

Clinical deterioration in pediatric asthmatic patients after September 11, 2001

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Background: New York City residents were exposed to a variety of inhaled substances after the collapse of the World Trade Center. Exposure to these substances might lead to an increase in asthma severity, with residential distance from Ground Zero predictive of the degree of change.

Objective: We sought to assess the effect of the World Trade Center collapse on local pediatric asthmatic patients.

Methods: We retrospectively reviewed the charts of 205 pediatric patients with established asthma from a clinic in lower Manhattan's Chinatown. Clinical data were obtained for the year before and the year after September 11, 2001. Measurements included numbers of visits, asthma medication prescriptions, oral corticosteroid prescriptions, weekly doses of rescue inhaler, and peak expiratory flow rates. Residential zip codes were used to compare the asthma severity of patients living within and beyond a 5-mile radius of Ground Zero.

Results: After September 11, 2001, these children had more asthma-related clinic visits ($P = .002$) and received more prescriptions for asthma medications ($P = .018$). No significant differences in oral steroid or rescue inhaler use were noted. Those living within 5 miles had more clinic visits after September 11, 2001 ($P = .013$); the increase in clinic visits for patients living more than 5 miles from Ground Zero was not significant. Mean percent predicted peak expiratory flow rates decreased solely for those patients living within 5 miles of Ground Zero during the 3 months after September 11, 2001. **Conclusions:** Asthma severity worsened after September 11, 2001, in pediatric asthmatic patients living near Ground Zero. Residential proximity to Ground Zero was predictive of the degree of decrease in asthma health. (*J Allergy Clin Immunol* 2004;113:420-6.)

Key words: Asthma; pediatric; World Trade Center; September 11, 2001; peak flow

Many months after the collapse of the World Trade Center (WTC), an image of dust, smoke, and fumes covering lower Manhattan endures. One and 2 days after the disaster, McGee et al¹ collected samples of fallen dust from sites near the WTC. Chemical analysis revealed calcium sulfate and calcium carbonate, 2 compounds that are known to irritate the upper airways, as major components of the dust and fine particulate matter measuring less than 2.5 μm . Particles of this size can possibly induce disease in the small airways. Prezant et al² demonstrated that occupational exposure to the aerosolized dust at the WTC site induced acute bronchial hyperreactivity and persistent cough in previously healthy rescue workers. Some of these workers also had chronic inflammatory respiratory diseases, such as reactive airways dysfunction syndrome.³ In addition to rescue workers, children with asthma living near Ground Zero make up another group of subjects at risk for respiratory complications after exposure to WTC dust. It is well known that asthma continues to increase in the United States, especially among inner-city children, and is a leading cause of chronic disability in this population.⁴ Clinical manifestations of asthma, such as wheezing, dyspnea, and cough, might be exacerbated by environmental exposures, such as outdoor airborne pollutants, allergens, and fumes.⁵

To study the effects of the WTC collapse on children with asthma, we conducted a retrospective chart review of Chinese-American pediatric asthmatic patients treated at a community health center in lower Manhattan in the year before and the year after September 11, 2001. We hypothesized that asthma severity would increase in this preexisting group of pediatric asthmatic patients after exposure to aerosolized pollutants from the WTC collapse. We further hypothesized that the proximity of a patient's residence to the WTC would correlate with the degree of increased asthma severity.

METHODS

Study population

Subjects for this study were Chinese-American pediatric asthmatic patients who live in New York City and receive medical care at the Charles B. Wang Community Health Center (CBWCHC), a

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Abbreviations used

CBWCHC: Charles B. Wang Community Health Center
PEFR: Peak expiratory flow rate
WTC: World Trade Center

facility located in lower Manhattan's Chinatown, approximately 1.5 miles from the WTC. Chinatown comprises one of the largest homogeneous ethnic neighborhoods nearest to the WTC. Eligible subjects included patients less than 18 years of age (as of September 11, 2001) who had established asthma and enrolled in an asthma registry at the CBWCHC. All patients included in the study were given a diagnosis of asthma by a pediatric allergist. Patients less than 6 years old were given a diagnosis of asthma if they had 2 or more episodes of wheezing or coughing within a 12-month period and their symptoms improved after administration of asthma medication in the clinic. Children more than 6 years old were given a diagnosis of asthma if they had wheezing, cough, or dyspnea on at least 2 occasions and their symptoms, physical examinations, and peak flow rates improved after bronchodilator therapy. We only included subjects who had at least one clinic visit for asthma between September 11, 2000, and September 10, 2001, and at least one clinic visit between September 11, 2001, and September 10, 2002.

