



Prevalence of asthma and allergic symptoms in Suzhou, China: Trends by domestic migrant status

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Abstract

Rapid urbanization in developing countries, with significant rural-to-urban and between-urban areas migration, presents a natural epidemiological model to better understand population-level trends in asthma and allergy prevalence without confounding by genetic factors. This cross-sectional study, conducted November 2014 to January 2015 in Suzhou, China, investigated differences in asthma and allergic symptoms between domestic migrant residents and long-term residents and their children. Using multivariate logistic regression, the odds ratios for children in migrant families compared to those in long-term resident families in Suzhou for doctor-diagnosed asthma, pneumonia, rhinitis, and eczema were 0.56 (95% CI: 0.42–0.73), 0.60 (95% CI: 0.49, 0.72), 0.63 (95% CI: 0.52, 0.77), and 0.73 (95% CI: 0.60, 0.89), respectively. While there was a lower prevalence of asthma and allergic symptoms for domestic migrants (children and parents) compared to the local population in Suzhou, migrant children had a higher asthma rate than their parents. This follows the trend of increasing asthma rates for children in the urban local population, suggesting an environmental component. Parental migration plays a role in both parental and children's health but further investigations are needed to determine how these results may be shaped by early life exposures, lifestyle differences, and other environmental factors.

Keywords Epidemiology · Child exposure/health · Disease

Introduction

In the past few decades, the prevalence of asthma and allergic symptoms has increased globally, affecting quality of life and economic development [1, 2]. Among many other potential factors, a person's migration status has been associated with development of these symptoms [3]. Several studies have investigated the effect of international migration

on asthma and allergic symptoms, and most of their results showed a “healthy migrant effect” [4–6]. Immigrants going to westernized countries, for example Australia, Italy and Germany, have lower rates of asthma and other respiratory symptoms compared to the native populations [7–10]. This “protective effect” attenuates the longer the immigrating person has been in the host country [8, 11–15]. However, several studies have reported different results. Studies in United States and United Kingdom [16, 17] found that the proportion of patients allergic to specific agents in the immigrant population is similar to the native population; and some investigators have reported more severe asthma among immigrants [18]. The majority of studies suggest it is reasonable to attribute this difference in migrant populations to environmental factors, while some have hypothesized that it might be related to the ethnicity of immigrants [18, 19]. Understanding factors associated with migration status could provide insight for mitigating or preventing asthma and allergic symptoms.

While most studies have focused on international immigration, domestic/internal migration also needs close attention, especially in China where the longstanding *Hukou*

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household registration system—categorizing individuals as rural or urban—has created a gap between rural and urban populations in various aspects of life. In the last few decades China has been experiencing rapid urbanization, particularly with rural populations moving to mega-cities. The migrant population reached 236 million, exceeding one sixth of the total population in China by 2012 [20]. This unprecedented mobility of large populations has interested social scientists and influenced both federal and local development and many policies. As recently as 2014, China's National Development and Reform Commission announced a new urban policy in favor of new city formation rather than increasing the population of existing large cities [21]. Increased research efforts are being made to examine the effects of migrant status on migrants' health, with most of the current public health focus on infectious diseases, reproductive health and mental health issues [22–25]. However, little attention has been given to asthma and other respiratory symptoms of migrating populations. These diseases can have long-term negative effects on people's efficiency and productivity, and are becoming a growing public health burden. Studying the migrant population in urban China could provide valuable insight into understanding the causes of asthma and allergy disparities within an ethnically similar group as well as generate guidance for the prevention and treatment of these diseases.

This analysis examined health differences between a migrant population and a native urban population and their children in Suzhou, China, with a focus on asthma and allergic symptoms. To our knowledge, this work is the first study to investigate asthma and allergic conditions by city resident status in a prefecture-level city in China.

Methods

Study design

The cross-sectional survey was conducted November 2014 through January 2015 in Suzhou, China. Distributed through 12 participating middle schools across the city, the survey was completed by parents and returned to teachers. The survey consisted of two questionnaires, one for parents/guardians and another for students. Items included demographic information (migration status), home and neighborhood location and environment, and detailed questions regarding children and family health. Questions on diagnosis and symptoms of asthma, pneumonia, rhinitis and eczema were based on ISSAC [26], and questions about Chinese-specific home characteristics were adapted from the China, Children, Home and Health study [27].

