

ORIGINAL ARTICLE

Influences on Childhood Asthma in Low-Income Communities in China and the United States

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For comparison of childhood asthma, the same case-finding survey and parent interview questionnaires were used to collect data from 639 children with asthma in 21 elementary schools in Beijing and 835 children with asthma in 14 elementary schools in Detroit, Michigan. Asthma prevalence in Beijing (7.3%) was more than three times lower than in Detroit (24%) despite a high level of smoking among Chinese parents. Body mass index (BMI; weight in kilograms divided by height in meters squared) levels were higher in Detroit but were not associated with persistent asthma in either country. Higher levels of past infection in Beijing and household allergens in Detroit were noted and may be associated with differences in prevalence. Despite less severe disease observed in Beijing, hospitalizations and office visits did not differ from Detroit. This may be partially associated with less use of anti-inflammatory medicine and lower levels of parental asthma management in China.

Keywords asthma, children, low-income, elementary schools

INTRODUCTION

Asthma is the most common chronic disease of childhood worldwide. Asthma prevalence in developed countries ranges between 7% and 25% (1). In the United States, highest levels are evident in low-income communities, with prevalence of more than 20% frequently reported (2). Lower prevalence has been evident in developing countries. In China over the decade of the nineties, prevalence was estimated from 2% to 6% (3, 4).

Variations in prevalence and correlates of asthma in different populations may provide clues for understanding the disease and its management. This study compared asthma prevalence and factors associated with the disease in school children in Beijing, China with those in Detroit, Michigan, USA. The aims of the research were to:

1. Determine asthma prevalence in samples of elementary-aged school children in both areas by using identical case-finding procedures
2. Describe differences in physician diagnosis, asthma severity, symptoms, medication use, and health care use between the two populations
3. Describe environmental factors potentially precipitating symptoms in each site
4. Describe differences in parents' asthma management behavior and perceptions of quality of life.

METHODS

There were two major phases in this study. The first phase was to use the same case-finding procedures to determine the prevalence of asthma in elementary school-children in Detroit and Beijing. The second phase was to collect in-depth information at both sites regarding management practices and potential influences on the child's condition by conducting a survey of parents of those children identified as having asthma. All study procedures were approved by the University of Michigan Institutional Review Board.

Study Sites

In Detroit, 14 schools located in the former Area D of the Detroit Public School System and in Beijing 21 schools in a large community comprising an industrial and an agricultural district participated in the study. The Detroit schools were predominantly African American (98%), with a reported 63% of families in the area living below the poverty level. Chinese children were 98% Han. No data were available describing specific economic level of the Chinese families, but the majority were judged by the site participants to be of low income.

Case Identification

Each student in the second through fifth grades of the elementary schools in Detroit was given a descriptive letter signed by the project staff and a questionnaire to take home to his or her parent. The letter gave information about the project, asked for written confirmation of the parent's consent to participate, and requested that the questionnaire be completed and returned to the school with the consent form. Questionnaires were collected by teachers and were

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subsequently retrieved from the schools by project staff. Of a total of 4653 children, 3649 parents returned the case identification questionnaire. The return rate was 84% adjusted for the daily Detroit absentee rate (7%). Of those returned, 3433 questionnaires were completed with sufficient information to include in data analysis for prevalence estimates of confirmed or probable asthma.

In Beijing, a questionnaire, consent form, and letter describing the project signed by the school principal, the directors of the district hospital, and the Chinese research project director were distributed by project staff to parents of children in the first to fifth grade in a meeting held in all schools during the first week of the school year. A total of 9040 parents received the survey, and 8768 completed and returned it on site for a response rate of 96.5%. Of forms returned, 8724 contained sufficient information for data analysis.