The study was approved by the CBWCHC and the State University of New York Stony Brook School of Medicine institutional review boards.

Data collection

Seven physicians trained in internal medicine or pediatrics reviewed 319 patient charts from an established asthma registry. Two hundred five patients met the inclusion criteria. Data were extracted onto standardized study forms and then entered into our study database. Data collected included the following: (1) number of asthma visits; (2) number of prescriptions for asthma medications (combination medications with a steroid inhaler and a long-acting β_2 -agonist were counted as 2 medications); (3) oral steroid use; (4) weekly doses of rescue inhaler; (5) age; (6) height and weight (data from before September 11, 2001, were collected from clinic appointments within 3 months of that date, and data from after September 11, 2001, were collected from within 3 months of that date); (7) sex; and (8) residential zip code. Physicians were blinded to the geographic location of the children's residences. Peak expiratory flow rates (PEFRs) in liters per minute were measured by using an Assess brand peak flowmeter. The best value of 3 trials was recorded at each visit. PEFRs were obtained from all patients who were able to consistently perform the maneuver.

Statistical analyses

We sorted all subjects according to their residential zip codes to assess the effect of distance from Ground Zero on asthma severity. Patients who lived within 5 miles of the WTC were classified as living in region 1, and patients who lived greater than 5 miles from the WTC were classified as living in region 2 (Fig 1).

To assess differences in demographic and clinical parameters between patients living in region 1 and region 2, we used *t* tests or χ^2 tests as appropriate. Wilcoxon signed-rank tests or McNemar tests, as appropriate, were used to assess changes in numbers of clinic visits, numbers of asthma medication prescriptions, percentage using oral steroids, and weekly doses of rescue inhalers before and after September 11, 2001, for all patients and within regional groupings.

PEFRs were converted into percent predicted values on the basis of expected values for a given height. The percent predicted was calculated by dividing the peak flow rates we obtained by the

expected values for healthy children at a given height.⁶ The mean percent predicted PEFRs were calculated for each month. Quarterly mean values for each 3-month period starting on September 11, 2000, are reported for region 1 and region 2 populations.

P values of less than .05 were considered statistically significant.

RESULTS

Demographics

A total of 205 eligible patients were identified. All patients were of Chinese descent. Table I displays select demographic characteristics of all eligible patients and of eligible patients according to residential regions. No statistically significant differences in age, sex, height, and weight were found between residents of region 1 and region 2. As expected, all subjects were taller and heavier after September 11, 2001, compared with the prior year (mean height, 48.69 inches before September 11, 2001, and 50.63 inches after September 11, 2001; mean weight, 63.94 lbs before September 11, 2001, and 71.43 lbs after September 11, 2001).

Clinical parameters before and after September 11, 2001

Table II shows the clinical parameters for asthma, including means per child for clinic visits, asthma medication prescriptions, rescue inhaler doses, and oral steroid prescriptions for all patients before and after September 11, 2001. After September 11, 2001, all patients had a significantly greater number of clinic visits for asthma (3.79 before September 11, 2001, vs 4.69 after September 11, 2001, *P* = .002). Patients were also prescribed a significantly greater number of asthma medications (2.05 before September 11, 2001, vs 2.33 after September 11, 2001, *P* = .011). There were no statistically significant differences in either the use of oral steroids or the number doses of rescue inhaler used before and after September 11, 2001.

