Table 4. India Studies*

Citation	Design	Study Location	Study Period	Study Sample	Exposure	Health Outcome	Summary of Published Findings
Agarwal KS, Mughal MZ, Upadhyay P, et al. 2002. The impact of atmospheric pollution on vitamin D status of infants and toddlers in Delhi, India. Arch Dis Child 87:111–113.	Cross section	Delhi	2000	34 children (9–24 mo)	Haze (visible atmospheric pollution)	Vitamin D status (serum calcium, alkaline phosphatase, parathyroid hormone, hydroxyvitamin D, dihydroxyvitamin D)	Children living in areas of high atmospheric pollution (haze) had significantly lower serum vitamin D indicators and significantly higher parathyroid hormone and alkaline phosphatase levels when compared with age-matched children from a low pollution area.
Agarwal R, Jayaraman G, Anand S, Marimuthu P. 2006. Assessing respiratory morbidity through pollution status and meteorological conditions for Delhi. Environ Monit Assess 114:489–504.	Ecologic	Delhi	2000–2003	Residents	SPM, RSPM, SO_2, NO_2	Respiratory morbidity, COPD, asthma, emphysema	Significant positive correlations of COPD with SPM and RSPM were observed. No significant correlation was observed between asthma and SPM or RSPM.
Anjaneyulu Y, Jayakumar I, Hima Bindu V, et al. 2005. Use of multi-objective air pollution monitoring sites and online air pollution monitoring system for total health risk assessment in Hyderabad, India. Int J Environ Res Public Health 2:343–354.	Health impact	Hyderabad	2003	Residents	TSPM, $PM_{2.5}$, PM_{10}, SO_2, NO_x, CO, O_3	Respiratory diseases	Particulate matter is a significant factor in the development and exacerbation of respiratory disease in Hyderabad.
Awasthi S, Glick HA, Fletcher RH et al. 1996. Ambient air pollution and respiratory symptoms complex in preschool children. Indian J Med Res 104:257–262.	Cross section	Lucknow	1993–1994	664 children (1 mo–4.5 yr)	SPM, SO_2, NO_2	Respiratory symptoms complex, morbidity due to pneumonia (having cough and difficulty breathing)	Airborne PM and SO_2, cooking and heating fuels, and indoor cooking were associated with increased respiratory symptoms, increased duration of symptoms, or both.
Bladen WA. 1983. Relationship between acute respiratory illness and air pollution in an Indian industrial city. J Air Pollut Control Assoc 33:226–227.	Time series	Bombay	1989	2980 patients records of respiratory illness	PM, SO_2, CO, HC	Acute respiratory illness	Air pollution from SO_2, PM, CO, and HC were markedly associated with acute respiratory illness. This finding was especially strong from November to February when pollution concentrations were higher due to thermal inversions.
Chandrasekaran R, Samy PL, Murthy PB. 1996. Increased sister chromatid exchange (SCE) frequencies in lymphocytes from traffic policemen exposed to automobile exhaust pollution. Hum Exp Toxicol 15:301–304.	Cross section	Madras metro	–	Policemen	Traffic emissions	Sister chromatid exchange frequencies	The policemen with long-term traffic air pollution exposure had significantly greater number of sister chromatid exchanges compared to matched controls.

* Last updated June 2006.