The case-finding questionnaire comprised items related to a child's asthma symptoms, a physician's diagnosis, and prescribed medication. These items were 1) a cough that won't go away, 2) wheezing with a cold, 3) wheezing without a cold, 4) wheezing that makes it difficult to catch one's breath, 5) wheeze with exercise, 6) cough with exercise, 7) chest feels tight or heavy, 8) a diagnosis of asthma by a physician, and 9) receipt of a prescription for asthma medicines from a physician. The details of the development of the questionnaire and criteria for determining probable asthma are described elsewhere (5). Criteria were consistent with those used in previous epidemiological surveys (6, 7) and with definitions provided by National Asthma Education and Prevention Program (8) and the Global Initiative for Asthma (9). A child was eligible for the study if he or she met any of the following: 1) three or more of the five non-exercise symptoms reported in the past year, 2) one or more exercise symptom reported with a frequency of three times or more in the past year, and 3) a physician's diagnosis of asthma and receipt of an asthma medicine prescription or any asthma symptoms in the past year.

A total of 639 children in Beijing and 835 in Detroit met asthma inclusion criteria. The second phase of data collection entailed an in-depth survey of parents concerning the child's asthma.

Survey of Parents of Children with Asthma

In-depth data on children identified with asthma were collected from parents in Beijing through a self-administered survey completed on site at the child's school with assistance as needed from a project data collector. In Detroit, parents were interviewed by telephone by project staff. Items on the parent questionnaire concerned the child's demographics, asthma diagnoses, symptoms, medication use, physical activity levels, height and weight, environmental factors, and health care use. A measure of the parents' asthma management practices was used on the basis of previous studies (10). The Pediatric Asthma Caregiver Quality of Life Questionnaire (11) was also used.

All questionnaires for China were translated into Mandarin. A back-translation from Chinese to English was conducted to ensure the accuracy of the Chinese translation.

To classify disease severity, the National Asthma Education and Prevention Program (NAEPP) Guidelines for Diagnosis and Treatment of Asthma (8) were used. FEV₁ or PEF data were not available. The frequency of daytime and nighttime symptoms was used for severity determination.

Data Analysis

All case identification and parent questionnaire data collected in Beijing were entered and edited there with assistance from the U.S. team and then electronically transferred to the University of Michigan for analysis. For prevalence estimates, a total of 3433 student-screening questionnaires in Detroit and 8761 in Beijing were available. For other variables, data from 835 telephone interviews in Detroit and 639 self-administered forms from Beijing were available.

To compare sites on items of interest, Wilcoxon two-sample tests, chi-squared, and odds ratio (OR) statistics were conducted for variables related to diagnosis, symptoms, health care use, environmental factors, management behavior, and quality of life. Odds ratio were calculated by using Detroit data as reference. Odds ratios larger than 1 indicate the value of the given variable in Detroit is greater than that in Beijing. Odds ratios less than 1 indicate the value of the variable is greater in Beijing than in Detroit. The 95% confidence interval (CI) was applied to determine significance level. Both upper and lower limits of a CI for greater or less than 1 indicate that an odds ratio is statistically significant. Body mass index (BMI) for children was calculated as weight in kilograms divided by height in meters squared.

RESULTS

Demographics

The mean age of Detroit children included in the sample was 8.7 years with a standard deviation (SD) of 1.3 years. The average age of children in the Beijing sample was 9.5 years old with SD of 1.6 years.

There were more male (55%) than female (45%) children in the Detroit sample, whereas gender was evenly distributed in the Beijing sample. Most parents in Detroit had graduated from high school or higher (87%) and had an annual household income less than \$20,000 (57%). As noted, individual data were not available for parents' income and education level in Beijing. The majority were judged to be of low income. The average BMI in Beijing ranged according to age from 16.1 to 16.9 for male and 16.7 to 17.3 for female students. In Detroit, the average BMI ranged from 17.6 to 22.4 for male students and 19.8 to 26.2 for females. Although children in Detroit were significantly heavier than those in Beijing, regression models conducted separately for both cities showed no significant association between BMI and persistent asthma.

Comparison of Prevalence and Severity

The prevalence of physician diagnosed or probable but unconfirmed asthma in Detroit was 24% compared to 7.3% in Beijing. In Detroit, 16% of children had a physician's diagnosis of asthma and in China 3% had such a diagnosis. The average age at diagnosis was 3.2 years in Detroit

TABLE 1.—Comparison of asthma severity (in percent).

	Detroit (n = 631)	Beijing (n = 623)
Mild intermittent	53.6	71.2
Mild persistent	26.9	20.0
Moderate persistent	14.6	8.8
Severe persistent	4.9	0.0
p value (chi-squared)	.001	

compared to 4.6 years in Beijing (OR 4.83; CI 3.8–6.1; $p = 0.0001$).