Clinical parameters by region

Table III compares clinical parameters on the basis of residential region. Before September 11, 2001, there were no statistical differences between region 1 and region 2 in numbers of clinic visits, numbers of asthma prescriptions, doses of rescue inhaler, or oral steroid use per child. In the year after September 11, 2001, residents of region 1, those living within 5 miles of Ground Zero, had significantly more clinic visits per child than in the previous year (3.95 before September 11, 2001, vs 5.10 after September 11, 2001, *P* = .013). There was also an increase in the number of asthma medications prescribed per child in region 1 in the year after September 11, 2001; however, this increase was not statistically significant. In region 2 no significant year-to-year differences were found in any of the 4 clinical parameters. In the year after September 11, 2001, region 1 patients had more clinic visits, prescriptions, and oral steroid use per child than patients in region 2; however, these differences did not reach statistical significance.



FIG 1. Region 1, highlighted in red, indicates zip codes less than or equal to 5 miles from the WTC. Region 2 includes all other zip codes.

PEFR trends

PEFRs were converted into percent predicted values on the basis of expected values for a given height. Means of the percent predicted values are reported for yearly quarters from September 11, 2000–September 10, 2002,

in Table IV and Fig 2. Throughout the 2-year study period, all values in region 2 were within normal limits (>80% predicted). In region 1, however, values decreased to 73.4% for the quarter after September 11, 2001. The values in region 1 gradually returned to baseline, within the normal range, 2 quarters after the disaster.

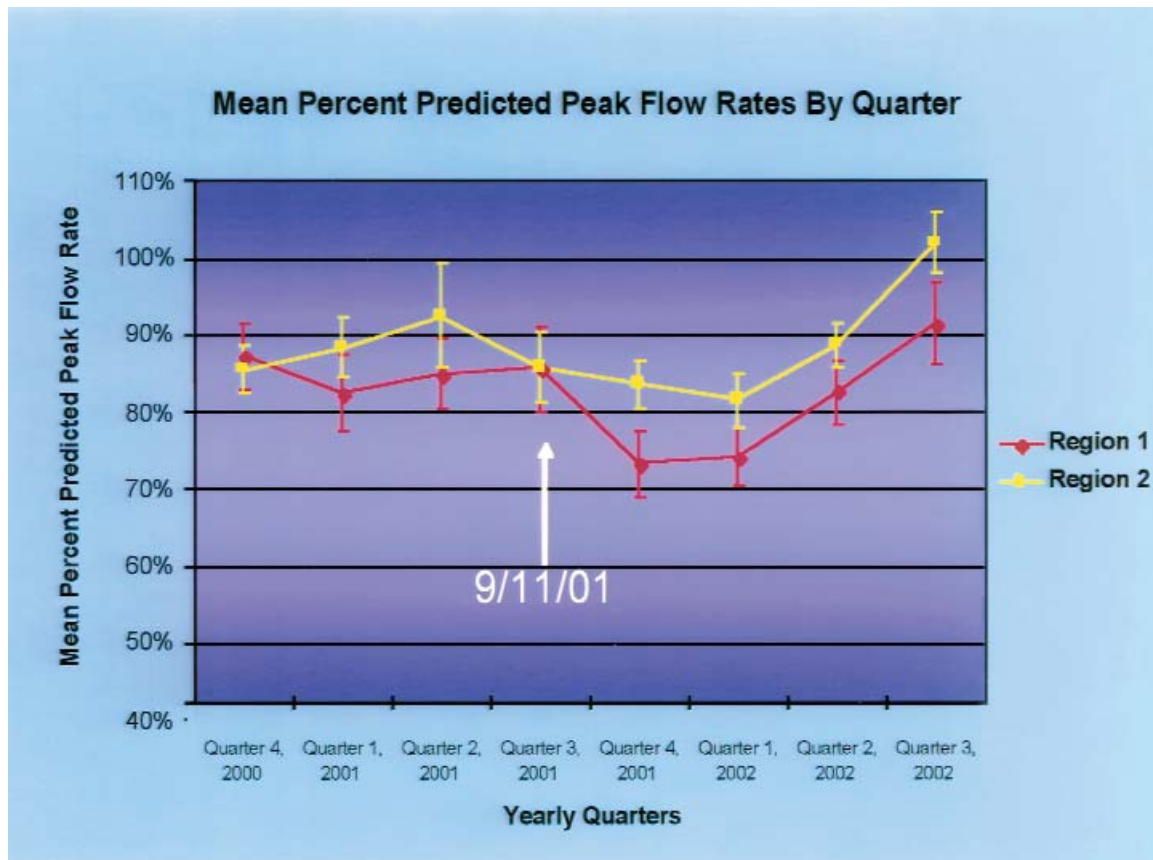


FIG 2. Mean percent predicted peak flow. All values in region 2 were within normal limits (>80% predicted) throughout the 2-year study period. In region 1, however, values decreased to less than normal (73.4%) for the quarter after September 11, 2001, and gradually returned to baseline (within the normal range) 2 quarters after the disaster.

