, et al. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases One and Three repeat multicountry cross-sectional surveys. Lancet 368:733–743, 2006.
2. Williams H, Robertson C, Stewart A, et al. Worldwide variations in the prevalence of symptoms of atopic eczema in the International Study of Asthma and Allergies in Childhood. J Allergy Clin Immunol 103(pt. 1):125–138, 1999.
3. Hanifin JM, Reed ML, and Eczema Prevalence and Impact Working Group. A population-based survey of eczema prevalence in the United States. Dermatitis 18:82–91, 2007.
4. Shaw TE, Currie GP, Koulidka CW, and Simpson EL. Eczema prevalence in the United States: Data from the 2003 National Survey of Children’s Health. J Invest Dermatol 131:67–73, 2011.
5. Laughter D, Istvan JA, Toffe SJ, and Hanifin JM. The prevalence of atopic dermatitis in Oregon schoolchildren. J Am Acad Dermatol 43:649–655, 2000.
6. Wegienka G, Zoratti E, and Johnson CC. The role of the early-life environment in the development of allergic disease. Immunol Allergy Clin North Am 35:1–17, 2015.
7. Miyake Y, Ohya Y, Tanaka K, et al. Home environment and suspected atopic eczema in Japanese infants: The Osaka Maternal and Child Health Study. Pediatr Allergy Immunol 18:425–432, 2007.
8. Mitchell EA, Beasley R, Keil U, et al. The association between tobacco and the risk of asthma, rhinoconjunctivitis and eczema in children and adolescents: Analyses from Phase Three of the ISAAC programme. Thorax 67:941–949, 2012.
9. Thacher JD, Gruzieva O, Pershagen G, et al. Pre- and postnatal exposure to parental smoking and allergic disease through adolescence. Pediatrics 134:428–434, 2014.
10. Aguiler J, Pedersen M, Garcia-Esteban R, et al. Early-life exposure to outdoor air pollution and respiratory health, ear infection, and eczema in infants from the INMA study. Environ Health Perspect 121:387–392, 2013.
11. Mendell MJ, Miret AG, Cheung K, et al. Respiratory and allergic health effects of dampness, mold, and dampness-related agents: A review of the epidemiologic evidence. Environ Health Perspect 119:748–756, 2011.
12. Fisk WJ, Lei-Gomez Q, and Mendell MJ. Meta-analyses of the associations of respiratory health effects with dampness and mold in homes. Indoor Air 17:284–296, 2007.
13. Keall MD, Crane J, Baker MG, et al. A measure for quantifying the impact of housing quality on respiratory health: A cross-sectional study. Environ Health 11:33, 2012.
14. Tischer CG, Hohmann C, Thiering E, et al. Meta-analysis of mould and dampness exposure on asthma and allergy in eight European birth cohorts: An ENRIECO initiative. Allergy 66:1570–1579, 2011.
15. McConnell R, Berhane K, Yao L, et al. Traffic, susceptibility, and childhood asthma. Environ Health Perspect 114:766–772, 2006.
16. Illi S, von Mutius E, Lau S, et al. The natural course of atopic dermatitis from birth to age 7 years and the association with asthma. J Allergy Clin Immunol 113:925–931, 2004.
17. Odhiambo JA, Williams HC, Clayton TO, et al. Global variations in prevalence of eczema symptoms in children from ISAAC Phase Three. J Allergy Clin Immunol 124:1251–1258, 2009.
18. Stelmach I, Bobrowska-Korzeniowska M, Smejda K, et al. Risk factors for the development of atopic dermatitis and early wheeze. Allergy Asthma Proc 35:382–389, 2014.
19. Sybilski AJ, Raciborski F, Lipiec A, et al. Epidemiology of atopic dermatitis in Poland according to the Epidemiology of Allergic Disorders in Poland (ECAP) study. J Dermatol 42:140–147, 2015.
20. Kim YH, Urm SH, Kim WK. Prevalence of allergic diseases and risk factors in preschool children, 2009. Pediatr Allergy Respir Dis (Korea) 21:165–175, 2011.
21. Kim HY, Jung YH, Hong K, et al. Gene-environment interaction between toll-like receptor 4 and mold exposure in the development of atopic dermatitis in preschool children. Allergy Asthma Respir Dis 1:129–137, 2013.
22. Sugiyama M, Arakawa H, Ozawa K, et al. Early-life risk factors for occurrence of atopic dermatitis during the first year. Pediatr Allergol 119:671–673, 2007.