Children in Detroit had more severe disease than children in Beijing. Table 1 shows that (using NAEPP criteria) slightly more than half the Detroit children had mild intermittent asthma, just over a quarter had mild persistent disease, 15% had moderate persistent, and 5% had severe persistent asthma. In Beijing almost three quarters of the children had mild intermittent disease, less than one quarter had mild persistent disease, and 9% had moderate persistent asthma. No severe persistent asthma was observed in Beijing. Differences in the distributions of severity were statistically significant ($p < 0.001$).

Comparisons of Asthma Symptoms and Health Care Use

Table 2 indicates that children with asthma in Beijing had significantly fewer days with symptoms and fewer days of restricted activity in the previous 12 months than did Detroit children. Children in Detroit had more emergency department (ED) visits for asthma in the previous 12 months. There were no significant differences between the two cities for office visits and hospitalizations.

Comparison of Medication Use

Table 3 presents data regarding medication use. Only 8% of children with asthma in Beijing used prescription bronchodilators and/or anti-inflammatory medicine, although 28.8% had persistent disease. They were more likely to use antibiotics to control asthma and, as would be expected, more Chinese medicine. Just over 15% of children with asthma in Detroit used anti-inflammatory medicine. Bronchodilators were used by 44% of children in Detroit. They did not commonly use antibiotics and natural medicines.

TABLE 2.—Comparison of symptoms days and health care use (in percent).

In the past 12 months	Detroit (n = 467–630)	Beijing (n = 426–618)	P value
Had office visits	36.3	38.4	0.48
Had emergency department (ED) visits	26.0	16.6	0.001
Had hospitalization	7.4	7.1	0.87
Days child had asthma symptoms	30.0	8.3	0.0001
Days asthma kept child from exercise	14.0	2.5	0.0001

TABLE 3.—Comparison of medication use (in percent).

	Detroit (n = 631)	Beijing (n = 611)	P value
Bronchodilator	43.6	8.0	< 0.001
Anti-inflammatory	15.1	8.3	< 0.001
Anti-allergy/histamine	8.2	6.6	< 0.001
Antibiotics	4.3	24.4	< 0.001
Chinese/natural medicine	1.1	17.0	< 0.001

Comparison of Conditions Diagnosed Other Than Asthma

Parents were questioned about other conditions diagnosed by the children's physicians. As Table 4 illustrates, significantly more parents in Detroit reported that their child had allergies, eczema, and hay fever. In contrast, significantly more parents in Beijing reported the child had had bronchitis, pneumonia, and croup at some time in the past.

Comparison of Triggers

Parents were asked to report the things that trigger the child's asthma symptoms. Table 5 shows that significantly more parents in Detroit reported dust, pets, pollens, and certain foods as responsible for the child's asthma symptoms. Precipitants such as sprays or strong smells, change in weather, air pollution, and smoke were reported by significantly more parents in Beijing. Almost 60% of parents in Detroit compared to 52% in Beijing reported exercise to be a trigger for their child's asthma symptoms. More than 75% of Chinese parents compared to 40% of those in Detroit said that colds or flu triggered their children's symptoms. No significant difference was found between the two cities for reports of mold/mildew and cockroaches as triggers to symptoms. About 3–4% of the parents in both cities did not know their child's triggers.

Comparison of Indoor Environmental Factors

Table 6 illustrates that significantly more parents in Detroit reported that carpeting or a rug was present in the child's bedroom and/or the family room. Moisture, mold, water leaks, and dogs and cats were more evident in Detroit homes. Significantly more parents in Beijing reported household problems with cockroaches and rats/mice. Cigarette smoke was a problem in both cities. However, the frequency of cigarette smoking by parents in China was almost double that of Detroit parents. Furthermore, only one

TABLE 4.—Comparison of diagnosis of conditions other than asthma (in percent).