DISCUSSION

Dust and fumes from the WTC collapse are credible triggers of worsening asthma severity in this cohort. Dust samples collected from sites near Ground Zero on September 12, 2001, were rich in calcium-based compounds, which are known to irritate the upper airways in human subjects.¹ Liou et al⁷ performed an analysis of the composition of dust and smoke aerosol from the collapse of the WTC collected on September 16 and 17, 2001. More than 70% of the collected specimens were composed of construction materials: primarily pulverized cement, wallboard, glass fibers (mineral wool and fiberglass), and office furnishings. In addition, soot, paint (leaded and unleaded), plastic, and partially burned jet fuel were detected. The analyses revealed inorganic metals, radionuclides, ionic species, asbestos (0.8%-3.0% of the mass), polycyclic aromatic hydrocarbons (>0.1% of the mass), polychlorinated biphenyls, polychlorinated dibenzodioxins, polychlorinated dibenzofurans, pesticides, phthalate esters, brominated diphenyl ethers, and other hydrocarbons. WTC dust has recently been shown to cause airway hyperresponsiveness in mice.⁸

In children with preexisting asthma, acute exposures to components of air pollution increase respiratory symptoms and decrease respiratory function.⁹ Koenig et al¹⁰ found that increased levels of particulate matter correlated with decreases in FEV₁ and forced vital capacity in asthmatic children. Other studies have demonstrated that exposure to increased levels of particulate matter are associated with an enhanced response to aeroallergens, such as pollen.^{11,12} Also, an increase in asthma symptoms and increased health care use are associated with increased levels of particulate matter.¹³⁻¹⁹

At the CBWCHC in lower Manhattan's Chinatown, asthma health care resource use increased nearly 50% in the year after September 11, 2001. Three hundred six pediatric patients had 1044 asthma-related visits in the year before September 11, 2001, and 510 patients had 1554 visits in the year subsequent to September 11, 2001. Although we did not study patients older than 18 years of age, there was also an increase in adult visits: 96 patients had 190 visits from September 11, 2000–September 11, 2001, and 125 patients had 268 visits the following year. Another study evaluated the effect of the WTC disaster on patients with preexisting asthma. In a random telephone

TABLE I. Demographic characteristics of Chinese American pediatric asthmatic patients, September 11, 2000–September 10, 2002

Characteristics	All patients	Region 1: ≤5 miles from WTC	Region 2: >5 miles from WTC	P value
Age (y)	8.18 ± 3.47	7.81 ± 3.07	8.42 ± 3.70	NS
Sex				
Female, n (%)	69 (34.2)	27 (33.3)	42 (34.7)	NS
Male, n (%)	133 (65.8)	54 (66.7)	79 (65.3)	NS
Height (in)				
Before 9/11	48.69 ± 9.71	47.53 ± 7.38	49.40 ± 10.98	NS
After 9/11	50.63 ± 8.05	49.99 ± 7.08	51.24 ± 8.67	NS
Weight (lbs)				
Before 9/11	63.94 ± 31.45	59.80 ± 26.26	66.57 ± 34.30	NS
After 9/11	71.43 ± 34.43	66.58 ± 28.91	74.93 ± 37.48	NS

NS, Not significant.

Two charts did not contain patient zip codes and could therefore not be classified into regions.