23. Liu CA, Wang CL, Chuang H, et al. Prenatal prediction of infant atopy by maternal but not paternal total IgE levels. J Allergy Clin Immunol 119:899–904, 2008.
24. Peters JL, Boynton-Jarrett R, and Sandel M. Prenatal environmental factors influencing IgE levels, atopy and early asthma. Curr Opin Allergy Clin Immunol 13:187–192, 2013.
25. Wegienka G, Johnson CC, Havstad S, et al. Lifetime dog and cat exposure and dog- and cat-specific sensitization at age 18 years. Clin Exp Allergy 41:979–986, 2011.
26. Martino D, Prescott S. Epigenetics and prenatal influences on asthma and allergic airways disease. Chest 139:640–647, 2011.
27. Peters JL, Suglia SF, Platts-Mills TA, et al. Relationships among prenatal aeroallergen exposure and maternal and cord blood IgE: Project ACCESS. J Allergy Clin Immunol 123:1041–1046, 2009.
28. Burke H, Leonard-Bee J, Hashim A, et al. Prenatal and passive smoke exposure and incidence of asthma and wheeze: systemic review and meta-analysis. Pediatrics 129:735–744, 2012.
29. Robison RG, Kumar R, Arguelles LM, et al. Maternal smoking during pregnancy, prematurity and recurrent wheezing in early childhood. Pediatr Pulmonol 47:666–673, 2012.
30. Singh SP, Mishra NC, Rir-Sima-Ah J, et al. Maternal exposure to secondhand cigarette smoke primes the lung for induction of phosphodiesterase-4D5 isozyme and exacerbated Th2 responses: Rolipram attenuates the airway hyperreactivity and muscarinic receptor expression but not lung inflammation and atopy. J Immunol 183:2115–2121, 2009.
31. Hogan AE, Corrigan MA, O’Reilly V, et al. Cigarette smoke alters the invariant natural killer T cell junction and may inhibit anti-tumor responses. Clin Immunol 140:229–235, 2011.
32. Tanaka K, and Miyake Y. Association between prenatal and postnatal tobacco smoke exposure and allergies in young children. J Asthma 48:458–463, 2011.
33. Henderson AJ, and Warner JO. Fetal origins of asthma. Semin Fetal Neonatal Med 17:82–91, 2012.
34. Erickson AC, and Arbour LT. Heavy smoking during pregnancy as a marker for other risk factors of adverse birth outcomes: A population-based study in British Columbia, Canada. BMC Public Health 12:102, 2012.
35. Harris JM, Cullinan P, Williams HC, et al. Environmental associations with eczema in early life. Br J Dermatol 144:795–802, 2001.
36. Zutavern A, Hirsch T, Leupold W, et al. Atopic dermatitis, extrinsic atopic dermatitis and the hygiene hypothesis: Results from a cross-sectional study. Clin Exp Allergy 35:1301–1308, 2005.
37. Lee YL, Li CW, Sung FC, et al. Environmental factors, parental atopy and atopic eczema in primary-school children: A cross-sectional study in Taiwan. Br J Dermatol 157:1217–1224, 2007.
38. Heinrich J, Popescu MA, Wjst M, et al. Atopy in children and parental social class. Am J Public Health 88:1319–1324, 1998.
39. Benndorf D, Muller A, Bock K, et al. Identification of spore allergens from the indoor mould Aspergillus versicolor. Allergy 63:454–460, 2008.
40. Chou H, Tam MF, Chiang CH, et al. Transaldolases are novel and immunoglobulin E cross-reacting fungal allergens. Clin Exp Allergy 41:739–749, 2011.
41. Norback D, Bjornsson E, Janson C, et al. Current asthma and biochemical signs of inflammation in relation to building dampness in dwellings. Int J Tuberc Lung Dis 3:368–376, 1999.
42. Verhoeoff AP, van Strien RT, van Wijnen JH, and Brunekreef B. Damp housing and childhood respiratory symptoms: The role of sensitization to dust mites and molds. Am J Epidemiol 141:103–110, 1995.
43. Bornehag CG, Sundell J, Bonini S, et al. Dampness in buildings as a risk factor for health effects, EUROEXPO: A multidisciplinary review of the literature (1998–2000) on dampness and mite exposure in buildings and health effects. Indoor Air 14:243–257, 2004.
44. Weinmayr G, Gehring U, Genuneit J, et al. Dampness and moulds in relation to respiratory and allergic symptoms in children: Results from Phase Two of the International Study of Asthma and Allergies in Childhood (ISAAC Phase Two). Clin Exp Allergy 43:762–774, 2013.