Condition	Detroit (n = 830)	Beijing (n = 623)	P value; OR (CI)
Allergies	38.0	8.4	0.0001; 6.73 (4.90, 9.24)
Eczema	20.6	10.9	0.0001; 2.12 (1.57, 2.87)
Hay fever	15.9	1.3	0.0001; 14.56 (7.08, 29.9)
Bronchitis	36.3	54.7	0.0001; 0.47 (0.4, 0.6)
Pneumonia	21.7	31.0	0.0001; 0.62 (0.5, 0.8)
Croup	10.8	15.4	0.009; 0.67 (0.5, 0.9)

TABLE 5.—Comparison of parent reported triggers of asthma symptoms (in percent).

Triggers	Detroit (n = 835)	Beijing (n = 623)	P value; OR (CI)
Dust	14.9	8.4	0.0002, 1.92 (1.37, 2.70)
Pets	9.9	3.2	0.0001, 3.33 (2.02, 5.49)
Pollens	11.3	2.3	0.0001, 5.52 (3.12, 9.78)
Certain foods	4.7	2.1	0.009, 2.30 (1.22, 4.23)
Smoke	14.9	28.1	0.0001, 0.45 (0.34, 0.58)
Exercise	59.3	52.2	0.007, 1.33 (1.08, 1.66)
Colds or flu	43.6	78.7	0.0001, 0.21 (0.17, 0.27)
Mold and mildew	1.9	1.3	0.35, 1.50 (0.64, 3.53)
Cockroaches	0.3	0.2	0.74, 0.11 (0.13, 16.5)
Don't know	3.1	4.0	0.36, 0.77 (0.44, 1.34)

third of the parents in Beijing reported limiting their smoking to one room in the home compared to two thirds of Detroit parents (31.5% vs. 72.4%, $p < 0.0001$; OR 5.72; CI 4.04–8.10). In both cities, approximately the same percentage (2–3%) reported that children had tried smoking cigarettes themselves.

Comparison of Asthma Management Strategies

The results in Table 7 reveal that overall significantly more Detroit parents used management strategies than Beijing parents. These behaviors included using prescribed medicine often or all of the time to try to control or prevent their child's symptoms (59% vs. 39%, $p < 0.0001$). Occasional to frequent use of peak flow meters was rare in China and more evident in Detroit (8% vs. 44%, $p < 0.0001$). Keeping the child away from things that may cause asthma symptoms was a strategy used by more parents in Detroit than Beijing (81% vs. 36%, $p < 0.0001$). Significantly more parents in Detroit reported that they could often or always keep themselves calm and the child quiet while the child was experiencing asthma symptoms (84% vs. 40%, $p < 0.0001$) and more Detroit parents sought asthma management help or advice (44% vs. 22%, $p < 0.0001$). Beijing parents were much less likely to look for early warning signs of the onset of the child's asthma symptoms (27% vs. 68%, $p < 0.0001$), changes during asthma episodes (33% vs. 81%, $p < 0.0001$), or changes after giving the child medicine (40% vs. 84%, $p < 0.0001$). Few parents in China reported making decisions regarding using appropriate medications (24% vs. 38%, $p < 0.0001$) or trying to reduce environmental precipitants in the child's

TABLE 6.—Comparison of home environmental factors (in percent).

Environmental factors	Detroit (n = 835)	Beijing (n = 623)	P value, OR (CI)
Carpeting/rug in child's room	56.7	13.9	0.0001, 8.11 (6.19, 10.5)
Moisture, mold, or mildew in the house	40.1	31.1	0.0003, 1.49 (1.20, 1.86)
Water leaks in the house	25.8	10.1	0.0001, 3.09 (2.28, 4.19)
Cockroach problems	19.7	33.2	0.0001, 0.49 (0.39, 0.63)
Rats/mice problems	18.0	22.6	0.032, 0.75 (0.58, 0.98)
Having dog in home	22.5	15.6	0.001, 1.57 (1.19, 2.07)
Parent smokes	34.3	71.8	0.0001, 0.21 (0.16, 0.26)

TABLE 7.—Comparison of asthma management strategies and quality of life.

	Detroit	Beijing	P value
Sum of management strategies scores	40.10	24.90	0.0001
Mean score on quality of life items	1.35	1.46	0.005

home (20% vs. 52%, $p < 0.0001$). Use of these practices in Detroit was more frequent but still used by half or fewer parents. The sum of scores on the asthma management strategies items was significantly higher for Detroit families than families in Beijing (40.1 vs. 24.9, $p < 0.0001$).