The study protocol was approved by Harvard T.H. Chan School of Public Health ethics committee and the local ethics

committees in Suzhou. Children's parents or trustees provided written informed consent. Permission to conduct the study was granted by the school boards of participating schools.

Questionnaire

Specific health outcomes were defined as described below.

"Asthma (father)", "Rhinitis (father)" and "Eczema (father)" were defined based on the positive answers to the questions "Does the child's father have asthma? (Yes/No)", "Does the child's father have rhinitis? (Yes/No)" and "Does the child's father have eczema? (Yes/No)", respectively. Mothers' questions were the same as fathers'.

"Asthma (child)", "Pneumonia (child)", "Rhinitis (child)" and "Eczema (child)" were determined by positive answers to the questions: "Has the child ever been diagnosed with asthma by a doctor? (Yes/No)", "Has the child ever been diagnosed with pneumonia by a doctor? (Yes/No)", "Has the child been diagnosed with hay fever or allergic rhinitis by a doctor? (Yes/No)" and "Has the child been diagnosed with eczema by a doctor? (Yes/No)", respectively.

Symptoms of "current wheeze (child)" were determined by positive answers to the written question "Have you (has your child) had wheezing or whistling in the chest in the past 12 months?" Symptoms of "ever wheeze (child)" were determined by positive answers to the written question 'Have you (has your child) had wheezing or whistling in the chest at any time in the past?'

Symptoms of "current sneezing (child)" were determined by positive answers to the written question "Have you (has your child) had sneezing, or a runny, or a blocked nose when not having a cold or the flu in the past 12 months?" Symptoms of "ever sneezing (child)" were determined by positive answers to the written question 'Have you (has your child) had sneezing, or a runny, or a blocked nose when not having a cold or the flu at any time in the past?'

Symptoms of "current itchy rash (child)" were determined by positive answers to the written question "Have you (has your child) had itchy rash at any time in the last 12 months?" Symptoms of "ever itchy rash (child)" were determined by positive answers to the written question 'Have you (has your child) ever had an itchy rash, which occurred on and off for at least 6 months?'

Participants were asked "Did the child's mother grow up in Suzhou? (Yes/No)" and "Did the child's father grow up in Suzhou (Yes/No)". Four groups were created to reflect different migrant status: "both local parents"; "only migrant mother"; "only migrant father"; and "both migrant parents". Participants were also asked to report their residency status by answering to the question "Do the child's parents currently have official Suzhou residency status (i.e., Hukou)?"

Statistical analysis

The Kruskal–Wallis nonparametric test and analysis of variance were used to test differences among groups. Univariate logistic regression and multivariable logistic regression were used to compare the prevalence of symptoms among different population groups and to evaluate the relation between symptoms of asthma and migrant status. Age, gender, family asthma history, paternal education, exposure to environmental tobacco smoke and home ownership were adjusted as confounding factors [28–30]. We also added an interaction term between children's gender and age. Results are presented as odds ratios (ORs) and 95% confidence intervals (CIs). All the computations were carried out using R version 3.2.3.

Results

A total of 5891 middle school children and their parents/guardians participated in our study, with 201 child–parent surveys excluded from the analysis due to the lack of migrant status information. Of the children included 51.6% were male, and most of them were 13 years old (43.7%) and 14 years old (40.2%). We classified them into four groups based on migrant status: 2213 children (37.6%) had parents who both grew up in Suzhou; 461 children had

only a father from Suzhou; 460 children had only a mother from Suzhou; and 2556 children had parents both identified as migrants. Sixty-seven percent of the study population had Suzhou residency, and 33% did not. Both parents growing up in Suzhou was highly correlated with having Suzhou residency status (P -value < 0.001 based on Pearson χ^2 test).

Detailed demographic and social-economic characteristics of the four different migrant status groups are shown in Table 1. When both parents were migrants to Suzhou, they were more likely to have boys (55.5%), multiple children (22.1%), higher environmental tobacco smoke (ETS) exposure (54.3%) and lower educational attainment than when both parents came from Suzhou. A higher percentage of migrants rented rather than owned their residence (43.6%). The prevalence of family asthma and allergic problems was lower among migrant households (9.5%).