TABLE II. Clinical parameters in Chinese American pediatric patients treated for asthma at the CBWCHC, September 11, 2000–September 10, 2002

Clinical parameter	9/11/2000–9/10/2001	9/11/2001–9/10/2002	P value
Clinic visits for asthma (no. of visits per child)	3.79 ± 3.18	4.69 ± 3.54	.002
Asthma prescriptions (no. of prescriptions per child)	2.05 ± 1.48	2.33 ± 1.19	.018
Rescue inhaler doses per week (no. of doses per child)	7.15 ± 9.46	5.25 ± 8.85	.058
Oral steroid use (% yes)	20 ± 45	19 ± 45	NS

NS, Not significant.

TABLE III. Asthma treatments in Chinese American pediatric patients treated at the CBWCHC, September 11, 2000–September 10, 2002, according to region of residence

Clinical parameter	Region 1			Region 2		
	9/11/2000–9/10/2001	9/11/2001–9/10/2002	P value	9/11/2000–9/10/2001	9/11/2001–9/10/2002	P value
Clinic visits for asthma (no. of visits per child)	3.95 ± 3.07	5.10 ± 4.01	.013	3.71 ± 3.26	4.40 ± 3.21	.063
Asthma prescriptions (no. of prescriptions per child)	2.15 ± 1.51	2.46 ± 1.14	NS	2.00 ± 1.46	2.23 ± 1.22	NS
Rescue inhaler doses per week (no. of doses per child)	4.61 ± 7.70	4.89 ± 8.41	NS	8.87 ± 10.17	7.57 ± 9.21	NS
Oral steroid use (% yes)	0.23 ± 0.45	0.20 ± 0.44	NS	0.18 ± 0.45	0.17 ± 0.45	NS

NS, Not significant.

TABLE IV. Mean percent predicted PEFs by yearly quarters (September 11, 2000–September 10, 2002): Region 1 versus region 2

Yearly quarter	Region 1 (n = 81)	Region 2 (n = 122)	P value
Quarter 4, 2000	87.4%	85.6%	.73
Quarter 1, 2001	82.5%	88.4%	.36
Quarter 2, 2001	84.9%	92.6%	.44
Quarter 3, 2001	85.8%	85.8%	.99
Quarter 4, 2001	73.4%	83.7%	.052
Quarter 1, 2002	74.2%	81.5%	.15
Quarter 2, 2002	82.6%	88.8%	.21
Quarter 3, 2002	91.5%	101.94%	.11

survey conducted 5 to 9 weeks after September 11, 2001, 13.4% of 1008 adult residents of Manhattan noted a pre-existing diagnosis of asthma. Twenty-seven percent of

these asthmatic patients reported subjective worsening of their symptoms after the terrorist attack.²⁰

We also gathered data from a satellite clinic in Flushing, NY, approximately 15 miles from Ground Zero. Total numbers of patients and visits, but not specific clinical criteria, were collected at this clinic, which also serves Chinese American patients. In contrast to our Manhattan data, total pediatric asthma visits in Flushing dropped from 751 visits before September 11, 2001, to 649 visits after September 11, 2001. The number of individual pediatric patients seeking asthma-related health care also decreased from 264 to 235. These data also support our conclusion that children with asthma living closer to the WTC had a greater increase in asthma severity after September 11, 2001.

Our findings also revealed trends in medication use over the study period. Use of a rescue inhaler and oral steroid prescriptions were expected to increase after Sep-

tember 11, 2001, as a reflection of increased asthma severity. Data regarding rescue inhaler use before and after September 11, 2001, could have strengthened our assessment of asthma severity.²¹ Unfortunately, documentation of inhaler use was found in only 63% of reviewed charts before September 11, 2001, and 69% of charts after September 11, 2001. Therefore the calculated mean frequency of inhaler use, although almost reaching statistical significance, might not be clinically meaningful. Our study also showed that oral steroid use did not significantly change after September 11, 2001. Increased use of anti-inflammatory medications, such as leukotriene modifiers and inhaled steroids, might have averted such an increase.