Comparison of Quality of Life

Table 7 also illustrates that significantly more parents in Detroit experienced less impact of the child's asthma on the quality of their lives. In Beijing, more parents were likely to feel helpless, frightened, frustrated, impatient, upset, or angry (19% vs. 7%, $p < 0.0001$). More believed that asthma interfered with their own lives (13% vs. 4%, $p < 0.0001$). More parents in Beijing reported that asthma caused sleepless nights (15% vs. 5%, $p < 0.0001$), changes in family plans (12% vs. 7%, $p < 0.0001$), or interference in family relationships (6% vs. 2%, $p < 0.0001$). Furthermore, significantly more Chinese parents worried about use of asthma medications and their side effects (21% vs. 11%, $p < 0.0001$). There were no significant differences in the two cities regarding parental concerns about the child being over-protected, about their performance of normal daily activities, or being able to lead a normal life. The mean of the scores of the quality of life items was significantly better (lower) for Detroit families than Beijing (1.35 vs. 1.46, $p = 0.005$).

DISCUSSION

The results of this study reveal that asthma prevalence is more than three times higher in Detroit than Beijing. A number of factors in this sample may have influenced these figures. About 10% more of the Detroit sample was male. Male gender has been shown to be associated with higher prevalence of asthma in children (12). More children in Beijing than Detroit had a previous diagnosis of an infection-related respiratory problem such as pneumonia, bronchitis, or croup. In contrast, more children in Detroit had allergic conditions, such as hay fever and eczema, and more allergens and allergen-producing materials present in their homes. Allergic diseases including asthma have been increasing at a higher rate in developed countries than in developing ones (13). It has been suggested that early exposure to naturally occurring infections and microbial exposures may provide protection against the development of asthma and allergic diseases (14–16).

Overweight and obesity have been linked to asthma severity. There were distinct differences in the study populations in BMI, with Detroit levels being much higher. However, in neither city was BMI associated with the frequency of asthma symptoms or classification of disease severity.

Children in Detroit exhibited more severe asthma and made more ED visits for the condition than children in Beijing. However, no differences in office visits and hospital admissions were observed in the two samples. If there were

more severe disease in Detroit, why were there no differences in admissions and office visits? In Detroit, hospitalization for asthma is seen as last resort care with efforts made to handle most cases in the physician's office or, if needed, the ED. In Beijing, where there was an absence of severe asthma and a low level of moderate persistent disease, one might expect lower rates of hospitalization and office visits. However, asthma management practices in China appear to deviate from those recommended in asthma guidelines. Levels of anti-inflammatory and bronchodilator use were low in Detroit, given the extent of disease observed. NAEPP Guidelines would indicate that 46.6% (those with persistent disease) of the Detroit children should be taking these medicines. However, rates in Beijing were lower. For example, no more than 8% of children in the Beijing sample used anti-inflammatory medicine, and almost one fourth were prescribed antibiotics to treat the disease. Incorrect or inadequate use of medicines could result in uncontrolled asthma and hospital admissions even among those with less severe disease. Furthermore, clinical experience suggests that infrequent but serious episodes may occur in children classified with moderate or mild disease. When it came to management practices in addition to medicine, families in Beijing used significantly fewer strategies. When the child had asthma symptoms, these families may have been more likely to seek help from a doctor.

Even though children in Detroit experienced more asthma symptoms and had more ED visits, parents in Detroit reported a significantly better overall asthma-related quality of life than those in Beijing. Socioeconomic conditions for which we have no comparisons may differ in the two cities and contribute to differences in perceptions of quality of life. However, strategies more evident in Detroit, such as giving the child the prescribed medications, correctly identifying and moving the child away from environmental triggers, and monitoring the condition to detect an attack, may have decreased the disruption and fears even mild disease can cause in daily life. Twice to four times as many parents in Detroit reported that they observed the child's early warning signs of an asthma attack and watched to determine how serious the symptoms were or if they changed in severity. They also reported more efforts to judge whether the child's medicine or their attempted environmental changes were effective. These behaviors may have increased parents' ability to reduce the impact of asthma on the quality of their lives.

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