Figure 1 illustrates the prevalence of asthma, rhinitis, and eczema for the children (second generation) and their parents' generation (first generation) in the "both local parents" and "both migrant parents" groups. The prevalence of all the three diagnoses was higher in the children's generation compared to their parents' generation. The doctor-diagnosed asthma rates in the local population for father and mother, and in the migrant population for father and mother were 1.5, 2.2, 0.9, 1.2%, respectively. The asthma rates for children in local and migrant population were 13.2 and

Table 1 Distribution of demographic characteristics by migrant status group in Suzhou, China, 2014–2015

		Overall (<i>N</i> = 5690)	Both local parents (<i>N</i> = 2213)	Only migrant mother (<i>N</i> = 461)	Only migrant father (<i>N</i> = 460)	Both migrant parents (<i>N</i> = 2556)	<i>P</i> -value
Children's gender	Male	51.6	48.0	47.7	51.0	55.5	<0.001
Children's age	12 and below	10.1	8.7	8.8	11.5	11.3	0.009
	13	43.8	44.2	49.6	44.6	42.3	
	14	40.3	44.9	38.2	40.5	36.4	
	15 and above	5.8	2.1	3.3	3.4	10	
Parental education	Primary school	6.0	1.4	3.8	3.1	10.8	<0.001
	Middle school	26.0	17.5	23.6	13.3	36.1	
	High school	24.5	29.7	29.9	14.2	21.0	
	College	37.3	46.7	37.8	52.4	26.3	
	Graduate	6.2	4.7	4.9	17.1	5.8	
Family asthma history ^a	Yes	12.8	15.1	14.9	17.9	9.5	<0.001
ETS at home	Yes	49.5	44.3	43.6	53.9	54.3	<0.001
Rent current residence	Yes	22.1	3.5	7.3	8.3	43.6	<0.001
Children living together	1	81.1	89.0	89.6	83.5	71.8	<0.001
	2 and above	15.0	8.7	6.9	15.3	22.1	

^aasthma or allergic problems exist in the family

Fig. 1 Comparison of doctor-diagnosed prevalence between children and parent generation in Suzhou, China, 2014–2015

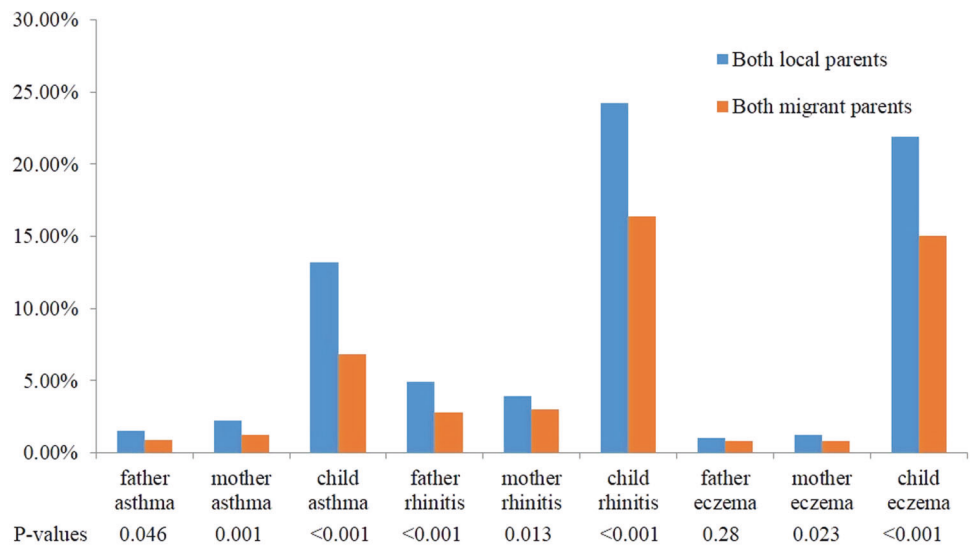


Table 2 Prevalence of children's asthma and allergic diseases and symptoms by parents' migrant status groups in Suzhou, China, 2014–2015