To provide an objective assessment of asthma severity, we analyzed the PEFs of our study group in the year before and the year after September 11, 2001. The National Asthma Education and Prevention Program guidelines recommend the use of PEFs as a gauge of asthma severity.^{22,23} The mean percent predicted peak flow rates for all patients were within normal limits (>80%) before September 11, 2001 (Table IV and Fig 2). In the quarter after the WTC collapse (September 11, 2001–December 10, 2001), patients living in region 1 had a decrease in mean percent predicted PEF. This decrease was not observed in patients living in region 2. The difference in mean percent predicted PEFs between the 2 regions approached statistical significance ($P = .052$) in the 3 months after the disaster. PEFs in region 1 gradually returned to baseline (>80% of predicted value) over the next 6 months. These findings support our hypothesis that asthma severity worsened in the months after September 11, 2001. The study of previously healthy adult firefighters who spent significant time at Ground Zero by Prezant et al² elucidated differences in methacholine reactivity. Although not available at the CBW-CHC, complete pulmonary function tests (with baseline and postdisaster values) and an assessment of methacholine reactivity could provide a more accurate measure of changes in asthma severity in this pediatric population.

Although the increase in airborne pollutants likely explains our observations of worsening asthma severity in this vulnerable population, other factors might play a role. For example, emotional distress can be a trigger for an asthma attack.²⁴ Patients might have been prompted to seek medical attention because of increased public awareness of possible effects of airborne pollutants after the disaster or as a result of a psychologic reaction to the WTC disaster by both adults and children. In fact, the number of visits to psychiatrists increased in lower Manhattan during the weeks after September 11, 2001.²⁵ A telephone survey of residents of New York, New Jersey, and Connecticut showed an increase in alcohol consumption and smoking.²⁵ In another study Chen et al²⁶ looked at emotional distress in an adult population in Chinatown, Manhattan. They found a higher prevalence of anxiety and depression immediately and 5 months after the WTC disaster. In a follow-up unpublished study of this population, there was a post–September 11, 2001,

increase in the average number of mental health encounters per patient (personal communication, Chen). Traditionally, Chinese patients do not readily volunteer information regarding their mental health.²⁷ Instead, they tend to somatize their symptoms.²⁸ Physicians who provide care to this population have to be culturally sensitive and explore the possibility of anxiety and depression masquerading as asthma. Emotional distress might be a confounding factor for the increased number of asthma encounters in this study cohort.

Our study highlights the immediate adverse repercussions of the WTC collapse on the respiratory health of pediatric patients with preexisting lung disease. Asthma severity worsened after September 11, 2001, in Chinese American pediatric asthmatic patients living near Ground Zero, as evidenced by an increase in numbers of clinic visits and numbers of medications. Residential distance from Ground Zero was predictive of the degree of decrease in asthma health. Specifically, patients living closer to Ground Zero had a significant increase in number of clinic visits in the year after September 11, 2001, whereas patients living further from the site did not. Additionally, the mean percent predicted PEF value in region 1 decreased to less than the normal value in the quarter after the disaster, whereas the corresponding value in region 2 remained stable.

Our findings suggest that exposure to substances released during the WTC disaster led to an acute increase in asthma severity. We are concerned about long-term health outcomes in this vulnerable population and are engaging in a study to explore whether the WTC disaster will have chronic respiratory consequences for these asthmatic children.

This study is dedicated to the victims of the World Trade Center disaster.

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REFERENCES

1. McGee JK, Chen LC, Cohen MD, et al. Chemical analysis of World Trade Center fine particulate matter for use in toxicological assessment. *Environ Health Perspect* 2003;111:972-80.
2. Prezant DJ, Weiden M, Banauch GI, et al. Cough and bronchial responsiveness in firefighters at the World Trade Center site. *N Engl J Med* 2002;347:806-15.
3. Banauch GI, Alleyne D, Sanchez R, et al. Persistent hyperreactivity and reactive airway dysfunction in firefighters at the World Trade Center. *Am J Respir Crit Care Med* 2003;168:54-62.
4. Sly RM. Changing prevalence of allergic rhinitis and asthma. *Ann Allergy Asthma Immunol* 1999;82:233-48.
5. Highlights of the expert panel report 2: guidelines for the diagnosis and management of asthma. Bethesda (MD): National Institutes of Health; 1997. NIH publication no. 97-4051A (3, 14, 16).
6. Voter KZ, McBride JT. Diagnostic tests of lung function. *Pediatr Rev* 1996;17:53-63.
7. Liou P, Weisel CP, Millette JR, et al. Characterization of the dust/smoke aerosol that settled east of the World Trade center (WTC) in Lower Man-