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Chhabra SK, Chhabra P, Rajpal S, et al. 2001. Ambient air pollution and chronic respiratory morbidity in Delhi. Arch Environ Health 56:58–64.	Cross section	Delhi	1988–1998	4171 adults residents in 2 areas with different pollution levels	TSP, SO_2, NO_x	Chronic respiratory morbidity (chronic respiratory symptoms, prevalence of chronic respiratory airways disease, and lung function)	Smoking, male sex, increasing age, and socioeconomic status were strong independent risk factors for chronic respiratory symptoms. Prevalence of bronchial asthma, COPD, and chronic bronchitis was not significantly different among residents of the two zones. Lung function of asymptomatic nonsmokers was consistently and significantly better among both male and female residents of the lower-pollution area.
Chhabra SK, Gupta CK, Chhabra P, et al. 1999. Risk factors for development of bronchial asthma in children in Delhi. Ann Allergy Asthma Immunol 83:385–390.	Cross section	Delhi	–	21,367 children (5–17 yr)	TSP	Asthma	Questionnaires completed by parents showed male sex, a family history of atopic disorders, and smokers in the family were significantly associated with asthma whereas economic class, ambient TSP, and type of kitchen fuel were not.
Cropper ML, Simon NB, Alberini A, et al. 1997. The health effects of air pollution in Delhi, India. PRD Working Paper 1860 (unpublished). New Ideas in Pollution Regulation, World Bank, Washington DC. Available from www.worldbank.org/nipr/work_paper/1860/index.htm.	Time series	Delhi	1991–1994	–	TSP, SO_2, NO_x	Mortality (nontraumatic deaths, RespD and CVD deaths)	Mortality for ages 5–64 yr was significantly associated with TSP. The authors note, however, that reducing TSP by 100 µg/m^3 led to a 2.3% increase in deaths compared with a 6% increase reported for other countries. They attributed the difference to differences in expected life span.
Deb SK. 1998. Acute respiratory disease survey in Tripura in case of children below five years of age. J Indian Med Assoc 96:111–116.	Ecologic	Tripura	1992–1993	800 children (< 5 yr)	Ambient air pollution	Acute respiratory infection–related morbidity and mortality	Air pollution in the urban area was responsible for the higher incidence of acute respiratory illness in all age groups when compared with children in the relatively unpolluted rural area.
Ghose MK, Paul R, Banerjee RK. 2005. Assessment of the status of urban air pollution and its impact on human health in the city of Kolkata. Environ Monit Assess 108:151–167.	Cross section	Kolkata, India	–	Middle class subpopulation	SPM, NO_x, CO	Respiratory disorders	Urban air pollution has a negative impact on human health.
Gupta D, Boffetta P, Gaborieau V, et al. 2001. Risk factors of lung cancer in Chandigarh, India. Indian J Med Res 113:142–150.	Case control	Chandigarh	1995–1997	235 cases and 525 controls matched by sex and age	Urban air pollution, indoor pollution, tobacco smoking, occupational exposure	Lung cancer	Questionnaire data on smoking and daily pollution levels indicated that urban residence (ie, exposure to higher air pollution) did not increase the risk of developing lung cancer.
Gupta SK, Gupta V, Joshi S, et al. 2002. Subclinically dry eyes in urban Delhi: an impact of air pollution? Ophthalmologica 216:368–371.	Cross section	New Delhi and Yamunanagar	2000	400 healthy volunteers (210 within Delhi, 190 outside)	Ambient air pollution	Tear break-up time	Long term air pollution were associated with the causation of dry eye.

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Ingle ST, Pachpande BG, Wagh ND, et al. 2005. Exposure to vehicular pollution and respiratory impairment of traffic policemen in Jalgaon city, India. Ind Health 43:656–662.	Cross section	Jalgaon	2003–2004	60 traffic policemen, 60 healthy adults	PM_{10}, SO_x, NO_x	Respiratory function	Spirometric analysis showed significant respiratory impairment for traffic policemen. The use of personal protective equipment (PPE) was recommended to help protect from vehicular pollution.
Joseph A, Ad S, Vastava A. 2003. PM(10) and its impacts on health—a case study in Mumbai. Int J Environ Health Res 13:207–214.	Health impact	Mumbai	1995–2000	General population	RSP	Mortality	The authors conclude that transfer of results from epidemiologic studies in developed countries can underestimate health effects in developing countries and should not be used for this purpose.
Kamat SR, Doshi VB. 1987. Sequential health effect study in relation to air pollution in Bombay, India. Eur J Epidemiol 3:265–277.	Cross section	Mumbai	1977–1979	4129 subjects	SPM, SO_2, NO_2	Respiratory morbidity; mortality (cardiac, respiratory, cancer)	Air pollution was related to several respiratory symptoms as well as an increase in mortality due to cardiac, respiratory, and malignant diseases.
Kamat SR, Godkhindi KD, Shah BW, et al. 1980. Correlation of health morbidity to air pollutant levels in Bombay City: results of prospective 3 year survey at one year. J Postgrad Med 26:45–62.	Cross section	Mumbai	1977–1979	4129 subjects	SPM, SO_2, NO_2	Prevalence of cardiac diseases, dermatitis, stuffy nose, chest pain, and eye irritation; respiratory symptoms; lung function	In the 3 urban areas of low, medium, and high air pollution levels, low pollution was associated with higher lung function at all ages. In the rural area, however, lung function was significantly lower despite lower pollution. Other factors possibly contributed to this difference.
Kamat SR, Patil JD, Gregart J, et al. 1992. Air pollution related respiratory morbidity in central and north-eastern Bombay. J Assoc Physicians India 40:588–593.	Cross section	Central and northeastern Bombay	1988–1989	1545 matched subjects	SPM, SO_2, NO_2	Respiratory and cardiac symptoms	Respiratory symptoms and cardiac diseases appeared to occur more often in more polluted areas.
Kumar KS, Prasad CE, Balakrishna N, et al. 2000. Respiratory symptoms and spirometric observations in relation to atmospheric pollutants in a sample of urban population. Asia Pac J Public Health 12:58–64.	Cross section	Hyderabad	1991	216 males (18–60 yr)	SPM, SO_2, NO_x	Prevalence of respiratory problems, lung function	A respiratory questionnaire and lung function spirometry tests revealed a higher prevalence of respiratory problems associated with higher levels of SO_2 and NO_x.
Kumar R, Sharma M, Srivastva A, et al. 2004. Association of outdoor air pollution with chronic respiratory morbidity in an industrial town in northern India. Arch Environ Health 59:471–477.	Cross section	Mandi Gobindgarh, Morinda	1999–2001	3603 residents (>15 yr)	TSP, PM_{10}, NO_x, SO_2, CO, O_3	Chronic respiratory morbidity, spirometric ventilatory defect	Air pollution, particularly high levels of TSP, has adversely affected the respiratory health of the general population residing in an industrial town in subtropical northern India.
Lahiri T, Roy S, Basu C, et al. 2000. Air pollution in Calcutta elicits adverse pulmonary reaction in children. Indian J Med Res 112:21–26.	Cross section	Calcutta, Parganas, and Burdwan	1997–1999	269 students (6–17 yr)	Ambient air pollution	Respiratory symptom complex, sputum cytology and micronucleus count of buccal epithelial cells	Urban children had significantly higher rate of respiratory symptoms, sputum alveolar macrophage number, and micronucleus count of buccal epithelial cells compared to rural children.