Symptom	Overall N = 5690	Both local parents N = 2213	Only migrant mother N = 461	Only migrant father N = 460	Both migrant parents N = 2556	P-value
Doctor-diagnosed asthma	9.8	13.3	12.5	12.6	5.8	<0.001
Doctor-diagnosed pneumonia	20.5	26.9	23.3	22.6	14	<0.001
Doctor-diagnosed rhinitis	20.1	24.4	23.5	30.9	13.8	<0.001
Doctor-diagnosed eczema	18.2	23.0	16.7	23.5	13.4	<0.001
Current wheeze	8.8	10.2	8.1	7.5	7.8	0.096
Ever wheeze	13.2	17.8	17.1	14.1	8.1	<0.001
Current sneezing	63.3	67.0	66.9	65.4	58.6	<0.001
Ever Sneezing	45.8	49.6	50.4	52.7	40.2	<0.001
Current itchy rash	27.2	30.5	29.7	27.9	23.1	0.001
Ever itchy rash	28.5	32.8	32.8	34.8	22.7	<0.001

P-value represents the statistical significance of difference between the "Both local parents" group and the "Both migrant parents" group.

6.8%, respectively. Within each generation, the prevalence of all three diagnoses in the migrant population was lower compared to the local population.

Table 2 reports the doctor-diagnosed diseases and symptoms for children by four migrant status groups. The overall doctor-diagnosed asthma, pneumonia, rhinitis and eczema rates were 9.9, 20.5, 20.1 and 18.3%, respectively. The prevalence of these four diseases was lower in children with both migrant parents than children with one or both local parents. For children with only one local parent, the reported doctor-diagnosed rhinitis and eczema rates were higher in children with only a mother growing up in Suzhou, compared to those with only a father from Suzhou, while the prevalence of doctor-diagnosed asthma and

pneumonia was similar for both a mother or a father growing up in Suzhou.

For the symptoms questions, having two migrant parents was positively associated with a lower prevalence of "ever wheeze", "current sneezing", "ever sneezing", "current itchy rash", and "ever itchy rash". The associations persisted after fully adjusted for potential confounders (data not shown).

Multivariate logistic regression results for the associations between the migrant group and local population (reference group as both local parents) for doctor-diagnosed diseases were shown in Table 3. There was no difference in the prevalence of doctor-diagnosed diseases between children with one migrant parent and local parents after adjusting for gender and age, even after controlling for other potential confounders. However, children with both migrant

Table 3 Multivariate logistic regression model for the associations between migrant group and local population (reference group as both local parents) for doctor-diagnosed diseases in Suzhou, China, 2014–2015

	Asthma	Pneumonia	Rhinitis	Eczema
Both local parents	1	1	1	1
Only migrant mother	1.07 (0.74, 1.50)	0.91 (0.70, 1.19)	1.02 (0.77, 1.35)	0.79 (0.59, 1.07)
<i>P</i> -value	0.724	0.511	0.875	0.132
Only migrant father	0.80 (0.55, 1.14)	0.76 (0.58, 0.99)	1.27 (0.97, 1.65)	1.02 (0.77, 1.33)
<i>P</i> -value	0.22	0.048	0.081	0.907
Both migrant parents	0.56 (0.42, 0.73)	0.60 (0.49, 0.72)	0.63 (0.52, 0.77)	0.73 (0.60, 0.89)
<i>P</i> -value	<0.001	<0.001	<0.001	0.002

Adjusted for children's gender, children's age, family asthma history, parental education level, environmental tobacco smoking at home, ownership status and interaction term between children's gender and age

parents had positive associations with lower prevalence of all outcome variables when compared to children with both local parents; the associations were confirmed when adjusting for additional potential confounders. The odds ratios between the “both migrant parents” group and host population for doctor-diagnosed asthma, pneumonia, rhinitis and eczema in the full model were 0.56, 0.60, 0.63 and 0.73, respectively. The associations tested by family residency status showed the same trend: children without city residency status had lower prevalence of all doctor-diagnosed asthma and allergic symptoms (Supplementary Table 1).