- hattan after the collapse of the WTC 11 September 2001. *Environ Health Perspect* 2002;110:703-12.
8. Gavett SH, Haykal-Coates N, Highfill HW, et al. World Trade Center fine particulate matter causes respiratory tract hyperresponsiveness in mice. *Environ Health Perspect* 2003;111:981-91.
 9. Dockery DW, Speizer FE, Stram DO, Ware JH, Spengler JD, Ferris BG Jr. Effects of inhalable particles on respiratory health of children. *Am Rev Respir Dis* 1989;139:587-94.
 10. Koenig JQ, Larson TV, Hanley QS, et al. Pulmonary function changes in children associated with fine particulate matter. *Environ Res* 1993;63:26-38.
 11. D'Amato G, Liccardi G, D'Amato M, Cazzola M. The role of outdoor air pollution and climactic changes on the rising trends in respiratory allergy. *Respir Med* 2001;95:606-11.
 12. D'Amato G, Liccardi G, D'Amato M, Cazzola M. Outdoor air pollution, climactic changes and allergic bronchial asthma. *Eur Respir J* 2002;20:763-76.
 13. Teague WG, Bayer CW. Outdoor air pollution. Asthma and other concerns. *Pediatr Clin North Am* 2001;48:1167-83.
 14. Update on asthma and air pollution research in inner cities [abstract]. *Environ Health Perspect* 1999;107:A617.
 15. Goldsmith CA, Kobzik L. Particulate air pollution and asthma: a review of epidemiological and biological studies. *Rev Environ Health* 1999;14:121-34.
 16. van der Zee S, Hoek G, Boezen HM, Schouten JP, van Wijnen JH, Brunekreef B. Acute effects of urban air pollution on respiratory health of children with and without chronic respiratory symptoms. *Occup Environ Med* 1999;56:802-12.
 17. Peden DB. Air pollution in asthma: effect of pollutants on airway inflammation. *Ann Allergy Asthma Immunol* 2001;87(suppl 3):12-7.
 18. Just J, Segala C, Sahraoui F, Priol G, Grimfeld A, Neukirch F. Short term Health effects of particulate and photochemical air pollution in asthmatic children. *Eur Respir J* 2002;20:899-906.
 19. Mortimer KM, Neas LM, Dockery DW, Redline S, Tager IB. The effect of air pollution on inner-city children with asthma. *Eur Respir J* 2002;19:699-705.
 20. Self-reported increase in asthma severity after the September 11 attacks on the World Trade Center—Manhattan, New York, 2001. *MMWR Morb Mortal Wkly Rep* 2002;51:781-4.
 21. von Klot S, Wolke G, Tuch T, et al. Increased asthma medication use in association with ambient fine and ultrafine particles. *Eur Respir J* 2002;20:691-702.
 22. Higgins BG, Francis HC, Yates C, et al. Environmental exposure to air pollution and allergens and peak flow changes. *Eur Respir J* 2000;16:61-6.
 23. National Asthma Education and Prevention Program Expert Panel Report: guidelines for the diagnosis and management of asthma update on selected topics—2002 November 2002, part 2. *J Allergy Clin Immunol* 2002;110(suppl):S141-219.
 24. Behrman RE, Kliegman RM, Jenson HB. *Nelson textbook of pediatrics*. 16th ed. Philadelphia: W.B. Saunders Co; 2000. p. 666.
 25. Galea S, Ahern J, Resnick H, et al. Psychological sequelae of the September 11 terrorist attacks in New York City. *N Engl J Med*. 2002;346:982-7.
 26. Chen H, Chung H, Chen T, Fang L, Chen JP. The emotional distress in a community after the terrorist attack on the World Trade Center. *Community Ment Health J* 2003;39:157-65.
 27. Chen JP, Chen H, Chung H. Depressive disorders in Asian American Adults. *West J Med* 2002;176:239-44.
 28. Yeung A, Deguang H. Somatoform disorders. *West J Med* 2002;176:253-6.