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Mukhopadhyay K, Forssell O. 2005. An empirical investigation of air pollution from fossil fuel combustion and its impact on health in India during 1973–1974 to 1996–1997. Ecol Econ 55:235–250.	Health impact	India	1973–1997	All Indian residents	SO_2, NO_x, CO	Death, asthma, respiratory diseases	Air pollution has severe effects on respiratory health in India. Fossil fuel emissions are the source of the air pollution.
Pande JN, Bhatta N, Biswas D, et al. 2002. Outdoor air pollution and emergency room visits at a hospital in Delhi. Indian J Chest Dis Allied Sci 44:13–19.	Time series	New Delhi	1997–1998	More than 10 million people	TSP, SO_2, NO_x, CO	Morbidity (COPD, asthma, acute coronary event)	Emergency room visits for acute asthma, COPD, and coronary events increased by 21%, 25%, and 24%, respectively, on days with higher levels of pollution (CO, NO_x, SO_2).
Pandey JS, Kumar R, Devotta S. 2005. Health risks of NO2, SPM and SO2 in Delhi (India). Atmos Environ 39:6868–6874.	Health impact	Delhi	–	–	SPM, NO_2, SO_2	Health risk	Health risks due to air pollution in Delhi are highest for children. For all age categories, health risks due to SO_2 are the lowest.
Paramesh H. 2002. Epidemiology of asthma in India. Indian J Pediatr 69:309–312.	Cross section	Bangalore	1979, 1984, 1989, 1994, 1999	20,000 children (<18 yr), 6550 children (6–15 yr)	Ambient air pollution and traffic emissions	Prevalence of asthma	The increased prevalence and severity of asthma in the metropolitan city correlated with environmental pollution, urbanization and change in the demography of the city.
Rao NM, Patel TS, Raiyani CV, et al. 1992. Pulmonary function status of shopkeepers of Ahmedabad exposed to autoexhaust pollutants. Indian J Physiol Pharmacol 36:60–64.	Cross section	Ahmedabad	–	Shopkeepers	NO_x	Lung function (VC, FEV_1 and $FEF_{25\text{-}75}$)	The shopkeepers in high traffic air pollution area, where NO_x level was higher than TLV (threshold limit value), had significantly higher impairment of FEV_1 and $FEF_{25\text{-}75}$.
Sahai A, Malik P. 2005. Dry eye: prevalence and attributable risk factors in a hospital-based population. Indian J Ophthalmol 53:87–91.	Cross section	Jaipur	–	500 ophthalmic patients (> 20 yr)	Air pollution	Dry eye	The air pollution exposed group has higher odds for dry eye. However, the difference was not statistically significant between exposed and nonexposed groups.
Sharma M, Kumar VN, Katiyar SK, et al. 2004. Effects of particulate air pollution on the respiratory health of subjects who live in three areas in Kanpur, India. Arch Environ Health 59:348–358.	Panel	Kanpur	2002–2003	91 subjects from 3 areas	PM_{10}, $PM_{2.5}$	Lung function	An increase of 100 mg/m^3 PM_{10} was associated with a reduction of the mean PEF rate by approximately 3.2 L/min for an individual.
Singh V, Khandelwal R, Gupta AB. 2003. Effect of air pollution on peak expiratory flow rate variability. J Asthma 40:81–86.	Cross section	–	–	313 nonsmoker students	RSP, SO_2, NO_2, CO	Lung function (peak expiratory flow)	Commuting healthy students, with long-term periodic exposure to air pollution, had significantly higher peak flow variability.
Srivastava A, Kumar R. 2002. Economic valuation of health impacts of air pollution in Mumbai. Environ Monit Assess 75:135–143.	Health impact	Kumar, Mumbai	1997	Population in Mumbai	Ambient air pollution	Health damage cost	A dose–response relation of air pollution to human health was based on time spent by an individual in different microenvironments during 1 day. Economic valuation of morbidity and mortality was estimated through lost salary. Results showed that avoidance cost was 29% of total health damage cost.

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