Discussion

Main findings and comparison with other studies

In the present study, we found substantial differences in the prevalence of asthma and allergic symptoms between recognized Suzhou citizens and those who have migrated to the city. Results are consistent when comparing answers to doctor-diagnosed questions and observation/symptom questions, and after further adjusting for number of children in the family. We also used parents' residency as an indicator for migration status and similar results were observed. Similar results have been found in studies of international immigrants to westernized countries. Grüber et al. studied children of Turkish origin living in Germany and found they had lower rates of atopic diseases, wheezing and itchy rash [10]. An Italian survey study of extra-European immigrants to Milan revealed that 84.3% of patients claimed to develop allergy/asthma symptoms after they arrive in Italy [9]. Wang et al. found the prevalence of asthma and wheezing higher in Canadian-born Chinese adolescents than Chinese immigrants [12]. Our study indicates that domestic migration resembles international immigration in the trend of asthma and allergic symptoms. The “healthy migrant” effect” also applies to domestic migrants from rural to urban areas. Interestingly these differences persisted even when

there was greater ETS exposure at home and a higher percentage of migrant families were renters with a lower social economic status, as indicated by educational attainment.

The explanation for these findings remains uncertain. Ethnic heterogeneity is not easily ruled out in some international studies. The different epigenetic nature of respiratory symptoms might partially explain the differences in the international migrant population [18, 19]. However, since our study focused on domestic migrants, who we assume to be ethnically similar to recognized Suzhou residents, it suggests possible environmental or behavioral explanations. Studies in the China, Children, Homes and Health project have identified indoor air pollution associated with housing characteristics as a risk factor for asthma and allergies. Some factors commonly identified include dampness and mold, new building materials/paint, and living close to a highway [27, 31–33]. We listed the comparison of these characteristics in our data set between migrant and non-migrant children (Supplementary Table 2). No clear difference in building materials is observed, but the migrant children generally have a higher rate of mold and dampness issues, and are more likely to live close to a highway. Differences in early life exposure (the hygiene hypothesis) are another possible explanation [34, 35]. This theory emphasizes the role of microbiota in regulating the normal immune responses to allergens. Factors that alter the natural colonization of the microbiota are believed to be associated with elevated risk for allergic symptoms. Identified risk factors include birth by cesarean section, prematurity, medication, hygiene measure, formula feeding, etc. [36] Protective factors include living with siblings, pet keeping, etc. Quite a few studies have supported this hypothesis, attributing the high prevalence of asthma symptoms in immigrants to changed microbial exposures and improved hygiene treatments [7, 9, 10, 37]. In our study we also observed differences in some of these factors between the two populations (Table 1), which might contribute to different asthma prevalence. Another explanation is the increased exposure to more polluted air in industrialized countries or cities. For example, the Milan study [9] pointed

out that higher level of exposure to diesel exhaust could be a strong stimulant to sensitization and development of allergy/asthma symptoms. Migration can be seen as a process and experience that involves a variety of environmental/lifestyle factors that can affect the development of childhood asthma and allergic symptoms. Our results may support a “healthy migrant effect”, which suggests that the protective factors outweigh the risk factors. Nevertheless, unraveling the full underlying mechanism requires further analysis of more detailed environmental/behavioral differences between the migrant and host populations.

Our results showed the asthma rate of the second generation of a migrant population increased compared to the first generation. An increase of asthma prevalence was previously observed in many westernized countries over the past few decades. A repeated cross-sectional survey in northern Norway reported a substantial increase in prevalence of asthma and allergic rhinoconjunctivitis (AR) in a subarctic children population between 1985 and 2008 [2]. Identical questionnaires were answered by parents of children aged 7–13 years to assess asthma and AR in 1985, 1995 and 2008. The asthma rate increased from 7.3% in 1985 to 17.6% in 2008, and AR increased threefold over the same period. An Italian study showed that from 1991 to 2010 the median prevalence of current asthma, wheezing and allergic rhinitis increased; the asthma prevalence increased by over 35%; and the prevalence of current asthma and allergic rhinitis was 6.6 and 25.8%, respectively, in 2010 [1]. Another study of trends in asthma prevalence in Ontario, Canada reported a 70.5% increase, from 8.5% in 1996 to 13.3% in 2005 [38]. Our results indicate that with rapid urbanization, China is also experiencing a dramatic increase in asthma prevalence. Our observed asthma prevalence among the studied population in Suzhou is similar to or even higher than westernized countries. This may be a key element of the health implications of urbanization, since families may have greater exposure to many elements of modern urban lifestyles that together impart greater risk of asthma and allergy development. Future research is needed to understand these trends and develop strategies to mitigate these effects.

Strengths and limitations of this study

The main strength of this work is our study population representing a specific group, i.e., domestic migrants, in the largest developing country. It allows us the unique opportunity to observe changes in disease prevalence without being confounded by genetic differences. However, Suzhou’s domestic migrant population differs from the local population in many key characteristics of environment and lifestyle. In addition, information gathered from both first and second generations represents a more complete model to assess the

environmental and lifestyle impact on development of respiratory diseases at both earlier and later life stages.

One limitation of our study is the inherent limitation of cross-sectional studies. The analyses relied on self-reported data for both the exposure and outcome variables, which may cause a misclassification bias. However, these limitations would only bias the results toward the null, as they are expected to lead to non-differential misclassifications of outcome. Information bias is not a problem for the exposure variable since it is not likely that people would misreport their migrant status. For the diagnostic information bias, since we used self-administrated surveys to obtain health status, a migrant population, having lower social-economic status, may forgo healthcare services and hence underreport their doctor-diagnosed conditions. However, the reported observational questions by parents were consistent with these questions on doctor-diagnosed outcomes. Therefore, we are confident that our findings reasonably reflect the true trend.

Conclusion

This is the first study in China to examine a domestic migration population for their asthma and allergic problems. We found a lower prevalence of asthma and other respiratory symptoms in the migrant population compared to local population in Suzhou, supporting the “healthy migrant effect” previously found in other studies. We also observed a rising trend of asthma prevalence in China, which calls for public attention to the prevention and treatment of this disease. Modernizing China presents a natural epidemiological model to better understand the causes of asthma and its prevention. Our findings suggest parental migration plays an important role in both parental and children’s health. An explanation for this observation is still elusive but the role of early life exposures and lifestyle differences are likely to be relevant.

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Author contributions LL designed the study, performed the field work, analyzed the data and wrote the manuscript; JDS designed the study and analytical strategies; S-jC conducted the field work, and

edited the paper; GA designed the study, supervised the field activities, and designed data analytical strategies.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Supplementary Materials

Supplementary Table 1. Age-gender-adjusted and fully-adjusted ORs (95% CIs) of asthma and allergic outcomes associated with family not having Suzhou residency

Outcome	Basic	Full
Doctor-diagnosed asthma	0.28 (0.21 , 0.37)*	0.59 (0.41 , 0.84)*
Doctor-diagnosed pneumonia	0.32 (0.26 , 0.38)*	0.44 (0.34 , 0.57)*
Doctor-diagnosed rhinitis	0.32 (0.26 , 0.38)*	0.53 (0.41 , 0.69)*
Doctor-diagnosed eczema	0.30 (0.25 , 0.37)*	0.51 (0.38 , 0.67)*
Current wheeze	0.97 (0.65 , 1.42)	1.13 (0.64 , 1.92)
Ever wheeze	0.29 (0.22 , 0.36)*	0.54 (0.38 , 0.74)*
Current sneezing	0.60 (0.51 , 0.71)*	0.74 (0.58 , 0.94)*
Ever Sneezing	0.64 (0.56 , 0.73)*	0.71 (0.59 , 0.86)*
Current itchy rash	0.62 (0.48 , 0.79)*	0.64 (0.44 , 0.92)*
Ever itchy rash	0.43 (0.37 , 0.50)*	0.63 (0.50 , 0.77)*

Adjusted for children's gender, children's age, family asthma history, parental education level, environmental tobacco smoking at home, ownership status and interaction term between children's gender and age.

*: p-value <0.05

Supplementary Table 2. Comparison of housing characteristics between local and migrant children

	Both local parents	Both migrant parents
Laminated wood floor in child's room	17.0%	17.9%
Oil-based paint on the wall in child's room	60.8%	52.1%
Mold in child's room	2.9%	4.7%
Damp stain in child's room	5.3%	7.4%
Living close to a highway (<300m)	49.2%	54.2%